Genuine Guitars and Game Enjoyment in Music Games

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Abstract

This article investigates how playing a digital music game with a genuine electric guitar impacts perceived difficulty and game enjoyment. Previous reseach suggests that the causal link between mapping and enjoyment lies in intuitiveness. In contrast, this paper argues that (1) difficulty positively affects game enjoyment, (2) a real life guitar is perceived as more difficult and more entertaining than a regular naturally mapped controller and (3) that mapping type has a stronger impact on game enjoyment than difficulty. To test these assumptions, 20 participants played three episodes of a music game with either a Guitar Hero controller or a genuine electric guitar. As expected, more complex game episodes and the real guitar were rated more difficult and more entertaining. Also, mapping type had a stronger impact on game enjoyment than perceived difficulty. Results indicate that the relation of controller mapping and fun should be traced back to simulation of extraordinary activities and identification with attractive roles rather than just intuitiveness.

Theory

Natural Mapping and Game Enjoyment

The term natural mapping refers to the extent of similarity between the actions performed by a player within the real world and the representation within the videogame (Skalski, Tamborini, Shelton, Buncher and Lindmark 2010, p. 3). Skalski et al. distinguish four grades of natural mapping: (1) *Directional natural mapping* relies on physical analogies or cultural standards. For example, within a side-scrolling videogame, the angles of a joystick correspond to the directions the avatar can be moved to. (2) With *kinesic natural mapping*, real-life body movements are mapped to corresponding actions within the videogame without any tangible controller, but by motion capturing (e. g. via Microsoft Kinect). (3) By *incomplete tangible natural mapping* Skalski et al. describe the use of game controllers that emulate the handling of the object represented within the game. For example, Nintendo's Wiimote simulates the feel of a racket within a tennis game. (4) Finally, *realistic tangible mapping* refers to the use of highly lifelike controllers like driving wheels or gun controllers. According to Skalski et al., with more naturally mapped controllers, players could quickly access pre-existing mental models of the action represented within the videogame, which reduces the need to focus actively on the controls. As a result, Skalski et al. presume natural mapping to lead to higher spatial presence, which in turn they assume has a positive effect on game enjoyment. On one hand, within two studies, Skalski et al. found evidence that natural mapping predicts spatial presence. On the other hand, spatial presence did not have a significant effect on game enjoyment. However, Skalski et al. (ibid., p. 16) found an unexpectedly strong direct effect of controller naturalness on game enjoyment. They reason that although natural mapping leads to spatial presence, the latter is not an essential requirement for game enjoyment.

Tamborini, Bowman, Eden, Grizzard and Organ (2010) conceptualize enjoyment as need satisfaction. They criticize that past research focuses mainly on hedonism and that the few existing approaches taking aspects of need satisfaction into account lack an organizing framework to understand these needs. With self-determination theory by Deci and Ryan (2000), Tamborini et al. seek to solve these issues. Self-determination theory (SDT) mentions several needs whose prospect of satisfaction motivates human behaviour. Autonomy (the sense of volition during an activity) and competence (the wish for effectance and challenge) have already been investigated as antecedents of game enjoyment by Ryan, Rigby and Przybylski (2006). Tamborini et al. hypothesized that naturally mapped game controllers provide intuitive handling. Since such intuitive controls were assumed to provoke stronger feelings of freedom and control (ibid. p. 350), naturally mapped controllers were expected to facilitate satisfaction of competence and autonomy needs, which in turn should predict game enjoyment. In a study comparing enjoyment with a regular controller to a simulated bowling ball, Tamborini et al. found empirical proof for their assumptions in a bowling game.

Real Musical Instruments: Real Life Tangible Mapping

Both Skalski et al. as well as Tamborini et al. argue that the more naturally mapped a controller, the more intuitive it is. Their assumption is not shared in this paper. In this section it will be concretized how, within music games, controller naturalness might lead to *less* intuitive controls and more complex gameplay. Considerations rest on the comparison of a real guitar and a Guitar Hero controller. In this article, using a real guitar for music gameplay implies that the original acoustic signals of the electric guitar are amplified and played back, whereas a Guitar Hero controller just triggers prerecorded guitar samples.

