Original Paper

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"Grandma! Grandpa! Let`s play together!" – Effects of game mode in multiplayer video games on intergenerational social interaction: A randomized field study

Abstract

Background: Maintaining social relationships is a basic human need and particularly essential in old age, including when living in a retirement home. Multiplayer video games can promote the establishment and maintenance of social relationships, due to facilitating positive social interactions between players, even from different generations. Such facilitation of positive social interactions depends, however, on specific game design. In order to systematically investigate possible effects of game design on social interaction between seniors and their co-players, the game *Myosotis FoodPlanet* has been developed for the present study and the impacts of three different game modes on social interaction were compared in a controlled field trial.
Objective: The study aims to compare the impacts of three different game modes (competitive, cooperative and creative) on social interactions (verbal and nonverbal communication) between seniors and their younger co-players during gameplay.
Methods: The study was conducted in a Swiss retirement home as a controlled field trial. Participants were residents of the retirement home (N=10; mean age = 84.8 years, SD = 5.9) and played in pairs with their caregivers. Each pair played three game modes in a random order. This resulted in N=30 game sequences of twenty minutes each. A within-subject design was applied with *Game Mode* as the within-factor - and *Social Interaction* as the outcome variable. To assess the quality of social interaction, the 30 video-recorded game sequences were analyzed regarding verbal and nonverbal communication sequences based on an event sampling method.
Results: ANOVA for repeated measurements revealed significant effects: There was significantly more verbal communication in the creative mode than in the

cooperative mode (*P*=.04) with strong effect size (*f*=0.611). A closer examination of verbal communication showed that there was more *game-related* communication in the creative mode than in the cooperative mode (*P*=.01) and the competitive mode (*P*=.09) with marginally significant effects and strong effect sizes (*f*=0.841). Additionally, significantly more biography-related communication occurred in the creative mode than in the cooperative mode (*P*=.03) with strong effect size (*r*=0.707). Regarding nonverbal communication (e.g., laughing together), ANOVA for repeated measurements showed significant differences between the game modes (P=.02) with strong effect size (f=0.758); results show that there was significantly more laughing together in the competitive mode (competitive > cooperative > creative).
Conclusions: In conclusion, the results show that game mode can be an important factor that shapes the social interactions of players playing together. More than other modes, creative game modes can increase verbal communication, stimulating both game-related and biography-related talk. In contrast, competitive modes may stimulate more laughing together. This has important implications on game design and the use of computer games for promoting social interaction between seniors and their co-players in practice.
Trial Registration: The study is not liable to registration according to Swiss Federal Human Research Act (HRA) or WHO International Standards (it is not a clinical trial). The study is in accordance with the principles of WMA Declaration of Helsinki.
Keywords: video games; computer games, elderly people, game mode; serious game; social interaction; video analysis methods

Introduction

Playing digital games as social activity connecting people from different age groups and generations

Maintaining social relationships is a basic human need and, therefore, highly relevant for psychological well-being [1]. This is particularly true in old age [2,3,4,5], including when living in a retirement home. Here, multiplayer video games can promote well-being and the maintenance of social relationships [6,7,8], because they can facilitate *positive* social interactions during play, even for players from different generations [9,10,11,12,13,14]. Imagine, for instance, a visiting grandchild playing a video game with their grandparent in a retirement home. Or imagine care-persons and residents playing together during activation therapy or recreation in a common room. Playing together is a rewarding experience [15] and connects people by joint action, cooperation, or playful and unthreatening competition. In this way, it can link people from *different* generations, bridging the gap between them. Research indicates that social interaction and entertainment are one of the main motivating factors for elderly people to play video games [16,17,18]. Specifically, players enjoy interacting with others, watching others playing, and talking about the game [19,20,21]. Digital technology, which is ubiquitous in the lives of younger and adult

people, has been investigated as a tool to connect generations, including those of advanced age [2]. For instance, intergenerational digital games can enhance social bonding [22] and pave the way for improved communication between players [23]. The term "intergenerational," therefore does not only include family bonds (e.g., grandchildren and grandparents), but can also be considered in a wider sense in terms of age (e.g., older and younger people) or community life (e.g., youth and elders) [24].

Taken together, playing video games seems to be a meaningful way to foster positive intergenerational social interaction between younger and elderly people, which, in turn, is likely to improve psychological well-being in the long run. As emphasized in a review [25] and various studies [26,27], games can have positive effects on the physical, cognitive, social, and emotional state, especially in the elderly.

However, there are important research gaps that must be considered concerning the potential of video games in real life scenarios – especially those concerning specific game design decisions and their impact on social interactions. For example, De la Hera, Loos, Simon, & Bloom (2017) state: "The decision to engage players in collaborative, competitive or cooperative competitive games has relevant implications on the effects of these practices." (p. 12 f) [23]. Previous research on intergenerational digital games describing major research gaps recommend that empirical studies in the future should directly compare different forms of playing in order to discover the effects on intergenerational interactions [24]. Likewise, related recent research from digital games in neurorehabilitation has addressed similar research gaps concerning different game modes [28]. It is, therefore, of utmost importance to further contribute to the scientific knowledge on the effects of game design decisions on players` behaviors via systematic empirical studies. In addition, it has also been recommended by previous research on intergenerational games that future research should include more types than only grandparents-grandchildren interactions [23].

In our study presented below, we investigate the possible effects of specific game design decisions regarding game modes on social interactions between players from different age groups in a retirement home. Below, we present the rationale behind our game design decisions.

Game design decisions and possible influences on players` social interactions

In multiplayer game design [29], *social game mechanics* are used to initialize and increase social interaction between players within the game. Systematic empirical research is rare in this area, however, isolated evidence has demonstrated that design for social interaction can impact players` behaviors in older age – not only concerning their verbal behavior, but also their non-verbal behavior: A study comparing social interaction design of a pervasive game (pervasive games interrelate to the virtual and the physical world), as opposed to *no* social interaction

design, revealed significant and positive effects on promoting physical activity in the older adult players [30].

