Fine Tuning the Terrible Twos: The Musical Aesthetic of the Atari VCS

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In 1982, I awoke on Christmas morning to find Santa had blessed me with an Atari 2600 (or Video Computer System (VCS) as it had been previously known). I was about ten years old at the time, and knew this gift would make me the envy of many neighbourhood children, who in the following couple of years would come over and play until the joystick button had dug creases into our thumbs, or my mother would come in and yell at us to "go enjoy the weather". I can't guess how many hours I spent in front of that console—probably hundreds—but upon beginning this research—some twenty years later—I realized I could still remember every song as I began to re-hear them. Burned into my consciousness, the songs at the time seemed inconsequential (although I think I can remember humming the tunes as the games loaded). I had not yet formulated the musical awareness that I have today, and did not, therefore, realize how odd those bits of music were. Unlike other games consoles of the era, the Atari VCS was unique when it came to sound, and, I will argue, helped to create a new musical aesthetic as a result of its awkward tuning system.

The Atari VCS saw limited success when it was first released, and the first few years of production saw few games created for the console. In 1980, however, Atari licensed the popular arcade game *Space Invaders*, which became a best seller and helped to spur on the sales of the VCS. Most remarkable, however, was the longevity of the machine. While today console makers can expect a shelf-life of perhaps two to three years, the Atari VCS was on store shelves from 1977 until 1989, making it the longest-running console ever. Eventually, over 25 million homes had owned a VCS, and over 120 million cartridges had been sold.[1]

The TIA

The majority of 8-bit video games machines (and early arcade and pinball machines) used what is known as programmable sound generators, or PSG sound, silicon chips designed for applications which generate sound based on a user's specifications. These specifications were usually coded in assembly language, and early sound programmers and musicians needed to understand the programming language to engage the chip. This meant that most early games composers were in fact programmers working on other aspects of a game, or at best, in-house programmer-musicians who had to work closely with programmers working on other aspects of the game. PSGs offered little control over the timbre of a sound, usually limiting sounds to single waveforms without much ability to manipulate that waveform. Many of these PSGs were created by Texas Instruments or General Instruments, but some companies, such as Atari and Commodore, designed their own sound chips to improve sound quality.

Early PSGs used what is known as analogue synthesis, or subtractive synthesis. Subtractive synthesis starts with a wave form created by an oscillator, and uses a filter to attenuate or subtract specific frequencies and then passes this through an amplifier to control the envelope and amplitude of the final resulting sound:

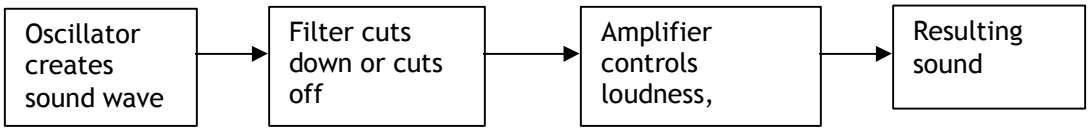

Figure 1: Subtractive synthesis.

The sound chip in the VCS was manufactured specially by Atari, and was known as the TIA chip, and also handled graphics. The audio portion had just two channels, meaning whatever music and sound effects were to come out of the machine, could only be heard on two simultaneous voices. Each channel had a four-bit volume control (sixteen volume options), and a four-bit waveform control selector, but of the sixteen possible settings, several were the same or similar to others. Typically, the voice options were two (sort-of) square waves (one high, one bass), one (sort-of) sine wave, one

(sort-of) saw wave, and several noise-based sound options useful for effects or percussion. The trouble with the tonal sounds, however, was that each had a different tuning (although two of the square-wave sounds were almost the same tuning), so the pitch value may be different between the bass and the lead.