With regard to naturalness, a real guitar actually exceeds the highest level of Skalski's et al. typology: Even realistic tangible mapping implies to reproduce and imitate a physical action within the virtual game world. In contrast, playing a music game with a guitar is not realistic, but *real* guitar play. It could therefore be called *real life tangible mapping*. The guitar-shaped game controller from Guitar Hero, on the other hand, can be regarded as a form of advanced incomplete tangible natural mapping or low-level realistic tangible mapping: Albeit reduced in size, its appearance loosely resembles a real guitar (compare figure 1). However, playing a game with such controllers differ from real guitars in various ways, which has some effects on difficulty.

Figure 1. A Guitar Hero game controller

First, there is the *physical handling of the controller*. A Guitar Hero game controller only consists of five buttons, representing five frets of a guitar. These five buttons can trigger a wide range of different musical notes. During the whole song, the player's left hand rests on these buttons. An electric guitar, on the other hand, features up to 24 frets and six strings, each of which produces a distinct musical tone on each corresponding fret. This forces the guitar player to perform a lot more different fingerings in order to cover a musical scale and constantly change the position of his left hand (Arsenault, 2008). Furthermore, a Guitar Hero controller only has 3/4th the size of the guitar model it resembles, which makes it easier to switch between different fingerings.

Second, requirements in *timing and reaction* differ. Rhythm plays a much more important role with real life tangible mapping than with natural mapping. In Guitar Hero's natural mapping, for example, sounds are automatically aligned to the rhythm of the song, because notes and chords consist of prerecorded, synchronized audio tracks. Thus, even with inferior timing, the music is always in time. In contrast, with real life tangible mapping, the slightest lag is hearable.

Third, there is the *complexity of the interface*. Since a controller button represents a fret and can trigger different musical notes, in Guitar Hero or other naturally mapped music games it is sufficient to display which button ("fret") to press at which time in order to play along to the song. However, with real life tangible mapping, the user interface must provide information not only on which fret, but also on which string has to be pressed. As a result, the user interface gets more complex with real life tangible mapping (cf. figure 2).

In short, a Guitar Hero game controller waives a significant amount of realism in favor of playability on three levels: physical handling, timing and interface complexity. Thus, a real guitar is less intuitive and its handling is less easy than a Guitar Hero controller not although, but *because* it is more authentically and naturally "mapped" to the events within the game.

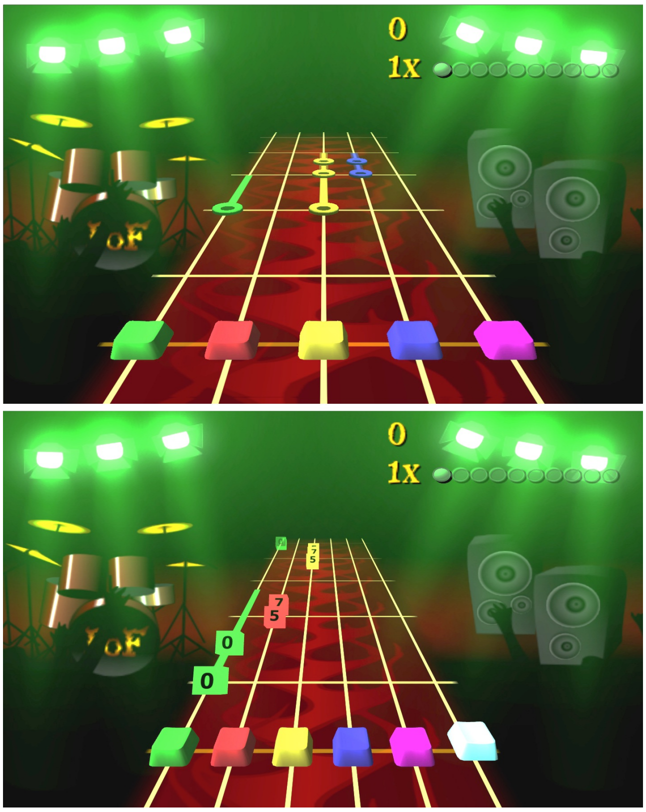

Figure 2. Compared to the reduced interface with natural mapping in *Frets in Fire* (top), real life tangible mapping requires a more complex user interface (bottom).