More specifically, social game mechanics provide different configurations – *game modes* that can influence social interaction between players. The established modes are: (a) competitive, if two players compete against each other, whereby only one of them can win [31]; (b) cooperative, if two players "operate together," having a dedicated task each, but winning the game together. These contrasting modes are both able to stimulate social interaction and motivation to play [32,33,34]. They correspond to basic categories of human social interaction behaviors well-known from a long history of social psychology research [35]. Additionally, modern games provide a (c) "creative" mode in which the game does not imply any rules and the players are free to explore or modify the game world in a creative way. Such games are referred to as open-ended simulation games or sandbox games [36,37].

Existing research reveals an ongoing debate with respect to the influence of game modes on social interaction. While some [35] assume an increased willingness to communicate in cooperative game structures, others [38] argue the existence of a correlation between competitive game structures and social interaction. More detailed findings and theoretical considerations on the different game modes and their influence on social interaction will be presented in the following section.

Game modes and players` social interactions – Empirical evidence

Competitive mode and social interaction: Research on game gratification shows a positive relation between social and competitive motives [39,40]: Players who engage with games primarily because they seek social interaction are often also competitive gamers [38]. This correlation can be explained by the basic human need for control, according to FIRO theory (fundamental interpersonal relationship orientation theory [41]): Competition with others or trying to control each other are an essential part of interpersonal dynamics [38]. Nevertheless, in contrast to younger players, elderly players find competition in playing a rather minor motivator [16,18,22,27], unless there is indirect competition against other teams [42]. Additionally, older players have been found to largely reject reflex-oriented games, such as fighting or racing games. They experience such games as more difficult, less interesting, and, hence, less enjoyable to play, due to their age-related physical condition or disabilities [43].

Cooperative mode and social interaction: Empirical findings suggest that cooperative video games support positive interdependence [e.g., for video games see 44,45], meaning players need each other to fulfil a certain task and all members must contribute their knowledge and skills for the group or team to be successful [35]. Positive interdependence plays a crucial role in improving intergenerational social interaction [23]. Thus, cooperative game structures should likely lead to increased willingness to communicate as a team, facilitating exchange of important

information, sharing of ideas, and reacting to the ideas shared by others [35]. However, to the knowledge of the authors, there have been no clear empirical results confirming this assumption for elderly or intergenerational games.

Creative mode and social interaction: The creative game experience has been seen to increase when the game does not specify any right or wrong paths [36]. This can foster creativity due to players collaboratively generating new ideas beyond what they could have come up with on their own [46,47,48]. Following this, the given level of freedom in the creative game is likely to initiate and increase communication (about the game-related activities and thoughts) and social interaction (joint decision making) between players. Talking about new ideas or things that are out of the ordinary can lead to discussion of new topics and even more communication. This, in turn, should further increase social interaction. Empirical studies examining this relationship are lacking to date.

Taken together, these empirical findings suggest that all three modes can stimulate social interaction and motivation to play [31,33]. However, empirical studies comparing different modes in relation to social interaction are inconsistent (competitive vs. cooperative modes) or lacking (creative mode) thus far. Since the theoretical considerations described above suggest that there may be differences, a comparative analysis investigating the differential effects of cooperative, competitive, and creative game modes on intergenerational social interaction can fill the research gap as described above [23] and inform game designers on how to design games which stimulate intergenerational social interaction [22].

Goals of the Field Trial

The goal of this article is to provide original results to contribute to an improved scientific knowledge about the effects of social game mechanics (game modes) on social interactions between aged players and younger co-players. To accomplish this, a controlled field trial is presented investigating these impacts with elderly participants from a retirement home. The game used for the trial is a serious multiplayer game called *Myosotis FoodPlanet* (see section on *Materials* below) designed specifically as an intergenerational game for use in retirement homes.

The study aims to compare the impacts of three different game modes (competitive, cooperative, and creative) on social interactions between seniors and their younger co-players during game play. With reference to the theory described above and previous research, we assumed that the game modes would differ in the extent to which they influence social interaction. We therefore differentiated between verbal social interaction (H1) and nonverbal social interaction (H2) between players. Specifically concerning H1, we expected the creative game mode to stimulate the highest amount of verbal social interaction as explained above. Despite somewhat controversial findings regarding the competitive and cooperative modes, we further assumed that a cooperative mode would stimulate more verbal social interaction, compared to the competitive mode, based on related research [35]. In brief: Creative Mode > Cooperative Mode > Competitive Mode.

Regarding nonverbal social interaction (H2), we hypothesized that there would be differences between game modes, however, due to the extremely limited research on nonverbal interaction in video games, the assumptions were non-directional and our research remains explorative. The study was conducted before the Covid19 pandemic, when physical interactions (like hand shaking, touching another`s hands, shoulders, etc.) was still not restricted due to potential health risks.

Methods

Participants and Study Design

Ten elderly residents from a Swiss retirement home voluntarily took part in a randomized controlled field trial in their leisure time (7 females, 3 males; mean age 84.8, SD 5.85; range 76-93). The elderly participants were healthy with the exception of minor age-related impairments (i.e., minor physical limitations, no severe dementia). A within-subject study design was applied with three game modes (competitive, cooperative, and creative) administered in randomized order. This resulted in a total of N = 30 game sequences. Four care professionals, three activation therapists, and one nurse (4 females; mean age 44, SD 15.60; range 21-55) participated as co-players of a younger generation, and to ensure the residents` safety at all times during study participation and liability to ethical standards. The study was not part of any therapeutic program and did not contain any clinical intervention. Social interaction was the only outcome variable (for details on measures see below, section Measures). There was no health-related outcome addressed in the study. The study was not liable to registration, according to the Swiss Federal Human Research Act.

Materials and Tools

The game used for the current study is a serious multiplayer game called *Myosotis FoodPlanet*, which was designed specifically as an intergenerational game for use in retirement homes. It is a game involving cooking a Swiss cheese fondue together, which is a traditional and well-known dish in Switzerland. From reminiscence therapy [49] it is known that food is an ideal topic for stimulating social interaction [50], because anybody can be assumed to have an opinion on food, and the interests of different generations can easily be taken into account [11]. *Myosotis FoodPlanet* was developed in the multidisciplinary research project Myosotis-Garden [37]. The games developed in this project were designed to provide an entertaining positive activity, thereby triggering intergenerational communication and enabling players to find new and exciting access to the memories and biographies of elderly people [23].