This tuning was down to the TIA's five-bit frequency divider (capable of dividing a frequency of 30KHz by 32 values). This frequency controller was incredibly limited, and used a polynomial counter, also known as a Linear-Feedback Shift Register (LFSR). LFSRs are type of binary counter that uses a pseudo-random way of counting, rather than the normal binary incremental/decremental sequences. The number was divided down from the system clock. Starting with one base tone, that frequency is then divided between one and 32. To compound the problem, there were slight variations between NTSC and PAL formats. At times, pitches were off by as much as fifty cents.[2]

Tuning sets could be quite variable, then, as some setups would allow for more bass notes, while others would allow for more treble, and since many sets would have conflicting tunings between bass and treble, they were for most tonal compositional purposes, useless. Paul Slocum, creator of an Atari VCS sequencer kit, warns "Although each set contains notes that are close to being in-tune, you can still end up with songs that sound pretty bad if you aren't careful. Playing a note from the set that is a bit sharp simultaneously with another note that is a bit flat can sound bad."[3] Slocum provides programmers with several somewhat function setups. The following example gives us five tonal voices from which to choose our melody or bass. Pitches are given as closest to calculated frequency, but depending on whether or not the system is NTSC or PAL (North American or European television broadcasting standards), the actual pitch can range—in this case, by as much as 29 cents. Recognizing that sounds below about C2 and above about C7 were not very practical for tonal elements (although they may be useful for sound effects), we are left with even further limitations (I have greyed these less useful notes out). The best we can get in terms of a complete chromatic scale within any one octave is the square wave, which will give us six out of the twelve notes.

Bass, Pitfall

NOTE	NTSC	PAL
F#2	-6	-19
F1	+16	+4
D#1	+4	-9
C1	0	-11

Low Bass

NOTE	NTSC	PAL
B0	-11	-22
G#0	0	-13

Lead

NOTE	NTSC	PAL
E8	-11	-25
E7	-11	-25
A6	-14	-27
E6	-11	-25
C6	+2	-11
A5	-14	-27
E5	-12	-25
D5	-16	-29
C5	+2	-11
A4	-13	-27
F4	0	-13
E4	-11	-25
D4	-16	-29
C4	+3	-11
A3	-14	-27
G3	-17	-31
F3	+1	-13
E3	-11	-25

Saw

NOTE	NTSC	PAL
C7	+2	-1
C6	+2	-1
F5	0	-1
C5	+2	-1
F4	0	-13
C4	+3	-11
A#3	-2	-15
F3	+1	-13
C3	+3	-11
B2	-3	-16
A#2	0	-14
A2	+5	-8
F2	0	-12
D#2	-5	-18
C2	+3	-11

Square

NOTE	NTSC	PAL
B8	-9	-23
E8	-11	-25
B7	-11	-25
G7	+4	-9
E7	-11	-25
B6	-9	-23
A6	-13	-27
G6	+4	-9
E6	-11	-25
C6	+2	-11
B5	-10	-23
A5	-14	-27
G5	+4	-9
E5	-12	-25
D5	-16	-29
C5	+2	-11
B4	-9	-23

Figure 2: One Tuning System for the Atari VCS.

Slocum (2003) shows how various effects can be accomplished using the limited technology. To simulate chords, fast arpeggios could be played. Portamento effects can also be made using a similar technique. Echo effects (see *Clown Down Town*) can be created by repeating notes and decreasing volume. Phasing effects can be simulated by playing simultaneous notes on both channels. "Once you start playing a simultaneous note on both voices, the phasing will stay the same until you switch notes. However, I've found that if you set the pitch on one voice to a random value for a few cycles and then set it back to the correct value, it will shift the phase" (Slocum 2003). The difficulty in programming tunes for the Atari VCS meant that there was less use of popular songs than other consoles had seen (see Collins 2005), although it certainly worked in a few cases, such as the cover of the title theme for *Halloween*. The cover version doesn't have the key changes of the originals, but it's not a bad rendition, given the Atari's limitations.