A Different Perspective

According to previous research, natural mapping leads to more enjoyment due to its intuitive handling (i. e. reduced difficulty). The following section argues that even higher difficulty may lead to game enjoyment and that possibly there are further entertainment mechanisms at work.

Klimmt's Model of Music Game Enjoyment

Klimmt (2003, 2006) presents a conceptual model that breaks down the process of gameplay into three hierarchical levels of complexity, each one providing different mechanisms of game enjoyment.

On the bottom layer, playing a videogame is described as a sequence of short *input-output loops*. Each of the player's input causes some kind of reaction on the part of the videogame system. Game enjoyment on this level is related to the concept of *effectance*, the satisfying feeling of having an impact on one's environment (White, 1959). Videogames are exceptionally capable of provoking perception of effectance (Klimmt, 2003; Hartmann & Klimmt, 2006; Klimmt, Hartmann, & Frey, 2007).

Episodes, the second level in Klimmt's model, consist of numerous input-output loops. Each episode usually features (1) a necessity and (2) particular possibilities to act, as well as (3) actions performed by the player which lead to (4) a result (Klimmt, 2003, p. 249). A player might add up necessities and possibilities to act to the more salient impression of an episode's difficulty (Klimmt, 2006, p. 135). Game enjoyment on the level of episodes can be linked to the concept of *suspense*: Facing the necessity to act, a player is uncertain if he or she could overcome the challenge, yet hopes for a positive outcome of the situation. As a result, suspense, the "condition of negatively valenced emotion" (Klimmt, Rizzo, Vorderer, Koch, & Fischer, 2009, p. 29), emerges. Once the player has successfully taken actions within the given possibilities and produced a positive outcome, suspense that has built up is transformed into relief. As a result, affects are amplified by the sustained physiological arousal the suspense created, leading to strong, positive feelings of euphoria. Higher levels of suspense (resulting from increasing and more demanding necessities to act) lead to greater game enjoyment, as long as the episode leads to a positive outcome (Klimmt et al., 2009).

The highest and most complex level within Klimmt's conceptual model consists of the entire *session of playing* (Klimmt, 2003, p. 250). Here, the player is involved in a complex narrative structure. The key to game enjoyment on the level of sessions lies in the combination of *identification, narrative and interactivity*: Computer games provide experiences that cannot be made in real life. Players are able to take on new exciting roles, be part of world shaking adventures and try out new appealing actions (for example do reckless stunts or use powerful weapons). Furthermore, Hefner, Klimmt and Vorderer (2007) suggest that a player gets entertained by identifying him or her with the game character he or she takes over. While playing, attractive attributes of the videogame character are transferred to the player. As a result, a courage-lacking player can feel courageous, reducing self-discrepancy and leading to positive perceptions (Hefner et al., 2007, p. 42).

Game Enjoyment in Music Games

In order to comprehend how real life tangible mapping might affect music game enjoyment, one needs to understand the gameplay of music games. This article focuses on the game Frets on Fire (Unreal Voodoo, 2006), since it was used in the experiment described later. As Frets on Fire imitates the game Guitar Hero (Harmonix, Neversoft, & Vicarious Visions, 2005-2010), the following explanations apply to both games. An episode of Frets on Fire consists of a song the player plays along to. As seen in figure 3, the user interface shows a guitar's fingerboard. From the back, symbolized musical notes (A) appear on top of the strings and move towards the player. As the notes reach a row of keys (representing guitar strings) at the bottom of the screen (B), the player must press these keys and a pick button. If successful, a tone or chord is played and points (C) are granted. Missing a note results in a prerecorded, scratchy "screw up sound". When the player misses too many notes in a row, he or she loses the game. Once the player hits ten notes without making any mistake, his or her score multiplier (D) increases by one, extending the amount of points he or she gets. The goal of the game is to score as much points as possible.