In *Myosotis FoodPlanet*, two players – one elderly person and one younger care professional in the case of this study – jointly prepare a Swiss cheese fondue on an iPad Pro (12.9 inch) by dragging floating ingredients into a fondue pot (Figure 1). With the aim of ensuring that the elderly – despite possible age-related handicaps – recognize the ingredients, a computer-generated voice announces the name of each

ingredient when it is tapped. In addition, the names of the ingredients are presented in written form. A traditional Swiss folk melody plays in the background, contributing to the creation of a pleasant atmosphere. The game is designed for two players sitting in the same room and sharing the touch screen. The entire screen is used by both players, as opposed to a split screen mode. While the game is commonly played synchronously, the creative mode also allows for a turn-based approach, where one after the other, the players add ingredients to the pot. Three variants of *MyosotisFoodPlanet* each offering a different game mode (Figure 1, left, center, right) were used in our field trial:

Figure 1: Game modes competitive (left), cooperative (center), creative (right).

- **Please insert Figure 1 about here –**

In the *competitive mode* (Figure 1, left) each player prepares a given fondue recipe as quickly as possible. Each player has their own fondue pot and their own but identical given ingredient list that is displayed on the respective side of the screen closest to the player. The goal for the player is to drag the given ingredients into their own pot faster than the other player. It is also possible to drag ingredients needed by the opponent into one`s own pot. The player who collects all the listed ingredients first wins.

In the *cooperative mode* (Figure 1, center) players work together to prepare a fondue by collecting ingredients from a list of typical fondue as quickly as possible into one pot for both. The ingredients are listed in the bar at the bottom of the screen. The order in which ingredients are collected is irrelevant, and ingredients can be dragged repeatedly. Once all the listed ingredients have been dragged into the pot, the total time taken and the current high score (best time of all players) are displayed.

In the *creative mode* (Figure 1, right) players collaboratively and freely choose ingredients for their cheese fondue. Each ingredient can be dragged into the pot as often as desired, while the bar at the bottom of the screen shows the ingredients already added. Players can choose typical (e.g., Gruyère cheese, white wine) as well as atypical (e.g., bug, soft ice) fondue ingredients. The latter will likely increase the fun factor and consequently the social interaction. When an atypical ingredient is added, a colored splash appears on the screen, accompanied by a squeaky sound effect. After a short period of time, the splash disappears but the cheese fondue now is colored like the atypical ingredient (e.g., adding a bug turns the fondue blue). The players end the game manually. As a reward, the players get the prepared fondue in a recipe form. In addition, the system automatically names the recipe with humorous names (e.g., “Dancing Hans” or “Singing Theodora”), again to increase the fun factor and the social interaction.

Procedure

The study was conducted in the activation room (a room with which the participants were familiar) of the retirement home as a free choice afternoon leisure activity. Each player participated on three different days and played one of the three game modes in random order. Each game sequence lasted for a maximum of 20 minutes. Participation was voluntary, and it was made clear that participants could withdraw their participation at any time without any consequence. The participants were informed beforehand about the goals of the research, duration and procedure of the study, voluntary nature of participation, and protection of their data. Informed consent was given in writing by all test participants before starting each game sequence, as well as by the institution before starting the trial. The players were seated next to each other, so that their dominant hand could easily access the tablet computer (Figure 2).

This procedure is in accordance with the Helsinki Declaration of 1975, as revised in 2000. As noted above, it was not liable to registration according to the Swiss Federal Human Research Act.

Figure 2. Study setting: Game sequence

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Measures of Social Interaction

Social interaction was measured by verbal indicators, such as verbal communication and non-verbal indicators, such as laughing together or eye contact [51]. Data gathering was thus based on video recordings of verbal and nonverbal communication between players. 30 game sequences were recorded by two video cameras. Gameplay recordings, as well as observations, rank among the most frequently used methods to investigate possible influences of digital game-playing on social interaction [23]. Video analysis has proven to be a suitable research tool for observing behavior and social interaction [52]. It enables complex social interaction data to be stored and reproducible, allowing for multiple observations by different observers at different times, depending on the individual research questions of interest. It was initially intended that self-assessment questionnaires with questions about the players` subjective experiences and well-being would also be administered, however, some elderly participants had difficulty understanding the questions. (It was unclear whether this was due to their Swiss language, minor impairments or a lack of motivation to fill out the questionnaires.) Due to this, the self-assessment questionnaire component was removed.

Data Analysis

The video data gathered comprised 30 recorded game sequences of approximately eight hours (7 hours 53 minutes 25 seconds). For video data analysis, a 2-step *coding and counting* approach [53,54] was applied. In the first step, the 30 recorded

game sequences were coded with text analysis software MAXQDA 2018 based on a preliminary category system (*event sampling*, [55]). In the second step, the final category system was developed, including new categories emerging from the data, by (re-)watching video recordings in an iterative process. As a result, social interaction in terms of *verbal* communication between players was divided into categories *game-related communication, fondue-related biography, general biography, help-seeking,* and *help-giving*. Social interaction in terms of nonverbal communication was divided into *laughing together, eye contact,* and *body contact*. Table 1 shows the definitions and corresponding anchor examples [56] for each category. The communication behaviors were then systematically coded by two trained raters (duration of behavior in minutes and seconds mm:ss). The raters were trained on examples from the videos; the raters discussed these examples and resolved any uncertainties. They then coded the videos. Intercoder reliability between the raters resulted in substantial agreement (κ=0.69). Finally, the durations of all relevant behavior indicators of a given code were summed up. Verbal communication (e.g., game-related communication) and nonverbal communication (e.g., eye contact) occurred simultaneously. Due to overlapping codes caused by this occurrence of simultaneous communication, finally – as an artifact – the sum duration of each observed communication exceeds the effective observation time of total social interaction (Figure 3):