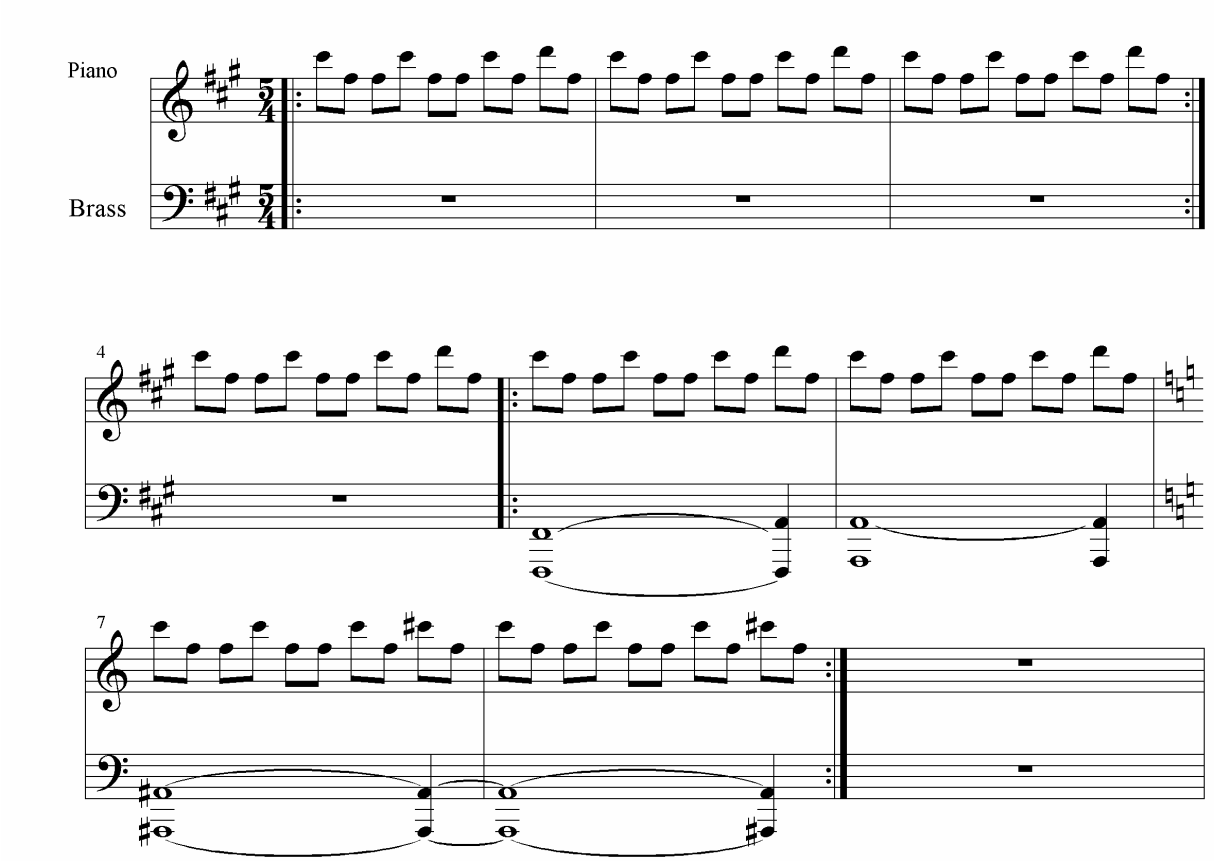

Figure 3: *Halloween* John Carpenter, 1978 (simplified)