Figure 3. Frets on Fire's regular user interface

In accordance with layer one of Klimmt's model of game enjoyment, music games like Frets on Fire or Guitar Hero supposedly cause strong sensations of effectance by their prompt and consequent acoustic feedback on the player's inputs: Hitting a note correctly triggers spectacular sounds, which should lead to strong feelings of effectance. But even a missed note immediately produces a sound and should therefore facilitate game enjoyment..

An episode of Frets on Fire consists of one single song. The player desires to succeed in the game and to achieve a high score. Necessities to act consist of the continuously appearing musical notes the player has to hit. Suspense arises not only from the risk of missing too much notes and therefore lose the game, but also from the score multiplier, that resets when a streak of correctly played notes gets interrupted. The end of an episode is clearly indicated by the end of the song, abruptly transforming suspense into relief. On the episode layer, real life tangible mapping presumably generates more enjoyment than regular or natural mapping: Due to the real guitar's more difficult physical handling, higher demands on the player's timing and a more complex user interface (cf. above), necessities to act are way more demanding than with natural mapping. This leads to higher uncertainty about the desired success, which in turn results in higher levels of suspense. The same holds true for game episodes with increasing and more challenging necessities to act (that is songs with more musical notes and more complex fingerings). Theoretically, as long as the game does not get too difficult to handle and the player is successful, higher suspense should lead to stronger relief as well as more intense feelings of accomplishment, pride and perceived self-competence (cf. Klimmt, 2006, p. 87f).

On the session layer of Klimmt's framework, music videogames probably are entertaining because a player can identify him or her with a musician (a role that is attractive to many), to feel like he or she can perform rock songs and guitar solos, even if in real life he or she never used a guitar before. Most likely on this layer, real life tangible mapping substantially exceeds other forms of controller mapping. After all, an authentic electric guitar offers far more authenticism and therefore more identification and simulation mechanisms than any artificial game controller.

Empirical Research: Game Enjoyment and Genuine Guitars

Hypotheses

Previous research suggests that natural mapping generally leads to more intuitive controls and therefore to higher levels of enjoyment. As argued in the previous sections, this study takes over a different perspective and comes to other conclusions:

H1: Due to the higher demands resulting from the physical handling, timing requirements and interface complexity, real life tangible mapping was expected to be perceived as more difficult than natural mapping.

H2: Since they featured increasing and more demanding necessities to act, later episodes with more musical notes and more complex fingerings were expected to be perceived as more difficult.

H3: Real life tangible mapping offered slightly more feedback, more suspension and relief as well as a more identification with attractive roles. Due to these more distinct features relevant for all layers of game enjoyment, real life tangible mapping was expected to be more entertaining than natural mapping.

H4: As feelings of accomplishment as well as suspense and relief emerge from the (successful) encounter of necessities to act, more difficult episodes were expected to be more entertaining than easier episodes.

H5: Since real life tangible mapping features additional powerful entertainment mechanisms such as efficacy and authentic simulation of attractive roles, it was expected to have a stronger impact on game enjoyment than difficulty alone.

Method

Participants

Participants were mostly computer science students and graduates from a German university as well as some senior pupils. The sample group consisted of 20 participants (40 percent female) in the age of 18 to 28 years (M = 22.7; SD = 3.28).

Material

This study used the music game Frets on Fire (Unreal Voodoo, 2006). Frets on Fire is an open source music game and provides a gameplay experience much like the commercial videogame Guitar Hero. For the purpose of this study, a modified version of Frets on Fire was created. This version supported real life tangible mapping. Signals from an electric guitar were transmitted via a guitar-to-MIDI system and an USB-MIDI- Interface. A MIDI module, offered by the Frets on Fire development community, processed the guitar MIDI signals and transformed them into game controls. This way, audio latency was reduced beyond perceivable level. A virtual guitar rack amplified and played back the original acoustic guitar signals. For further technical details see Merz (2011). Thus, the modified version of Frets on Fire with real life tangible mapping support provided all features and entertainment mechanisms as described above and incorporated experimental conditions to test all hypotheses.