Table 1. Category system for the observation of social interaction behaviors

	Category	Definition	Anchor examples [a]
Verbal communication			
	Game-related communication	All statements resulting directly from the game (e.g., discussing results, outcomes, or new strategies).	"Oh my God, that's fun." "You won again, congrats."
	Fondue-related biography	When players discuss the method of preparation or consumption of a cheese fondue in the past (i.e., anecdotes).	"My son-in-law doesn't like garlic. So, when he came to visit, I always had to make a cheese fondue without garlic." "Do you like onions in the fondue?"
	General biography	Whenpersonal	"You know, I used

		biographic information is shared (i.e., when players tell or ask about their professional life, family, military, childhood, etc.).	to work in a cheese factory and there was this one customer, who…" "Originally I come from Austria, but after the war my family moved to Switzerland."
	Help seeking	When the elderly participant actively ask for help for technical operation of the game or when actively asking about content aspects during the game.	"Why can I not grab that cheese over here?" "Have I collected all the needed ingredients?"
	Help giving	When co-players answer questions regarding technical or content matters. Furthermore, when co-players help the elderly by giving them hints.	"Try using your fingertip instead of your fingernail." "Look, over there is the onion you still need to collect."
Nonverbal communication			
	Laughing together	When players laugh out loud together. Also includes when one person laughs and simultaneously talks and the other smiles.	
	Eye contact	When players look directly into each other's eyes (i.e., eyes are	

		meeting).	
	Body contact	When one player is patting the other on the back, or when one player is touching the other's hand/arm.	

[a]Anchor examples: translated from Swiss German

Figure 3. Coding example – overlaps

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Results were visualized by means of MAXQDA2018, including the overlapping of codes. Thus, it was possible to illustrate which verbal and nonverbal categories tend to occur simultaneously (Table 2). For quantitative analyses, data was transferred to the statistical software SPSS. Due to the small sample size, the data was checked for normal distribution and variance homogeneity. Statistical analyses compared each category of social interaction by using absolute values (ie mean duration of social interaction in minutes and seconds, mm:ss), as well as relative values, (ie percent duration in relation to the total playing time) for the three game modes. Hypotheses were tested by analyses of variance (ANOVA) with repeated measurements or its nonparametric counterpart (Friedman Test).

Results

Overall Findings

Influence of game modes on total playing time. Analysis revealed that average total playing times per game mode (in mm:ss) slightly vary between different game modes. On average the creative mode (mean 16:39, SD 6:45) was played the longest, followed by the competitive mode (mean 16:01, SD 5:46), and the cooperative mode (mean 14:40, SD 6:32). The playing times did not differ significantly between game modes as shown by a Friedman test (P=.67). Note: Playing time for each mode was restricted by the study instructions to a maximum of 20 minutes.

Influence of game modes on total time of social interactions.
Results revealed that for approximately half of the total playing time (in hh:mm:ss), social interactions were observed (3:51:47 with 7570 coded social interactions). It is important to note that different categories of social interaction occurred simultaneously, and the addition of these categories resulted in an “artificially” prolonged total duration (5:10:34, 7570 coded social interactions). Table 3 summarizes the absolute and relative values of verbal and nonverbal social

interaction (along with the respective subcategories) for the different game modes. Figures 4 to 7 represent a graphical depiction of these results.

As can be seen in Table 3, on a descriptive level, the *absolute total values* of social interaction were longest in the creative mode, followed by the competitive and cooperative modes. However, analysis of variance for repeated measurements showed no significant differences between game modes (P=.29). The same holds true for the *relative values* (Table 3, i.e., percentage of time with observed social interaction in relation to the total playing time (P=.78).

Simultaneous occurrence of verbal and nonverbal codes.

Since verbal and nonverbal categories tend to occur simultaneously, overlapping frequencies between verbal and nonverbal codes are presented in Table 2. During game-related communication, players often laugh together and look each other in the eyes. However, during biographical communication (i.e., fondue-related and general biography) players rarely had eye contact or laughed together. Regardless the contents of verbal communication, body contact occurs very rarely.

Table 2. Simultaneous occurrence of verbal and nonverbal codes.

	Laughing together	Eye contact	Body contact
Game-related communication			
	604	556	83
Fondue-related biography			
	31	204	1
General biography			
	12	119	2

Table 3. Absolute and relative values of social interaction in the different game modes.

		Game mode			**Hypothesis**
		(absolute values in mm:ss, relative values below in % of total time), mean (SD)			
	Social interaction category	**creative**	**cooperative**	**competitive**	**H1**
Verbal	Game-related communication	7:47** (4:43)	5:05 (3:19)	4:48 (2:20)	v

	%	43 (18.7)	33 (15.8)	31.2 (16.4)	v
	Fondue-related biography	1:15 (1:35)	0:38 (0:47)	0:51 (1:18)	
	%	6.4 (7.3)	5.2 (7.8)	4.9 (6.6)	
	General biography	0:21 (0:40)	0:17 (0:30)	0:52 (2:02)	
	%	1.8 (3.3)	1.4 (2.3)	4.9 (9.9)	
	Help seeking	0:09 (0:16)	0:09 (0:11)	0:06 (0:17)	
	%	1 (1.6)	1.6 (2.3)	.6 (1.4)	
	Help giving	0:22 (0:36)	0:25 (0:41)	0:44 (1:28)	
	%	2.1 (3.4)	4 (6.2)	4.4 (7.3)	
	Total verbal communication	9:56 (6:2)	6:36 (4:12)	7:22 (4:47)	v
	%	54 (25.9)	45 (20.4)	46 (25.3)	
					H2
Nonverbal	Laughing together	1:09 (0:55)	1:25 (1:17)	1:33 (1:22)	
	%	6.1 (4.1)	8 (5.5)	8.8 (6.3)	v
	Eye contact	0:32 (0:31)	0:54 (0:49)	1:15 (1:39)	
	%	3 (2.4)	5.8 (4.3)	6.8 (7.8)	
	Body contact	0:03 (0:08)	0:09 (0:12)	0:04 (0:05)	
	%	.3 (.7)	1(1.2)	.6 (.8)	
	Total nonverbal communication	1:45 (1:25)	2:29 (2:07)	2:53 (2:47)	
	%	9.4 (6.2)	14.8 (9.3)	16.2 (12.5)	
	Total social interaction	11:41 (7:11)	9:06 (5:45)	10:16 (6:44)	
	%	63.7 (28)	59.9 (23)	62.2 (31.1)	

Figure 4. Verbal communication (absolute values)
Figure 5. Nonverbal communication (absolute values)
Figure 6. Verbal communication (relative values)
Figure 7. Nonverbal communication (relative values)

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Hypothesis 1: Verbal communication

Influence of game modes on total verbal communication. On a descriptive level, the *absolute total values* of verbal communication were higher in the creative mode, followed by the competitive and cooperative modes (Table 3). Analysis of variance for repeated measures yielded marginal significance ($F_{2,18}$=3.37, P=.06, partial η2=.272, N=10). The effect size *f,* according to Cohen (1988), was 0.611 and corresponds to a strong effect. Bonferroni-corrected pairwise comparisons revealed that there was significantly more verbal communication (P=.04) in the creative mode (mean 9:56, SD 6:21) than in the cooperative mode (mean 6:36, SD 4:12). For the *relative values,* analyses did not yield significance (P=.11).

