Sonotris: Testing the Influence of Musical Tempo on Tetris Players Performance.

Hufschmitt Aline*, Cardon Stéphane†, Jacopin Éric‡
CREC, *Écoles de Saint-Cyr Coëtquidan*, Guer, France
*aline.hufschmitt@st-cyr.terre-net.defense.gouv.fr
†stephane.cardon@st-cyr.terre-net.defense.gouv.fr
‡eric.jacopin@st-cyr.terre-net.defense.gouv.fr

***Abstract*—In this demo paper, we present *Sonotris*, a Tetris game with a dynamic soundtrack specifically designed to experiment with the influence of musical tempo on player performance. The different stages of the game use music whose tempo is either perfectly synchronous with the game, or accelerates progressively to prepare the speed steps, or is slightly out of sync, or in total opposition to the tension of the game. Our first tests on a group of 41 players showed a significant influence of tempo on the performance of novice players in Tetris and even more for those with a neutral evaluation of the music.**

***Index Terms*—Game difficulty, music, tempo, player performance, stress, Tetris**

I. Introduction

Keeping a player in the flow in a game is a central goal for game designers who seek to make the game neither too easy nor too difficult. The difficulty of the game is usually adjusted by inflicting more or less damage to the player for the same attack or by reducing the strength of the enemies, i.e. their health or points of attack. It has been shown that music influences human behavior [10] and that it can influence the sports endurance [13] or cognitive performance (memory [2], reflexes [1]). Our project is to use music to vary the difficulty of a video game. That is to say, we seek to use music to hinder or help the player. A study shows that tempo has no effect on the performance of players in Tetris [7]. However, this study uses very slight variation of a tempo moreover not related to the game, whereas the relationship between music and gameplay is very important and plays a significant role, for example to improve the immersion of players [3].

We designed *Sonotris*, to test the effects of a synchronous or asynchronous musical tempo in the game Tetris [12], in order to determine if the tempo can affect the performance of the players in this sensory motor task which also requires strategic thinking.

In the following section we present *Sonotris*, its implementation, the design of its music and the settings of the experience it embodies.

II. Sonotris

We chose to implement a Tetris game because it is a widely known game and one of the most used in academic research [7]. We can therefore benefit from the studies that have established the standard behavior of players of different skill levels [6], [8]. Although the mechanics of the game are quite simple, Tetris is very difficult to master with subtleties such as T-spin [9] to twist a T tetrimino into a tight space.

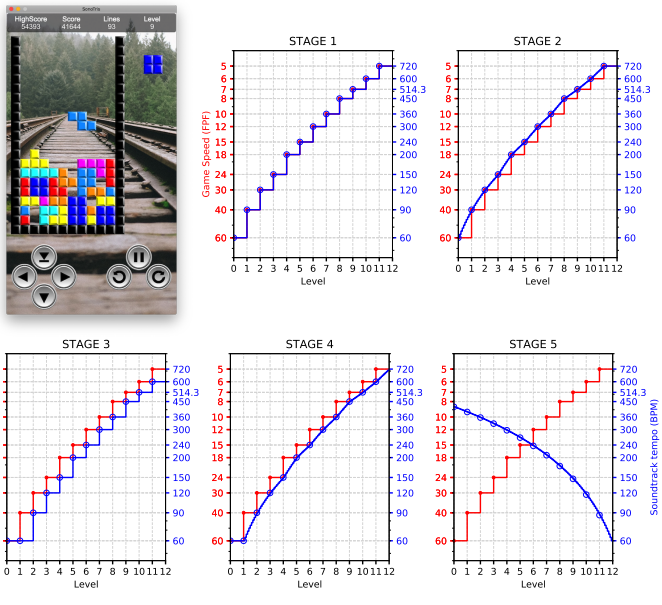

Fig. 1. Shotscreen of *Sonotris* and music tempo (Beat Per Minute) related to game speed (Frame Per Fall) for the *stages* 1-5 of the game.

A. Tetris implementation

Sonotris, presented on the top left of figure 1, has been created with *Unity* and is available online at `http://www.alinehuf.fr/sonotris.php`. For the selection of tetriminos, we use a variation of the original *Grab Bag algorithm* [11] allowing a fair distribution of the different tetriminos and minimizing the risks of getting a bad draw. The next tetrimino is announced to the player and to be as close as possible to the original game, we have included the possibility of doing a T-spin with a *super rotation system* [14][1].

B. Music chosen and arrangement

To experiment on the influence of a musical tempo synchronous with the Tetris gameplay, it was necessary to choose

[1]This *super rotation system* was recommended to us by the Ubisoft team.

978-1-7281-4533-4/20/$31.00 ©2020 IEEE

a music that could be accelerated without affecting its aesthetics or its intelligibility. We chose an instrumental version of a traditional Russian children's song called *"Petrushka, don't cry"* which has the interesting feature of starting each verse at a very slow tempo and accelerating to finish the chorus at a frenzied speed (3 times higher). We rewrote it to be able to multiply the tempo by 12 in accordance with the speed of the levels without affecting the quality of the music. At the resumption of the verse, the tempo is divided by two when it reaches a given limit (♩=150 or ♪=360) but the beat is doubled to go from a quarter note beat, to an eighth note beat and then a sixteenth note beat. To focus attention on the new beat, we modified mainly the bass with plated, split then arpeggiated chords and add some ornaments in the melodic voices. We then obtained 3 instrumental versions with different beats, linked without noticeable break by a continuously increasing tempo. We used MIDI to be able to manipulate the tempo and change dynamically the instrumental version with, to avoid music degradation, high quality sampled piano and cellesta sounds (full range) provided to us by Sylvain Brunet (Ubisoft R&D). We set up this dynamic music with *Wwise* a professional sound engine used for AAA games which provides a callback system ensuring perfect sound (de)synchronization or allowing to re-synchronize visual with sound when necessary.