Procedure

The study was conducted in a computer lab at a German university. Participants were recruited among students and acquaintances. Based on previously collected control variables (see below), participants were assigned to one of two parallelized groups. On a descriptive level, effect sizes of control variable differences were mostly irrelevant, with the exception of smaller differences in dummy-coded sex ($p = .39$, $d = .4$) and interest in music games ($p = .46$, $d = .33$). A t-Test ($\alpha = .05$) revealed no significant difference of control variables between both groups. Members of the both groups played the same three episodes, with each episode featuring a different song (approx. 3 to 4 minutes long). Necessities to act increased and got more demanding with each episode, as more musical notes had to be hit in shorter intervals. After each episode, game enjoyment and perceived difficulty were measured using a questionnaire. Participants assigned to the control group used a naturally mapped game controller from the music game Guitar Hero (figure 1). Participants of the treatment group played the game with a genuine electric guitar.

Measures

Control Variables. Before the experiment, interest in music, interest in computer games in general, interest in music games and experience in playing the guitar were measured as control variables using single self-report items. On a Likert scale ranging from 1 to 4, higher values represented more interest/experience. Furthermore, frequency of playing games in general was assessed by one single self-report item asking for the average number of game sessions per week. A similar self-report item measured how often participants have played music videogames before.

Dependent Variable: Perceived Difficulty. Difficulty of each game version was assessed using two self-report items. One item addressed the game's overall difficulty and the other item the handling of the input device[1]. On a Likert scale ranging from 0 to 10, lower values reflected too low and higher values to high demand. Value 5 indicated optimal balance. Internal consistency was high ($\alpha_{EP1} = .9$, $\alpha_{EP2} = .86$, $\alpha_{EP3} = .82$), so a mean score calculated from both items served as an index variable measuring perceived difficulty.

[1] e.g. „How easy/ difficult did you perceive the game as a whole?", „How easy/ difficult was the handling of the input device?"

Dependent Variable: General Game Enjoyment. Game enjoyment was measured by a rating scale adopted from Klimmt (2006). It featured a 4-point Likert response format, with higher values representing higher levels of enjoyment. During item analysis, some items were removed due to suboptimal item difficulty or poor factor loadings, leading to a total of six items. The final scale was expected to be one-dimensional, which was confirmed by separate confirmatory principal component analyses for each episode, and demonstrated good internal consistency ($\alpha_{EP1} = \alpha_{EP2} = \alpha_{EP3} = .86$). Factor loadings of items varied from .58 (with one exception of .37) and .92, and explained variance ranged from 58.67 to 61.41 percent.

Statistical Procedures

For H1, H2, H3 and H4, a 2x3 mixed-design ANOVA was conducted with independent measures on input device (natural mapping vs. real life tangible mapping) and repeated measures on game episodes ($\alpha = .05$). Post-hoc multiple comparisons of game episodes were conducted using Bonferroni correction. Due to violation of sphericity, Greenhouse-Geisser corrected values were used for both game enjoyment scales. H5 was tested using multiple linear regression analysis with both perceived difficulty and mapping type (dummy-coded with 0 = natural mapping and 1 = real life tangible mapping) as predictor variables and game enjoyment as dependent variable ($\alpha = .05$). All statistical tests were conducted with SPSS 19. Effect sizes within a priori test of differences in control variables were conducted with G*Power 3 (Faul, Erdfelder, Buchner, & Lang, 2009).

Results

Perceived Difficulty

Descriptive values are shown in table 1 and results of omnibus significance testing and can be observed in table 2. As expected, participants who played the guitar version of Frets on Fire rated the game more difficult than the ones who played the game controller version (H1). This main effect, induced by the *type of mapping*, was statistically significant, and effect size was large. Additionally, omnibus testing showed that increasing and more demanding necessities to act within successive *episodes* had a significant and large main effect on perceived difficulty, supporting H2. Post-hoc testing revealed significant differences between both episode 1 and 2 ($p < .001$), 1 and 3 ($p < .001$) as well as episode 2 and 3 ($p = .001$). However, participants who played the natural mapping condition reported a steeper slope of difficulty from episode to episode than participants of the real life tangible mapping group (figure 4). This large interaction effect was found to be statistically significant.

