Jingle Jigsaw - Playful Dance Scaffolding Through Motion Detection

JoDee Allen
Concordia University
Montreal, QC, Canada
jodeenadene.allen@mail.concordia.ca

Adrian Holzer
University of Neuchâtel
Neuchâtel, NE, Switzerland
adrian.holzer@unine.ch

Abstract
Extended screen-time can have negative health effects in both children and adults. With the advent of motion detection sensors and other novel interaction methods, it is possible to envision digital games that move away from screen-centered design. However, such interaction is still underrepresented in both the mainstream and academia. To address this issue, this paper proposes a screenless dance game, called Jingle Jigsaw, that encourages players to physically explore the space around them by using spatial tracking and audio feedback. We conducted a preliminary usability evaluation that conveys the fact that such interaction is perceived as enjoyable by users and pointed to promising future work.

Author Keywords
Exer-games; dancing; digital-physical games, motion sensors; HCI.

CCS Concepts
•**Human-centered computing** → **Human computer interaction (HCI);** User studies; *Interaction design theory, concepts and paradigms;*

CHI '20 Extended Abstracts, April 25–30, 2020, Honolulu, HI, USA.

ACM ISBN 978-1-4503-6819-3/20/04.
http://dx.doi.org/10.1145/3334480.3382961

Introduction

Videogames are more popular than ever[1] with people spending around 7 hours of their week playing.[2] At the same time, screen-time is associated with adverse effects on the body that can include obesity, poor sleeping habits, or lowered attention span [4, 32]. With this in mind, a new genre of game, called *exer-games* has emerged [26]. Within this genre, dance games have been amongst the most popular [17]. And early research on such games has shown that they can positively affect social life and physical health of users [17]. These games leverage on the advances in consumer electronics to produce more immersive forms of interaction. For instance, Dance Dance Revolution, the object of the above mentioned research (i.e., [17]), is an arcade game that uses a connected floor mat to track user moves. Gesture gaming consoles have started to release games that do not require a screen during gameplay, such as the Quick Draw game for Nintendo Switch. In this game players use the game controller as pistols that they draw in cowboy-style face-off. Others dispense with controllers all together. For instance Microsoft Kinect, a low-cost motion sensing device, allows players to interact using natural gestures [21]. However, despite the growing popularity of movement-based games, researchers argue that the diversity of movement and interactions are still underexplored [13, 1]. For instance there are mainly standing movement interactions for dancing. Furthermore, in many games, instructions or outcomes still require a screen so the game is not completely unreliant on visual feedback. In this paper we address this issue and propose the design of Jingle Jigsaw, a novel screenless dance game that exclusively uses movement as input and sound as feedback.

[1] https://www.statista.com/statistics/490522/global-esports-market-revenue/

[2] https://www.statista.com/statistics/273829/average-game-hours-per-day-of-video-gamers-in-selected-countries/

Methodology and Roadmap

Since this research aims at addressing a human-centered problem through a novel digital artefact, it follows a Design Science Research Methodology (DSRM) adequate for such projects [27, 15]. The paper itself follows the six steps of the DSRM [27]. In the introduction we investigated the problem (Step 1). Step two (the objective of the solution) is presented with the related work. Then, we discuss the design (Step 3) and demonstration (Step 4) of the artefact based on Mueller and Isbister's game design guidelines [19, 25]. Then, we evaluate the artefact (Step 5) and then wrap up with a conclusion. The last step of the DSRM is communication of the project (this article).

Related work

There are several interaction technologies for dance games. Among these we find motion sensing technologies (e.g., [24, 5, 22]), mobile sensors to be attached to the body such as a phone or an armband (e.g., [30, 8, 18, 12]), and virtual reality glasses (e.g., [33]). In this paper we focus on motion sensing technologies that allow users to move freely without the need to use any attached device. Examples of games using motion sensors include Dance Central on the Kinect [5], where instructions are given on a screen and players must follow them by making movements. Another example is Super Mirror, a Kinect-based app that provides ballet dancers with real time instructional feedback [22]. Dance training apps in virtual environments have been shown to be a form of enjoyable exercise [3] providing physical, cognitive and psychosocial benefits [29]. In terms of learning dance move, some studies have shown that dance training apps are more interesting, stimulating and more effective than simply watching instructional videos [6]. However, others have argued that the best combination is instructional videos with dance games, as opposed to dance games only [7]. Finally in terms of interface, a study cov-