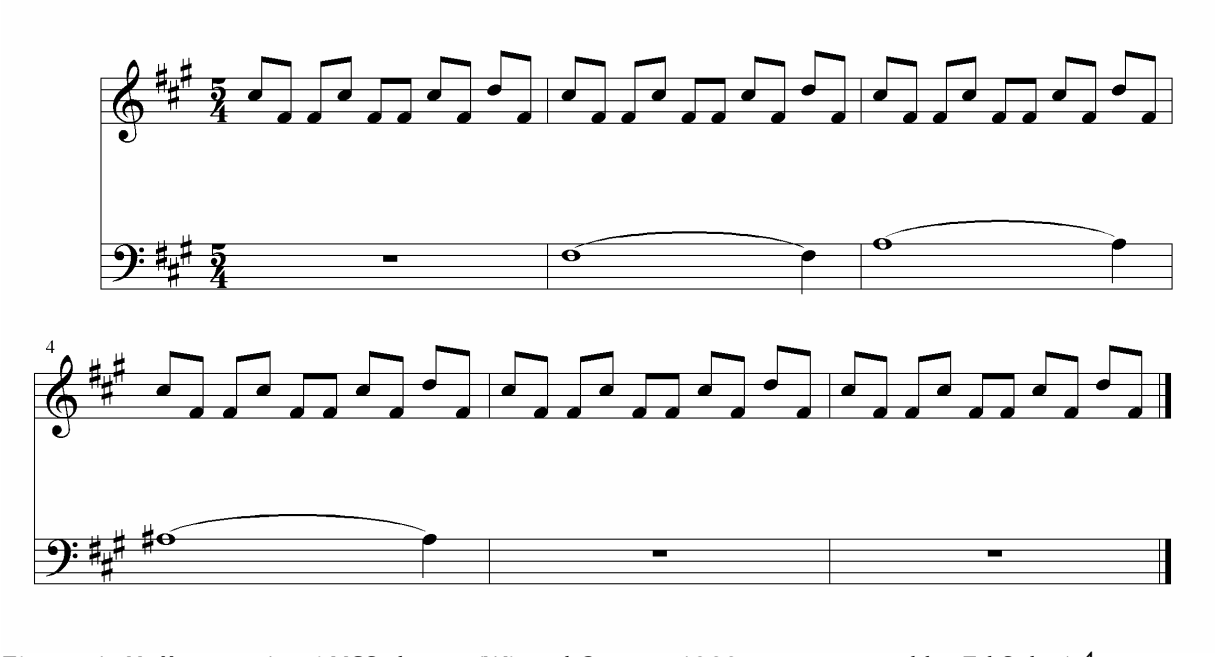

Figure 4: *Halloween* Atari VCS theme (Wizard Games, 1983, programmed by Ed Salvo).[4]

METHODS

Downloading as many VCS games as I could find, I ended up with 486 files for my StellaX v1.1.3a Atari VCS emulator. Of these files, only 121 had music or were working, a fact that is notable as many Atari programmers did not even try to write music for the machines. I eliminated any prototypes and games categorized as "unbelievably rare", took out any games that were duplicate soundtracks (e.g. *Summer Games* and *Winter Games*), as well as any that used popular song, or title themes for their music. Left with eighty games to choose from, I randomly selected half of these to analyse.

The fact that the tuning system may be different between different voices (there may be a "G" available in the bass, but only a G# in the treble, for instance), complicated programming in harmony, and it is little wonder that only seventeen of the forty songs analysed contained songs with both bass and treble voices.

Minor Seconds and the Atari Tuning

One thing I immediately noticed was the prominence of flat seconds in the songs. Of the forty games analysed, fourteen of them had the odd characteristic of containing flat seconds, which at the time was very unusual in Western music. As Tagg notes, "With the exception of a few rock songs from the early eighties which sported lyrics expressing alienation, hopelessness and a sense of doom, no internationally popular music of this century has shown such a leaning toward (aeolian and phrygian) modes with their downward pulling minor sixths and/or seconds."[5]

It is the minor second which characterizes the phrygian mode, although the examples for the Atari are not necessarily in any mode or key. Acoustically speaking, the minor second is considered to have the strongest dissonance in the Western chromatic scale, and feels particularly unstable in the bass register. Cooke argues that the minor second represents "unrelieved hopelessness", "hopeless anguish" and "despair", and that

> Its tension is obviously akin to that of the minor sixth: it is an acute dissonance in relation to the minor triad, but whereas the sixth is drawn by semitonal tension down to the dominant, the minor second is drawn by semitonal tension down to the tonic. This means that whereas the minor sixth is an expression of anguish in a context of flux, the minor

> second is an expression of anguish in a context of finality; in other words, the minor sixth expresses an active anguish, the minor second a hopeless anguish.[6]

The phrygian has been called the "austere" or "severe" mode, and is often referred to by many Westerners as "dark", "heavy", "brooding", "somber", or "gloomy".[7] William B. Kimmel has shown that phrygian inflections are common to Western "death" music, specifically as recurring elements in requiems.[8] In the civil war saga *Cold Mountain*, novelist Charles Frazier describes it as "the frightening and awful Phrygian mode, and when the girl's mother heard it she burst into tears and ran from her chair out into the hall".[9]

The prominence of minor seconds in the music of the Atari seems linked more to the limited tunings available than to any musical affect for the most part. For instance, if I chose the saw wave sound from the chart above, my bass (lets say the lower two octaves of the chart) is primarily limited to C, D#/E♭, F, A, A#/B♭, and B. Not having either a diatonic or chromatic scale to play with, it is simply statistically more likely that I will end up using a flat second. Given these notes, of the major keys, I have a choice of six (A, B, C, F, B♭, and E♭), though two of these will contain flattened seconds. Of the minor keys, I can use eight (A, A#, B, B♭, C, D#, E♭, and F) but three of these will have flattened seconds. If I use A# minor then I' m using a phrygian mode, and if I use A major, I' m into Locrian modal territory, with the flat five.