Entertainment

As for H3 and H4, table 1 shows descriptive values and table 2 shows results of omnibus significance testing. As predicted, participants from the real life tangible mapping group experienced higher levels of game enjoyment than participants who only used the game controller (figure 5) (H3). ANOVA revealed these main effects to be large and statistically significant. As expected, game enjoyment also significantly increased with each episode (H4). However, post-hoc analysis revealed significant differences only between first and second ($p < .001$) as well as between first and third ($p = .002$) game episode. No statistically significant *interaction effects* between type of mapping and episodes were found.

Table 1. Mean scores and standard deviations for dependent variables.

		Episode 1		Episode 2		Episode 3	
		M	*SD*	*M*	*SD*	*M*	*SD*
Natural mapping	Perceived difficulty	2.85	1.36	3.95	1.17	5.1	1.35
	Game enjoyment	2.17	.34	2.33	.29	2.52	.36
Real life tangible mapping	Perceived difficulty	5	1.51	5.6	1.17	6	1.18
	Game enjoyment	2.98	.55	3.32	.41	3.45	.46
Total	Perceived difficulty	3.93	1.78	4.78	1.42	5.55	1.32
	Game enjoyment	2.58	.61	2.83	.61	2.98	.62

Table 2. ANOVA table of two-way repeated measures with type of input device as Between Factor, episode (with increasing necessities to act) as repeated factor.

Source of variance	*df*	Error	*F*	*p*	η_p^2
Perceived difficulty					
Type of mapping	1	18	8.12**	.01	.31
Episode	2	36	53.15**	< .001	.75
Episode * type of mapping	2	36	7.96**	.001	.31
Game enjoyment					
Type of mapping	1	18	32.3**	< .001	.64
Episode	1.28	23.06	13.91**	.001	.44
Episode * type of mapping	1.28	23.06	.6	.49[a]	.03

Note: *$p \leq .05$, ** ≤ .01; observed power within SPSS ($\alpha = .05$): .12

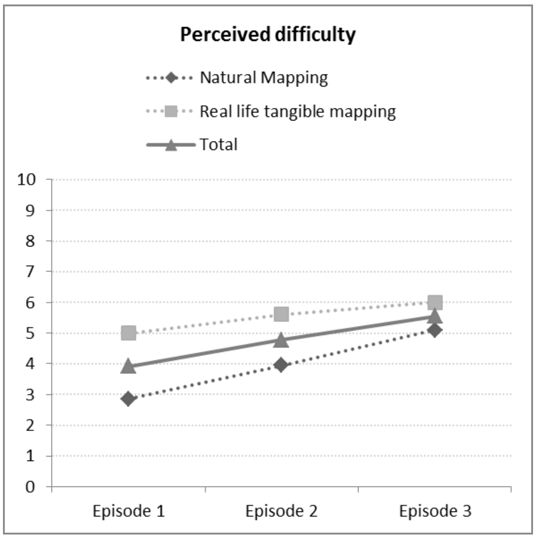

Figure 4. Differences in perceived difficulty for Between factors (natural mapping with a Guitar Hero controller vs. real life tangible mapping with a real guitar) and repeated factors (game episode). Main and interaction effects are statistically significant. A value of 5 represents optimal balance of difficulty.

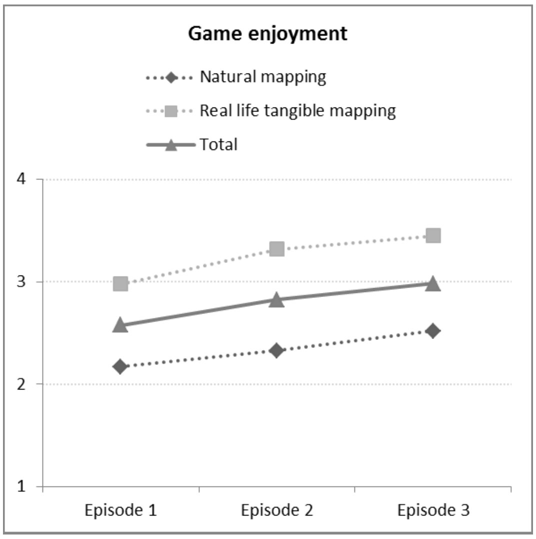

Figure 5. Differences in game enjoyment for Between factors (natural mapping with a Guitar Hero controller vs. real life tangible mapping with a real guitar) and repeated factors (game episode). Each factor had a statistically significant main effect.