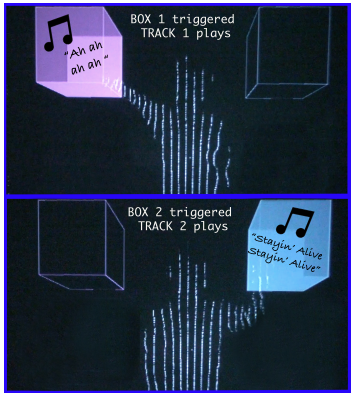

Figure 1: Shown here is the player as perceived by the Kinect, during level-one gameplay of "Stayin' Alive".

Figure 2: Shown here is the player playing level-one, "Stayin' Alive".

ering five exer-games (StepMania on a PC, Dance Dance Revolution on the Wii console, Just Dance 30 on XBox, Just Dance 20 on the Wii, Dance Central on Kinect) found that user interface mattered, but usability even more; when controls are harder to use they are a barrier to engagement [5]. The literature indicates that dance games are promising forms of exer-game. However, an unresolved research question that guides the objectives of our solution is: *how to design a playful dance game that has no screen interface?*

Jingle Jigsaw Design

To address this issue and design a playful screenless dance game using motion detection we present a novel game called Jingle Jigsaw. Hereafter, we begin by describing the gameplay and then highlight the most salient ways our design relates to the three design guideline clusters of Mueller and Isbister's framework [19, 25].

Gameplay

Jingle Jigsaw is a Kinect-based puzzle/dance game. The goal of the game is for players to find and assemble pieces of an audio puzzle using dance-like movements. In the game the puzzle to be solved is a song, and the pieces of the puzzle are sound clips of that song. The pieces of the puzzle are placed as virtual boxes in the physical dance space around the player. The player cannot see these boxes–there is no visual interface–so they must explore their immediate space to find and activate the boxes. To solve the level, the parts of the puzzle need to be played in the correct sequence with the correct timing. The player determines the sequence by first listening to the sound clips and then assembling them from prior knowledge of the song, or trial and error. If the player succeeds in playing the sequence correctly three times consecutively, they pass to the next level. The player is guided by audio feedback that tells them when they have passed a level. There are five levels to the game. Each level adds one additional box to the gameplay: the first level has two active boxes, the second level has three, and so on. The final level is a bonus, with all boxes containing beatboxing sounds recorded from Montreal beatboxer Lateef Martin. It is a freestyle level where the player can playback the sounds in any order they choose for as long as they like. When the player is done playing and leaves the gameplay area, the game automatically resets for the next player. The start and the end of the game are also indicated to the player through audio feedback. Figure 1 shows how a player is perceived by the Kinect motion sensor and figure 2 shows a player activating the virtual boxes with her arms.

Cluster 1: ambiguity, movement articulation, movement cognitive load, body focus

The design guidelines advise to *embrace ambiguity*, in the sense of addressing the unreliability of current movement tracking technologies, as well as the imprecision of human movement. By using basic boxes as triggers and assigning them to precise locations in space Jingle Jigsaw mitigates the tracking limitations of the Kinect system. The mechanics are simple–virtual button presses–but the gameplay still allows for a wide range of movements. Players might use their hand, head or foot to trigger the same box.

The design guidelines advise to *celebrate movement articulation* as it acknowledges the rewarding potential of movement. In Jingle Jigsaw the player's movements are actually what makes the song unfold, so the discovery of the song is rewarding as well as the feeling of moving with the music. The positioning of boxes also suggests a mode of moving that broadly relates to the genre of the song and associated dance styles i.e. disco dances move from side to side and funk dances from up to down.

The design guidelines advise to *consider the movement's cognitive load* with the intention to not overload the player's coordination, by balancing in-game movement challenges and feedback. Jingle Jigsaw is an audio puzzle game that requires the player to first physically locate the invisible boxes in space, remember their location, discern the correct order of the song clips, and move in a manner that triggers the correct playback of the song. There are quite a lot of challenges in fact, but our game allows the player time for exploration and learning. There is no time restriction to the levels so the player can learn and practice the positions of the boxes at their own pace while receiving audio feedback.