Influence of game modes on game-related communication. As can be seen in Table 3, on a descriptive level, the *absolute values* of game-related verbal communication were higher in the creative mode, followed by the cooperative and competitive modes. An analysis of variance for repeated measurements showed that the *absolute values* of game-related communication differed significantly between the game modes ($F_{2,18}$=6.36, P=.01, partial η2=.414, N=10) with a strong effect (f=0.841). Bonferroni-corrected pairwise comparisons showed that there was significantly more game-related communication (P=.01) in creative mode (mean 7:47, SD 4:43) than in cooperative mode (mean 5:05; SD 3:19), and marginally significantly more game-related communication in cooperative (P=.09) than in competitive mode (mean 4:48, SD 2:20).

Analysis of variance for repeated measurements also showed significant differences between game modes ($F_{2,18}$=4.85, P=.02, partial η2=.350, N=10) with a strong effect (f=0.734), for the *relative values* of game-related communication. Bonferroni-corrected pairwise comparisons revealed that in the creative mode (mean 43%, SD 18.7%), the percentage of game-related communication was significantly higher (P=.01) than in the cooperative mode (mean 32.9%, SD 15.8%).

Influence of game modes on fondue-related biography talk. As can be seen in Table 3, on a descriptive level, the *absolute values* of fondue-related biography communication were higher in the creative mode, followed by the competitive and cooperative modes. According to relative values, values were higher in the creative mode than in the cooperative mode, followed by the competitive mode. The Friedman test showed marginally significant differences between the game modes for the *absolute values* (χ^2_2=5.56, P=.06, N=10), but not for the *relative values* (P=.37; Table 3). For the absolute values, post-hoc tests (Dunn-Bonferroni tests) revealed significantly more verbal communication regarding fondue-related biography (z=2.24, P=.03) in the creative mode (mean 1:15, SD 1:35) than in the cooperative mode (mean 0:38, SD 0:47) with a strong effect (r=0.707).

Influence of game modes on general biography talk. As seen in Table 3, on a descriptive level, the *absolute values* of general biography were higher in the competitive mode, followed by the creative and cooperative modes. No significant differences were found between the game modes (P=.91). This also holds true for the *relative values* (P=.91).

Influence of game modes on help seeking and help giving. Table 3 shows on a descriptive level the *absolute values* of help seeking and help giving. No significant differences were found between the game modes for help seeking (P=.28) and help giving (P=.47). For the relative values, a Friedman test showed a significant difference between the game modes (χ^2_2=6.44, P=.04, N=10) for help seeking. Subsequent post-hoc tests (Dunn-Bonferroni tests) revealed that help seeking was significantly higher (z=2.24, P=.03) in the cooperative mode (mean 1.6%, SD 2.3%) than in the competitive mode (mean 0.6%; SD 1.4%) with a strong effect (r=0.707). Concerning the *absolute and relative values* for the category help giving, no significant differences were found between the game modes.

In sum, we expected the creative game mode to stimulate the highest amount of verbal social interaction, because players are given a high degree of freedom, which could stimulate verbal interaction. Despite somewhat controversial findings regarding the competitive and cooperative modes, we assumed in the current study that a cooperative mode would stimulate more verbal social interaction than the competitive mode based on related research (H1). The hypothesis could partly be confirmed: for total verbal communication, and the sub-categories game-related and fondue-related communication, where data indeed show higher values for the creative mode, indicating more time spent on verbal communication here than in the other modes, partly with strong effects. Concerning the effects of cooperative and competitive modes, the picture is less clear. The same is true for the other sub-categories (general biography talk, help seeking, and help giving). In light of the rationale behind the assumptions of H1, this pattern of results is interesting and can be explained so that in creative mode, more verbal communication occurs, because players are given a high degree of freedom to exchange and develop new ideas. However, as the data shows, this could only hold true for *some* sub-categories of communication – namely those that directly relate to playing the game itself (game-related; fondue-related biography). On a more general level, game modes may influence verbal communication in different ways, but only for specific content.

Hypothesis 2: Nonverbal Communication

Influence of game modes on total nonverbal communication. The mean *absolute values* of nonverbal communication as shown in Table 3 were highest in the competitive mode, followed by the cooperative mode and the creative mode. An analysis of variance for repeated measurements (Greenhouse-Geiser correction was applied) indicated marginally significant differences (P=.09), but the differences did not reach significance in the subsequent post-hoc tests (all $P \geq .14$).

A Friedman test for the *relative* values showed a significant difference between the game modes (χ^2_2=9.80, *P*=.01, N=10). Following post-hoc tests (Dunn-Bonferroni tests) revealed that the nonverbal communication was significantly higher (*z*=-2.91, *P*=.004) in the competitive mode (mean 16.2%, SD 12.5%) than in the creative mode (mean 9.4%, SD 6.2%) with a strong effect (*r*=0.919), and significantly higher (*z*=-2.46, *P*=.01) in the cooperative mode (mean 14.8%, SD 9.3%) than in the creative mode with a strong effect (*r*=0.778).

In the following sections, results will be reported for the different categories of nonverbal communication.

Influence of game modes on laughing together. The mean *absolute values* of laughing together as shown in Table 3 were highest in the competitive mode, followed by the cooperative mode and the creative mode. An analysis of variance for repeated measurements with the absolute values for laughing together showed marginal significant difference between game modes (*P*=.08) but this difference did not hold significant in the subsequent post-hoc tests (all *P*≥.26). Regarding the *relative values*, an analysis of variance for repeated measurements showed significant differences between the game modes ($F_{2,18}$=5.18, *P*=.02, partial η2=.365, N=10) with strong effect (*f*=0.758). Bonferroni-corrected pairwise comparisons revealed that there was more laughing together in the competitive mode (mean 8.8%, SD 6.3%) than in the creative mode (mean 6.1%, SD 4.1%, *P*=.047), and marginally significantly more laughing together (*P*=.07) in the cooperative mode (mean 8%, SD 5.5%) than in the creative mode.