Table 3 shows results of regression analysis that was conducted to test which predictor had the stronger effect on game enjoyment (H5). Due to the nature of multiple regression analysis, each predictor's influence is cleared out of the other predictor's effect. As expected, mapping type had a significant and the strongest effect on game enjoyment. Difficulty, on the other hand, had much weaker and (except for episode 3) no significant influence on entertainment.

Table 3. Multiple linear regression analysis of game enjoyment on difficulty and mapping type

	Perceived Difficulty		Mapping Type	
	β	*p*	*β*	*p*
Game enjoyment in episode 1	.31	.16	.49*	.03
Game enjoyment in episode 2	.11	.66	.76**	<.001
Game enjoyment in episode 3	-.31*	.05	.88**	<.001

Note: *$p \leq .05$, ** ≤ .01; Perceived difficulty represents values of respective game episode

Discussion

Perceived Difficulty (H1)

Empirical results support hypotheses 1 and 2: Probably due to the more demanding fingerings and more complex user interface, participants perceived real life tangible mapping (i. e. a real guitar) more difficult than natural mapping (a Guitar Hero controller). Later episodes of the music game were rated more difficult than earlier episodes. Results confirm that, at least when it comes to music games, authentic mapping is not necessarily more intuitive. Complex actions, such as guitar play, are perceived as more difficult when executed with lifelike devices than with artificially reduced and therefore less naturally mapped controllers. In music games, real life tangible mapping is more natural and authentic, and, as a result, it seems to be less intuitive.

Entertainment (H3, H4, H5)

ANOVA results confirm hypotheses 3 and 4. The real life electric guitar exceeded the naturally mapped game controller by far in terms of enjoyment, supposedly due to its increased feedback and suspension as well as richer simulation and identification potential. Increasing and more demanding necessities to act in the form of more difficult game episodes also strongly influenced game enjoyment. This may be due to higher levels of suspension and relief as well as more feelings of accomplishment, induced by higher difficulty. However, the effect might be limited to the transition from easy to medium game episodes. Contrary to Skalski's et al. (2010) as well as Tamborini's et al. (2010) approaches, in this study, the most difficult condition (episode 3 and real life tangible mapping) produced the most enjoyment (figures 4 and 5). Results of regression analysis (table 3) indicate that this effect may be due to the various entertainment mechanisms supported by real life tangible mapping and not by the higher difficulty of real life tangible mapping. As a result, in recent research on mapping types, intuitiveness might be overrated as a cause for entertainment. Probably it is mainly the simulation and identification associated with realistic controller mapping that provides enjoyment.

Practical Implications

The study described in this article raises some implications for practical application. Since a genuine electric guitar exceeds a naturally mapped game controller in both entertainment and realism, real life tangible mapping in music games could provide both authentic and intrinsically motivating guitar exercise. For example, otherwise unexciting, but important finger exercises may become far more attractive when integrated into a music game. As the game urges the player to play as accurately as possible and keeps track of the user's high scores, the player can easily track his or her improvement. One does not even need to modify Frets on Fire to play a music game with an authentic guitar. Within the last few years, several commercial games with guitar support have been published. For example, Rock Band 3 (Harmonix & Backbone Entertainment, 2010) features a "ProMode" where the songs are played note-for-note (instead of the usual simplified tracks) with either an authentic game controller or even a real guitar, exclusively built for this game. With the game Rocksmith (Ubisoft, 2011/2012) it is even possible to use a regular electronic guitar. However, as the software computes user input from acoustic signals, many players criticize audio latency. This might be counterproductive for both experiencing effectance and exercising musical (micro)timing. With guitar-like game controllers or MIDI guitars, audio lag is reduced beyond a perceivable level. Such intrinsically motivated music practice could also be applied to keyboard and drum exercise, as many keyboards or electronic drums come with MIDI support.

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