The design guidelines advise to *focus design on the body* of the player. Note that this guideline prompted some push-back from some of Mueller and Isbister's study participants. The participants who worked in the commercial videogame industry (those working on Dance Central) counselled against focusing on the player. They said because some players feel shy when they are the physical centre of attention, the screen-aspects of the game help to alleviate this pressure on players [19]. In imitation dance games, such as Dance Central, the choreographies are often stereotypical gendered representations of the dance [23]. In this case focusing on the body could evoke negative feeling for players. To overcome this issue, Jingle Jigsaw focuses on outcome rather than on precise movements, which lets participants explore motions on their own. By players being allowed to perform movements they are more comfortable with, rather than stereotypical dance steps, we aim at designing a more positive focus on the body and thereby alleviated the need for a screen as distraction.

Cluster 2: fatigue, risk, mapping
The design guidelines advise to *intend fatigue*. This guideline suggests that the game design must be intentional towards the body's internal responses to exertion. Jingle Jigsaw provides players an opportunity to scale the intensity of their interaction. Success in the game can be achieved equally by using simple gestures or more complex gestures. This format allows for broad accessibility in terms of mobility and levels of fitness.

The design guidelines advise to *exploit risk*. Physical games have more concrete risk (injuries, soreness) than traditional videogames but are potentially more rewarding experiences [25]. Dance games typically show players what movements to do. Risk in Jingle Jigsaw is mediated through a series of choices rather than mimicked responses. Players can choose their level of physical risk which could have both positive and negative effects. Positively, players could choose stay within their personal comfort zone of risk. Negatively, they could also choose to attempt very risky moves.

The design guidelines advise to *imaginatively map* the inputed player movements to extraordinary in-game results. The examples used were of screen-based movement games i.e. in Wii Tennis, where even a small flick of the wrist results in a successful serve. In Jingle Jigsaw, the imaginative mapping takes on a different form. With the rise of personal assistants certain non-screen interactions (especially voice input and output) are becoming ubiquitous [28]. Players of Jingle Jigsaw navigate a similar kind of hybrid space that overlays the virtual and the physical. The addition of virtual boxes to the player's physical environment provides additional challenges for the player [25] that solicits in particular the body's haptic and aural systems. Through hitting the right virtual boxes, a player suddenly becomes both dancer and musical conductor.

Cluster 3: rhythm, self-expression, social fun
The design guidelines advise to *highlight rhythm*. This guideline points to the benefits of highlighting the rhyth-

Figure 3: Users in action in Lausanne, Switzerland.

mic nature of movement, both as a guide for the player and because it feels good to move that way. In Jingle Jigsaw the player must trigger the boxes not only in the right order but in the right rhythm to succeed.

The design guidelines advise to *support self-expression* so players can contribute positively to their experience of the game. Instead of proscribing a set choreography as is the case in the majority of dancing videogames, Jingle Jigsaw is a spatial body puzzle that players solve. To trigger a virtual box the player could use any part of their body thereby creating their own unique dance as they play the game.

The design guidelines advise to *facilitate social fun* amongst co-players or player/spectators. Jingle Jigsaw is currently designed for a single player so social fun is not an integrated part of the design. However since gesture games are inherently performative due to the shift in focus towards the body of the player [20] the possiblity for social fun exists when an audience is present during gameplay.

Evaluation

We conducted preliminary evaluations with three expert user groups to focus on different aspects of the game: (1) dancers, (2) gamers, and (3) musicians.

Dancers

Dancers were tested on two separate occasions. A first evaluation was conducted with six experienced dancers (3 male, 3 female, age 18-35) in Lausanne Switzerland, the second evaluation took place at Concordia University in Montreal with 6 female students from the department of Contemporary Dance (age 17 - 29).

The evaluation in Lausanne took place at a dance studio where street dancers practice regularly in Lausanne, Switzerland (see Figure 3). We asked the dancers to come to the room one at a time, test the game and give us feedback about their experience. Each session was around 15 minutes including the discussion. In terms of game play, most participants started slowly at the beginning in order to understand the concept and find the boxes. Then several of them, as they started to gain confidence tried to add moves, such as spins, headbutts, highkicks, to the simple gestures that were required to play the game. Also several laughed while playing the game. One participant tried hitting the sounds in a different order to create a new song. In terms of feedback, the dancers appreciated the game saying it was "Cool", "So Cool", "Excellent", "Very fun", "Super stylish". One of the dancers found the idea of "being a conductor" very interesting, whereas another like the concept of "being a beatmeaker". Despite the overall positive attitudes, several of the dancers mentioned some frustration with the game. For example one participant found it frustrating not to find the sounds, whereas another argued that the sound clips were not cut correctly, leading to her dancing off beat.