Influence of game modes on eye contact. There was no significant difference between the game modes, for neither the absolute (*P*=.21), nor the relative values of eye contact (*P*=.12).

Influence of game modes on body contact. There was no significant difference between the game modes, for neither the absolute (*P*=.63), nor the relative values of body contact (*P*=.41).

In sum, regarding nonverbal social interaction, it was expected that there would be differences between game modes (H2), but expectations remained on an explorative level, due to a lack of a theoretical or empirical research basis for directional assumptions. Results reveal that the total time spent with nonverbal communication and laughing together was highest in the competitive mode and lowest in the creative mode with significant differences. No significant differences were found in the subcategories eye and body contact.

Discussion

In the study presented here, the influence of three different game modes of the multiplayer video game *Myosotis FoodPlanet* on the social interactions between elderly players living in a retirement home and their younger co-players was

investigated. It was expected that different game modes would influence verbal and nonverbal communication between players in different ways (H1, H2 above).

Firstly, overall (across all modes) it was demonstrated that the game could successfully be applied and played as intended in the field situation (retirement home) by the residents and their younger co-players (care professionals). All three game modes could *successfully* stimulate positive social interactions such as talking and laughing together between the elderly and their younger co-players (albeit in different ways, see below). Simultaneous occurrence (Table 4) of game-related verbal communication and the two nonverbal categories of laughing together and eye contact were found. No matter what the game mode, players tended to stop playing and listen carefully when the other player told a story from the past. Overall, these study results are in line with prior research showing that game-mediated play paves the way for positive social interactions [13,14] and can facilitate communication between players belonging to different age groups or generations [9,10,12]. Thus, important practical goals of the study were met, since it was specifically designed as an intergenerational digital game for use in retirement homes. The game was designed to be fun and entertaining for different generations - to support mutual empathy and active listening – and it obviously worked.

Secondly, partly confirming our assumptions about *differential* effects of *different* game modes on social interaction, some significant differences were found. To highlight the most important outcomes, it is noted that the creative game mode was significantly more supportive than the other modes with respect to the sub-categories of verbal communication, game-related communication, and fondue-related biography talk, but not for general biography talk or help giving. In other words: the creative game mode of *Myosotis FoodPlanet* could – better than other game modes – foster social interactions between the elderly and their younger co-players with regard to talking about the game and their joint activities during playing. The elderly seemingly related their memories from the past to the present game content (i.e., remembering past fondue-events). Furthermore, our results revealed significantly more help seeking communication in the cooperative mode than in the competitive mode. Taken together, these findings support H1. Yet, concerning the cooperative and competitive modes, the picture remains fuzzy. Results were inconsistent mirroring the situation in prior research, where results from empirical studies comparing different modes in relation to social interaction are inconsistent as described above (in the Introduction section on game design decisions and their possible influences on social interaction). Finally, the competitive mode was significantly better than other modes in promoting the sub-category of laughing together in nonverbal social interaction, while no effects were found for eye or body contact. Thereby, H2 was partly only confirmed. This result is in line with related research showing positive relations between social and competition motives [39,40]. It seemingly contradicts previous results showing that the elderly (in contrast to younger players) would find competition in playing a minor motivator [16,18,22 27]. This can be explained by the unthreatening but still

exciting and humorous character of the specific game *Myosotis FoodPlanet* used here.

In summary, the results show how design decisions concerning the choice of game mode can be an important factor to shape social interactions of players of different age groups while playing together. In a scientific sense, these original results add to the research gap identified in research on intergenerational games [23, see above], because they provide comparative evidence that can be explained by theory. The creative mode included a high level of freedom for the players and practically demanded communication during the game in order to "prepare" the players' favorite fondue. It stimulated negotiations about what ingredients to use, resulting in more game-related communication, compared to the other modes. The creative mode additionally provided an environment in which the players were not under pressure of wanting to win. Hence, they could talk freely while playing the game, which in turn could have stimulated the cued recalling of associated individual memories concerning fondue-related biographical communication.

The study has its strengths, but also limitations. An important strength of this study pertains to the study setting. In comparison to previous studies, which were often conducted in a lab situation and therefore might lack ecological validity, our study was conceptualized as a field trial. Thus, we could examine the participants in their natural environment, which is important when looking at aspects like social interaction and drawing real world conclusions [57]. Yet, there are limitations to this approach. In the following we will address these limitations and justify the value of the study despite those limitations.

The small number of participants involved is a serious limitation. It was due to practical limitations on the side of the retirement homes (e.g., their willingness, trust, and available resources to undergo the effort of participating in this field research with researchers coming to their place, bringing in video games for the residents, and placing video cameras to do recordings). We justify the study despite this limitation by the amount of field data gathered despite the low number of participants. We recorded N = 30 game sequences, resulting in approximately eight hours of video material (7 hours 53 minutes 25 seconds). Social interactions were observed, comprising a volume of almost four hours of video (3:51:47) with 7570 coded social interactions in the different categories, coded thoroughly according to well-established methods in experimental psychology. Our fine-grained videotaping and coding procedure allowed us to analyze both verbal and, especially, nonverbal communication and from which we gained crucial insights into the differences between the game modes. Hence, an important further strength of this study arises from this systematic effort: not only verbal communication, but also nonverbal interactions, such as laughing together or eye contact, are available and produced interesting new results in this area of research. But most importantly, significant results were obtained despite the small N, and sometimes with effect sizes indicating strong effects, such as the results on influence of game modes on game-

related and fondue-related biography talk, and on total nonverbal communication (see section on *Results).*

We must also critically note that the younger co-players in this study were care professionals. Although this fills a gap in research on intergenerational games by looking "further than only grandparents-grandchildren interactions" [23], this may have compromised our study and demands additional caution in interpretation and generalization. Such professionals are trained to read the skill levels of the elderly and adapt their own pace accordingly. Furthermore, the elderly residents may have viewed them as their "care-givers," in addition to viewing them as "members of the younger generation". Thus, it remains open at this point how non-trained younger co-players or family members would behave in such gaming situations – and how social interactions would differ from the situation studied here. For instance, it may be that some study outcomes would look different; with family members as younger co-players, there might be more (joint) general biography-related memories to discuss. The players may invest more time in general biography talk with implications for the effects of the three game modes on this sub-category of social interaction. In addition, the patterns of help seeking and help giving types of communication would very likely produce different results. The same might be true for body contacts. This limitation characterizes our study outcomes as "intergenerational" only in terms of age (younger vs. older), but does not necessarily generalize to other characterizations like family links (e.g., grandparents and grandchildren) or organizational membership (e.g., juniors and seniors) or other [24]. This may be the subject of a future study.