C. Experimental settings

Following the design of a continuous acceleration of the music up to 12 times, we enforced the frame rate to 60fps to implement 12 *levels* of difficulty with tetriminos falling every 60, 40, 30, 24, 18, 15, 12, 10, 8, 7, 6 and 5 frames. We first thought of creating 12 regularly spaced speed steps but it appeared that the same increase in speed could be barely noticeable from a slow speed when it seemed enormous at an already high speed. We therefore opted for a logarithmic increase in speed. In a second step, to avoid problems of desynchronization between the *Unity* and *Wwise* engines, we specifically chose whole numbers of frames which corresponded to whole numbers in BPM (as much as possible). We have also specifically chosen these values to create a smooth and regular speed curve.

To test the influence of tempo and synchronization on players performance, we have designed 5 *stages*, i.e. 5 game *sessions*, with different presets for the evolution of the music tempo. Each *stage* uses the same progression of 12 speed levels. Figure 1 presents the different tempo preset used for the *Stages* 1 to 5: (1) the tempo increases with each *level* and is perfectly synchronized with game speed, (2) it increases at each line and "prepares" the game speed increase of the next *level*, (3) it is increased with one *level* of delay and is then slightly out of sync, (4) it is also one *level* late, out of sync but steadily increasing, (5) it is in total contradiction with the speed of the game and decreases regularly.

III. Conclusions

As part of a project to use music to vary the difficulty of a video game, *Sonotris* has already allowed us to test the influence of musical tempo on 41 Saint-Cyr cadets.

Our first results with *Sonotris* confirm those of Lawrence [7] that do not significantly differentiate the global performance of players in different tempo conditions. However, a more detailed study [4], shows that a synchronized and steadily increasing tempo makes Tetris significantly harder for the novice players and the players who have a neutral evaluation of the music. We also show [5] that a given tempo preset in a *stage* can prepare the player positively or negatively for the next *stage* e.g. players play significantly better in *stage* 4 if they have played *stage* 3 rather than another one before and they play significantly less well in *stage* 2 if they are prepared by *stage* 1 rather than another one.

Our work with *Sonotris* will now focus on identifying signs of stress in the playing data, which will help to explain the negative influence of a synchronous and steadily increasing tempo in Tetris. A metric to measure the stress induced by the tempo will then allow us to verify our findings with different music as well as in different other games.

Acknowledgment

We wish to thank Sylvain Brunet and Camille Durif (Ubisoft R&D) respectively for designing the sounds and for testing *Sonotris*.

References

[1] C. Amezcua, M. Guevara, and J. Ramos-Loyo, "Effects of musical tempi on visual attention erps," *The International journal of neuroscience*, vol. 115, pp. 193–206, 03 2005.

[2] Q. T. Chie, Karthigeyan, and Kartpagam, "The effects of music tempo on memory performance using maintenance rehearsal and imagery," *Sunway Academic Journal*, vol. 6, pp. 114–132, 01 2009.

[3] H.-P. Gasselseder, "Re-scoring the games score: Dynamic music, personality and immersion in the ludonarrative," 2014.

[4] A. Hufschmitt, S. Cardon, and E. Jacopin, "Can musical tempo makes tetris game harder?" in *IEEE Conference on Games (CoG)*, 2020, pp. 1–4.

[5] ——, "Manipulating player performance via musical tempo in tetris," 06 2020, [submitted to AIIDE 2020].

[6] D. Kirsh and P. Maglio, "On distinguishing epistemic from pragmatic action," *Cognitive Science*, vol. 18, no. 4, pp. 513–549, 1994.

[7] D. Lawrence, "The effect of musical tempo on video game performance," Master's thesis, University of Jyväskylä, 2 2012.

[8] D. Lora, A. Sánchez-Ruiz, P. González-Calero, and M. Gómez-Martín, "Dynamic difficulty adjustment in tetris," *Proceedings of the Twenty-Ninth International Florida Artificial Intelligence Research Society Conference*, 2016.

[9] T. Oikawa, C.-H. Hsueh, and K. Ikeda, "Improving human players' t-spin skills in tetris with procedural problem generation," *16th Advances in Computer Games Conference*, 2019.

[10] J. Spenwyn, D. Barrett, and M. Griffiths, "The role of light and music in gambling behaviour: An empirical pilot study," *International Journal of Mental Health and Addiction*, vol. 8, pp. 107–118, 01 2010.

[11] K. Spiel, S. Bertel, and F. Kayali, ""not another z piece!" adaptive difficulty in tetris," 05 2017.

[12] Tetris-Holding. About tetris. [Online]. Available: https://tetris.com/about-us

[13] A. Thakur and S. Yardi, "Effect of different types of music on exercise performance in normal individuals," *Indian journal of physiology and pharmacology*, vol. 57, pp. 448–51, 10 2013.

[14] J. Thompson, "How to properly rotate tetris pieces - game development tutorial," accessed: 2020-05. [Online]. Available: https://www.youtube.com/watch?v=yIpk5TJ_uaI&app=desktop