The evaluation in Concordia took place with all of the dancers in the room together (see Figure 4). They played the game one at a time while the others watched. After all dancers had played the game we discussed their experiences. The total session was 1.5 hours. During the play session the dancers on the side would help the player with verbal cues. At some points the group would start singing the song along with the game. One negative result of the group evaluation was that after the first player solved the game players who followed knew the songs and the position of the boxes. However the spectators began giving each other additional challenges such as “Try to hit the boxes only with your feet!” In future work we have considered randomizing the position of the boxes to make it more challenging in a social format. The participants were asked to fill out a questionnaire about the game (5 out of 6 completed the form).

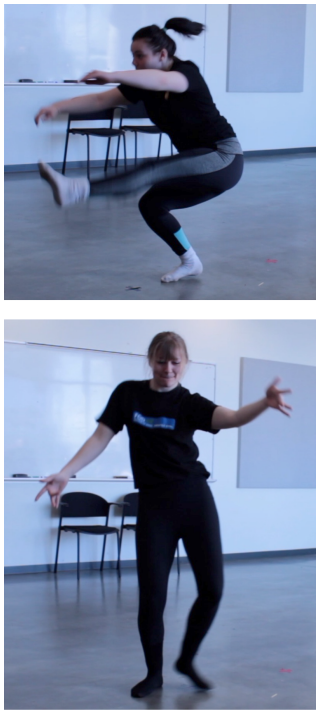

Figure 4: Users at Concordia.

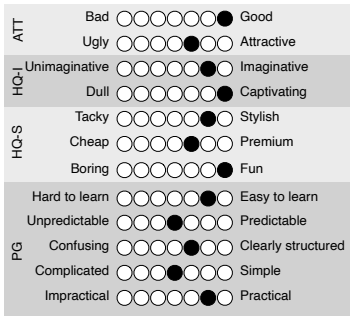

Figure 5: Attrakdiff results. Black dots are median values. N=6.

We evaluated their attitude with the AttrakDiff 2 [14] survey to which we added two dimensions, i.e, boring/fun and hard to learn/easy to learn. The results are depicted in Figure 5 and convey the fact that the game was received very positively. It was found to be especially captivating, imaginative, fun and easy to learn. Furthermore, the respondents all either agreed or strongly agreed that the game gave them sense of freedom and suspense. All participants agreed they wanted play the game again. All but one person entered a positive response to the game's audio enhancing the experience. In terms of feedback in the game, all participants either agreed or strongly agreed that they understood when they succeeded or failed in the game and they all responded that their awareness of space had improved.

Gamers

This playtest was also at Concordia University with members of the Technoculture and Games Lab. There was a group of eight people; three people played the game and the rest watched. In discussions following the playtest the gamers indicated the game's most unique feature was that it did not use a screen. One player responded to the questionnaire and wrote: "It was great to explore a space in which audio is materialized. It was cool to "dance" without imitating a model on screen but as the result of playing." In both tests at Concordia University, players expressed the importance of using songs that were easily recognizable.

Musicians

We conducted two additional playtests with a total of 9 playtesters that included four female and two male experienced musicians. In these sessions the players were all in the room and took their turns playing the game. The playtests each lasted 1 hour with a discussion at the end that lasted 30 mins. Overall, the musicians enjoyed the game, but contrary to gamers and dancers they focued on techincal aspects and highlighted a lag between triggering the virtual boxes and the sound playing; they were expecting the virtual buttons to react more like playing music on a drum kit, or playing rhythm games such as Rock Band.