The game used for the current study is a serious multiplayer game called *Myosotis FoodPlanet*, which was designed specifically as serious intergenerational game for practical use in retirement homes. It was also used for local game events with the elderly in different areas in Switzerland. Using this real game supports the ecological validity of the study, but somewhat compromises internal validity, since control over all elements and features in the game was not possible. During the game design process, we could not control for all possible confounds across game modes, for example, the creative mode including some additional elements, such as additional effects and the recipes with humorous names. This has to be discussed in terms of alternative explanations for the findings showing more verbal communication in the creative mode than the other modes (confirming H1): Could it be that more talking was stimulated by a more humorous game mode? When viewed together with the results on nonverbal communication this alternative seems rather unlikely, since significantly more time of "laughing together" was found in the competitive mode than in the creative mode. This suggests that humour was not limited to the creative game mode, but a characteristic of the game *Myosotis FoodPlanet* in all modes investigated here. Therefore, we understand our study results still as confirming H1. Nevertheless, this interpretation must remain cautious and initial. Further systematic experimental studies are needed to deepen scientific knowledge on this specific topic.

Associated with the previous point, the game addresses a specific theme (Swiss fondue cooking), represents a specific genre (casual), and has a specific target (intergenerational game playing in retirement homes to improve social interactions). Generalization of the study results to other games and situations is not easily possible. Thus, comparisons between different games (genres, mechanics, themes) and co-player`s profiles in systematic experimental research could be interesting in future research.

Nevertheless, it is a strength of the current study in comparison to prior work that it examines the creative game mode with this specific game in a field trial and that it systematically compares the effects of three game modes on social interactions in a natural setting. Previous studies have primarily addressed the influence of either cooperative or competitive play on social interaction [33,38], while a direct comparison of cooperative, competitive, and creative game modes regarding their similarities and differences in promoting different types of social interaction was lacking so far.

Final Conclusion

What does the study reveal for the community in the end? In sum, this study generally highlights the importance of game mode when designing serious multiplayer games for intergenerational game-playing and additionally can inform game designers on *how* to design games to stimulate specific types of intergenerational social interaction. Moreover, the results have implications for game-playing situations similar to the one investigated here in a retirement home, when the aim is to promote intergenerational social interaction between care professionals and residents (younger and elderly). Depending on the type of social interaction (e.g., verbal or nonverbal communication) that is intended, a specific game mode or specific elements may be more appropriate than others. When an increase in verbal communication is desired and when the elderly should be motivated to talk with younger (care) persons, a creative game mode with no distinct goal and no right or wrong pathway should be considered. On the contrary, when an increase in laughing together is intended (e.g., to provide for a positive mood and atmosphere), one might recommend a competitive game mode with an unthreatening, though arousing and stimulating, character. These conclusions remain tentative due to the study limitations and limited research in this area. We hope, our research can stimulate future works.

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Conflicts of Interest

Co-author Marco Soldati is the owner of Holunder Games GmbH, a recently funded small game studio, which creates computer games for elderly people. Holunder Games GmbH relies on the outcomes of various projects, including the outcome of the Myosotic project. No other conflicts of interest are declared.

Multimedia Appendix: Figures 1-3

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List of Tables:

List of Figures:

Figure 1: Game modes competitive (left), cooperative (center), creative (right).

Figure 2: Study setting: Game sequence

Figure 3. Coding example – overlaps

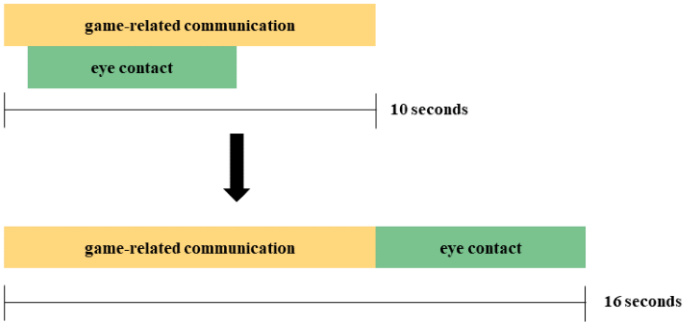

Figure 4. Verbal communication (absolute values)