In the limited tonal language of the Atari, minor seconds often seem to have the affect of being slightly "off", rather than signifying any kind of doom in some of the tracks, although this could be influenced the lack of any modal or tonal setting in which these minor seconds are found. The games *Base Attack*, or *Room Doom*, for instance, include a minor second as part of their intros, which are both just quick ascending scales:

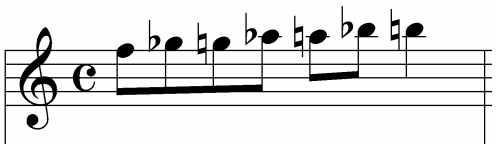

Figure 5. *Base Attack* (Home Vision) unknown year and programmer.

Likewise, it is unclear whether or not *Clown Down Town's* echo-plex-like tones are meant to spell "doom", though it is unlikely given the setting of having a clown walking around the city meeting people:

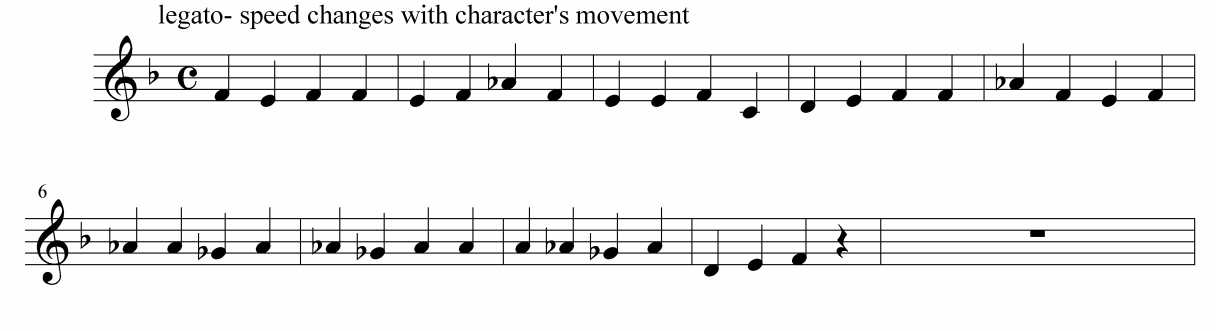

Figure 6. *Clown Down Town* (unknown)

And my particular favourite, *Tapeworm's* hilariously bizarre title theme, which seems unrelated to the action of the game:

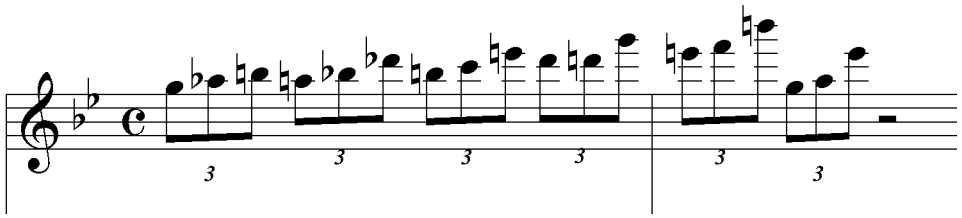

Figure 7. *Tapeworm* (Spectravision 1982)

Other games seem to use phrygian modal elements for more traditional reasons, such as to conjure up images of deserts, pyramids and snakes, as in *Desert Falcon*, described in the manual as

> "A Daring Desert Quest for Treasure! All around you are long stretches of sand, ancient pyramids baking in the hot dead air, and constant danger. The legends that brought you here are 30 centuries old. The tales tell of thieves who plundered the Pharaoh's tomb, loading bags of gold, silver, and precious gems onto their camels, then making off into the desert. But in the night, horrible desert beasts pursued the robbers, and the priceless treasure was scattered and lost. Not even a camel was ever seen again. Now you search for the lost treasure, daring the beaks and claws of the desert guardians. As you scan the endless sand for the glitter of jewels, your eye catches sight of gliding shadows. Something's coming!"