Conclusion and future work

Screenless digital-physical games open up the potential for a wider variety of health benefits for players. In this paper we have started investigating how to push the design boundaries of dance games towards unorthodox interactions using only movement as input and audio as output. To do so we designed a dance game called Jingle Jigsaw. In the design we were careful to include underexplored features such as free movement dancing [13] which also reduced potential inclusion concerns [23]. Our preliminary evaluations concur with previous findings that showed that dance exer-games are enjoyable [3] for expert users. Furthermore, we observed that players were creative in the way they played. This could be interpreted in the light of research on ambiguous and counter-intuitive design where users find their own meaning in uncertain situations [9, 2, 11]. An aspect that could be further investigated in a screenless digital game is the player-spectator role. In traditional videogames (not movement-based games) it can generally be argued that players become spectators to their own gameplay, because they are watching their performance on the screen [10]. In Kinect games, spectatorship usually refers to people engaged in watching the player as well as the screen [31]. Our screenless, Kinect game presents an interesting case for study. Future work will investigate a broader user base and will further investigate health aspects. Previous research on dance exer-games paint a positive picture [17], however in the broader context of outdoor games, the play benefits are compromised by the introduction of a digital artefact even if they are not screen-based [16].

REFERENCES

[1] JoDee Allen. 2015. *Break the Game: A Practice-Based Study of Breaking and Movement Design for Video Games*. Master's thesis. Concordia University.

[2] Paul M. Aoki and Allison Woodruff. 2005. Making Space for Stories: Ambiguity in the Design of Personal Communication Systems. In *CHI'05*. 181–190.

[3] Alethea Blackler, Shital Desai, Levi Swann, Marianella Chamorro-Koc, Gene Moyle, and Mikaela Stephens. 2019. Using technology to enhance and encourage dance-based exercise. *Heliyon* 5, 3 (2019), e01241.

[4] Janne E Boone, Penny Gordon-Larsen, Linda S Adair, and Barry M Popkin. 2007. Screen time and physical activity during adolescence: longitudinal effects on obesity in young adulthood. *International Journal of Behavioral Nutrition and Physical Activity* 4, 1 (2007), 26.

[5] Shaw Bronner, Russell Pinsker, Rutika Naik, and J Adam Noah. 2016. Physiological and psychophysiological responses to an exer-game training protocol. *Journal of science and medicine in sport* 19, 3 (2016), 267–271.

[6] Jacky CP Chan, Howard Leung, Jeff KT Tang, and Taku Komura. 2010. A virtual reality dance training system using motion capture technology. *IEEE Transactions on Learning Technologies* 4, 2 (2010), 187–195.

[7] Emiko Charbonneau, Andrew Miller, and Joseph J LaViola Jr. 2011. Teach me to dance: exploring player experience and performance in full body dance games. In *Proceedings of the 8th International Conference on Advances in Computer Entertainment Technology*. ACM, 43.

[8] James Clawson, Nirmal Patel, and Thad Starner. 2010. Dancing in the Streets: The design and evaluation of a wearable health game. In *International Symposium on Wearable Computers (ISWC) 2010*. IEEE, 1–4.

[9] William W Gaver, Jacob Beaver, and Steve Benford. 2003. Ambiguity as a resource for design. In *ACM CHI'03*. 233–240.

[10] Victoria K Gosling and Garry Crawford. 2011. Game scenes: Theorizing digital game audiences. *Games and Culture* 6, 2 (2011), 135–154.

[11] Dimitris Grammenos. 2014. Abba-dabba-ooga-booga-hoojee-goojee-yabba-dabba-doo: stupidity, ignorance & nonsense as tools for nurturing creative thinking. In *CHI'14 EA*.

[12] Carla F. Griggio, Mario Romero, and Germán Leiva. 2015. Towards an Interactive Dance Visualization for Inspiring Coordination Between Dancers. In *Proceedings of the 33rd Annual ACM Conference Extended Abstracts on Human Factors in Computing Systems (CHI EA '15)*. Association for Computing Machinery, New York, NY, USA, 1513–1518. DOI: http://dx.doi.org/10.1145/2702613.2732925

[13] Perttu Hämäläinen, Joe Marshall, Raine Kajastila, Richard Byrne, and Florian Floyd Mueller. 2015. Utilizing gravity in movement-based games and play. In *Proceedings of the 2015 Annual Symposium on Computer-Human Interaction in Play*. ACM, 67–77.