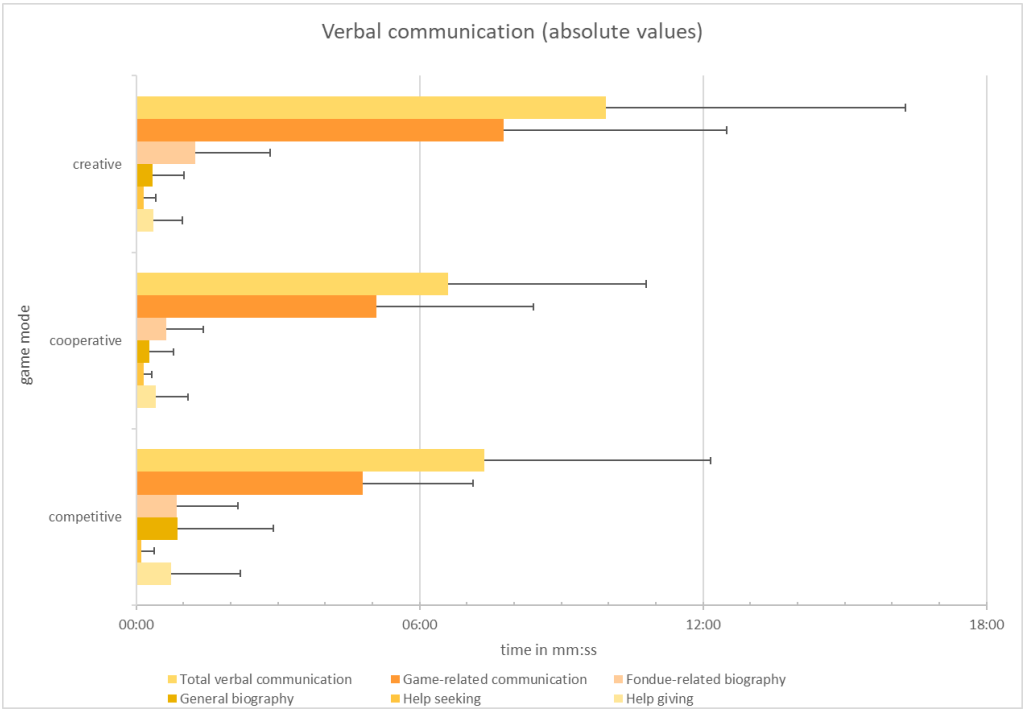

Figure 5. Nonverbal communication (absolute values)

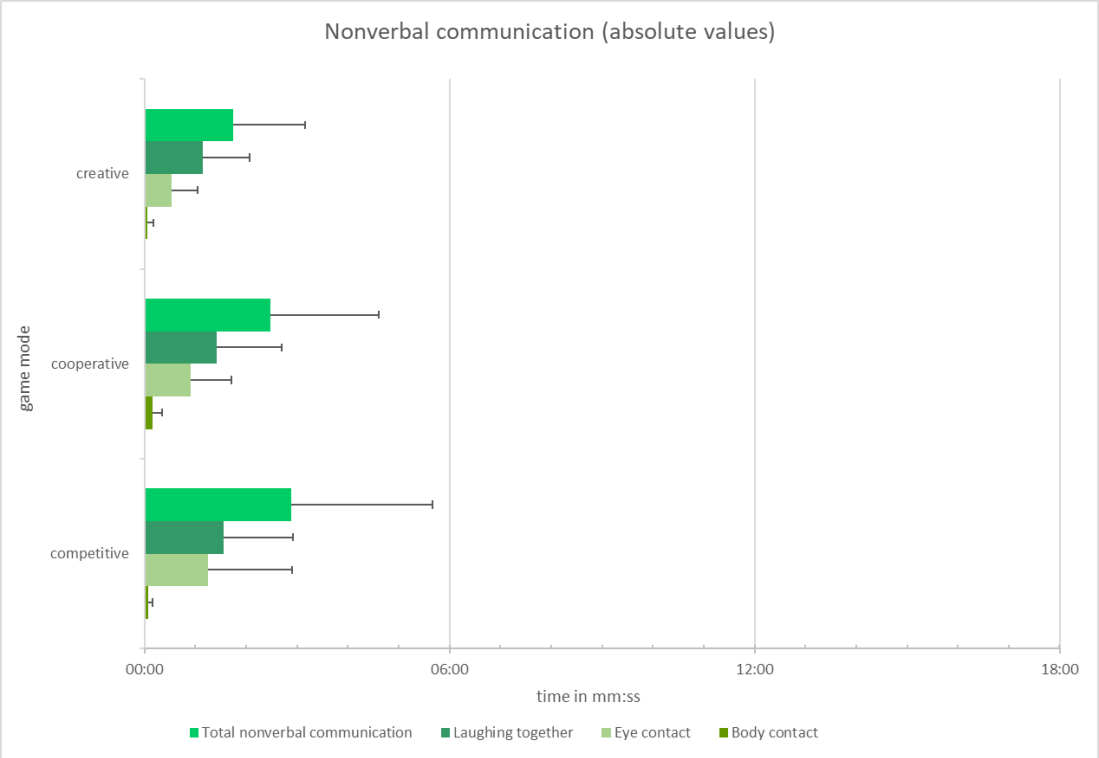

Figure 6. Verbal communication (relative values)

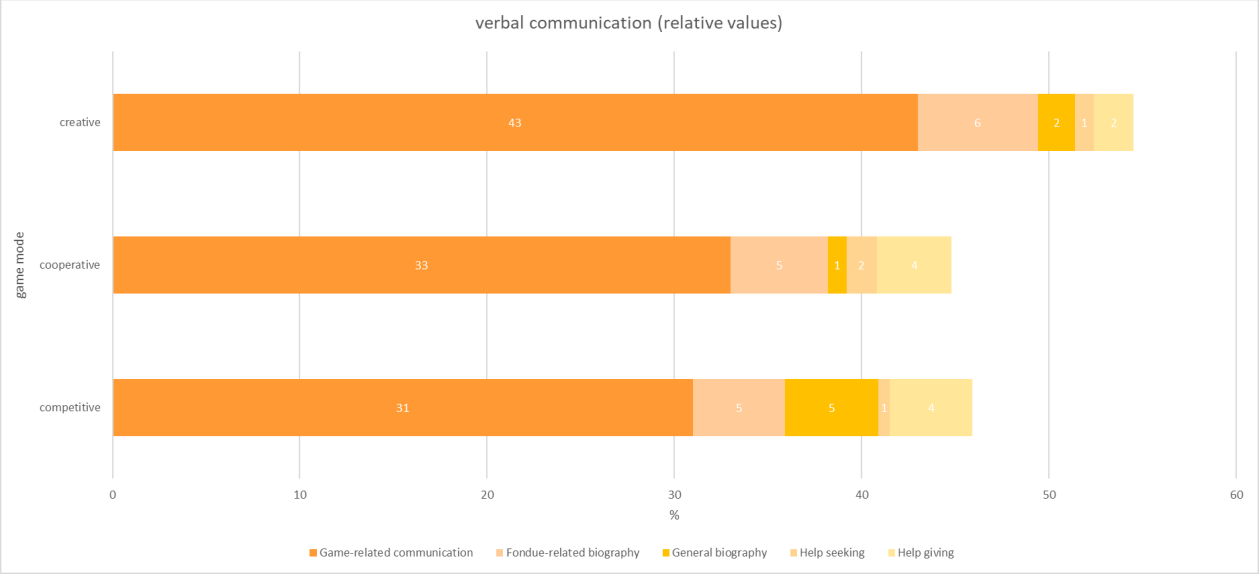

Figure 7. Nonverbal communication (relative values)