[14] Marc Hassenzahl, Michael Burmester, and Franz Koller. 2003. *AttrakDiff: Ein Fragebogen zur Messung wahrgenommener hedonischer und pragmatischer Qualität*. Vieweg+Teubner Verlag, Wiesbaden, 187–196. DOI: http://dx.doi.org/10.1007/978-3-322-80058-9_19

[15] Alan Hevner and Samir Chatterjee. 2010. Design science research in information systems. In *Design research in information systems*. Springer, 9–22.

[16] Tom Hitron, Idan David, Netta Ofer, Andrey Grishko, Iddo Yehoshua Wald, Hadas Erel, and Oren Zuckerman. 2018. Digital Outdoor Play: Benefits and Risks from an Interaction Design Perspective. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*. ACM, 284.

[17] Johanna Hoysniemi. 2006. International survey on the Dance Dance Revolution game. *Computers in Entertainment (CIE)* 4, 2 (2006), 8.

[18] Katherine Isbister, Elena Márquez Segura, and Edward F Melcer. 2018. Social Affordances at Play: Game Design Toward Socio-Technical Innovation. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*. ACM, 372.

[19] Katherine Isbister and Florian “Floyd” Mueller. 2015. Guidelines for the design of movement-based games and their relevance to HCI. *Human–Computer Interaction* 30, 3-4 (2015), 366–399.

[20] Steven E Jones and George K Thiruvathukal. 2012. *Codename revolution: the Nintendo Wii platform*. MIT Press.

[21] Roanna Lun and Wenbing Zhao. 2015. A survey of applications and human motion recognition with microsoft kinect. *International Journal of Pattern Recognition and Artificial Intelligence* 29, 05 (2015), 1555008.

[22] Zoe Marquardt, João Beira, Natalia Em, Isabel Paiva, and Sebastian Kox. 2012. Super Mirror: a kinect interface for ballet dancers. In *CHI'12 Extended Abstracts on Human Factors in Computing Systems*. ACM, 1619–1624.

[23] Kiri Miller. 2015. Gaming the system: Gender performance in Dance Central. *New media & society* 17, 6 (2015), 939–957.

[24] Ob-orm Muangmoon, Pradorn Sureephong, and Karim Tabia. 2017. Dance training tool using kinect-based skeleton tracking and evaluating dancer's performance. In *International Conference on Industrial, Engineering and Other Applications of Applied Intelligent Systems*. Springer, 27–32.

[25] Florian'Floyd' Mueller, Darren Edge, Frank Vetere, Martin R Gibbs, Stefan Agamanolis, Bert Bongers, and Jennifer G Sheridan. 2011. Designing sports: a framework for exertion games. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, 2651–2660.

[26] Bjorn Nansen. 2009. Exertion gaming as kinaesthetic technicity. *Second Nature: International journal of creative media* 1, 2 (2009), 64–97.

[27] Ken Peffers, Tuure Tuunanen, Marcus A Rothenberger, and Samir Chatterjee. 2007. A design science research methodology for information systems research. *Journal of management information systems* 24, 3 (2007), 45–77.

[28] Martin Porcheron, Joel E Fischer, Stuart Reeves, and Sarah Sharples. 2018. Voice interfaces in everyday life. In *proceedings of the 2018 CHI conference on human factors in computing systems*. ACM, 640.

[29] Paula Alexandra Silva. 2019. Are We Ready to Dance at Home?: A Review and Reflection of Available Technologies. In *International Conference on Human-Computer Interaction*. Springer, 216–231.

[30] Misha Sra and Chris Schmandt. 2015. Expanding social mobile games beyond the device screen. *Personal and Ubiquitous Computing* 19, 3-4 (2015), 495–508.

[31] Burak S Tekin and Stuart Reeves. 2017. Ways of spectating: Unravelling spectator participation in Kinect play. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*. ACM, 1558–1570.

[32] Xiaoyan Wu, Shuman Tao, Yukun Zhang, Shichen Zhang, and Fangbiao Tao. 2015. Low physical activity and high screen time can increase the risks of mental health problems and poor sleep quality among Chinese college students. *PloS one* 10, 3 (2015), e0119607.

[33] Zhuoming Zhou, Elena Márquez Segura, Jared Duval, Michael John, and Katherine Isbister. 2019. Astaire: A Collaborative Mixed Reality Dance Game for Collocated Players. In *Proceedings of the Annual Symposium on Computer-Human Interaction in Play*. ACM, 5–18.