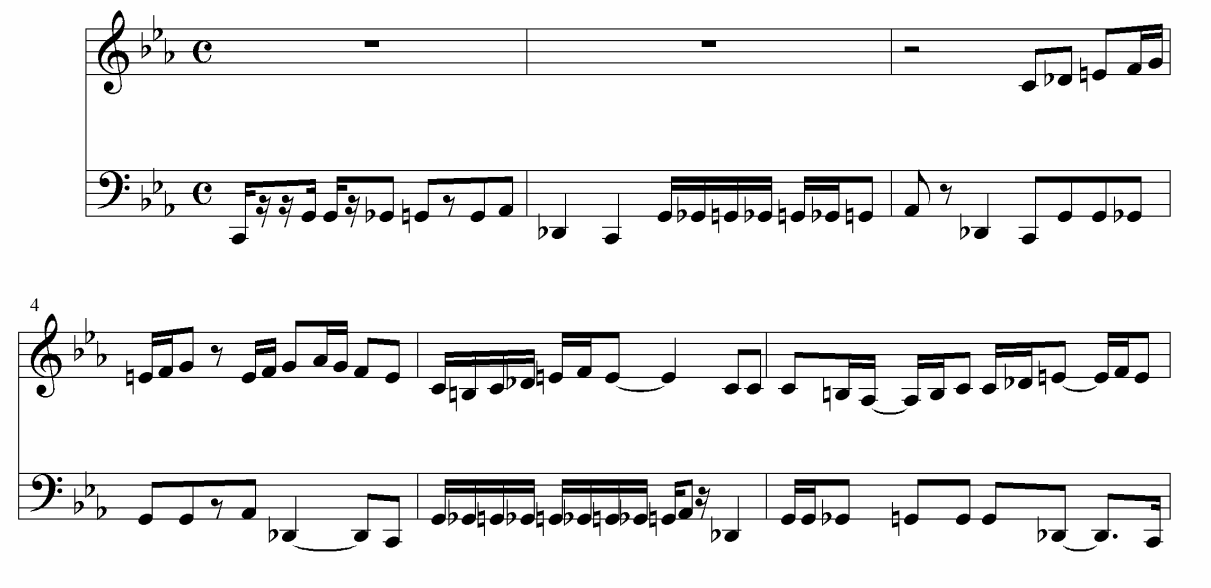

Figure 8. *Desert Falcon* (Atari 1988, programmer Bob Polaro)

But other games where we would expect this music are absent, such as *Tutankhamun*, and *Montezuma's Revenge*. It is unclear whether still others, such as the composer of *No Escape!* (set in an ancient Greek temple) intended the inclusion of modal elements to connote ancient times. Likewise, *Entombed* combines horror with archaeology, but does not seem to be invoking the flat twos to conjur Arabic imagery, but rather invoking the *Dies Irae* for the horror of it: "You and your team of archaeologists have fallen into the "catacombs of the zombies" reads the manual.[10]

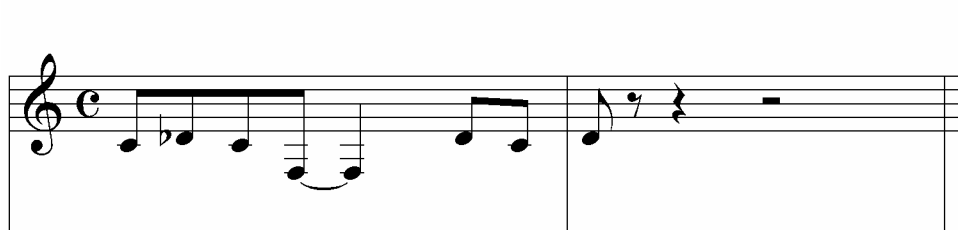

Figure 9. *Entombed* (US Games, 1982)[11]

Seven of the fourteen games containing minor seconds were ports from arcade versions, so I checked the original soundtracks, four of which contained flat seconds, and three of which did not. *Kangaroo*, *Super Cobra*, *Crystal Castles* and *Burger Time* were all fairly comparable versions, although a few notes were swapped (likely due to the VCS' tunings). The basslines were generally abandoned, as the chances of finding both compatible lead and bass voices on the TIA chip would be minimal.

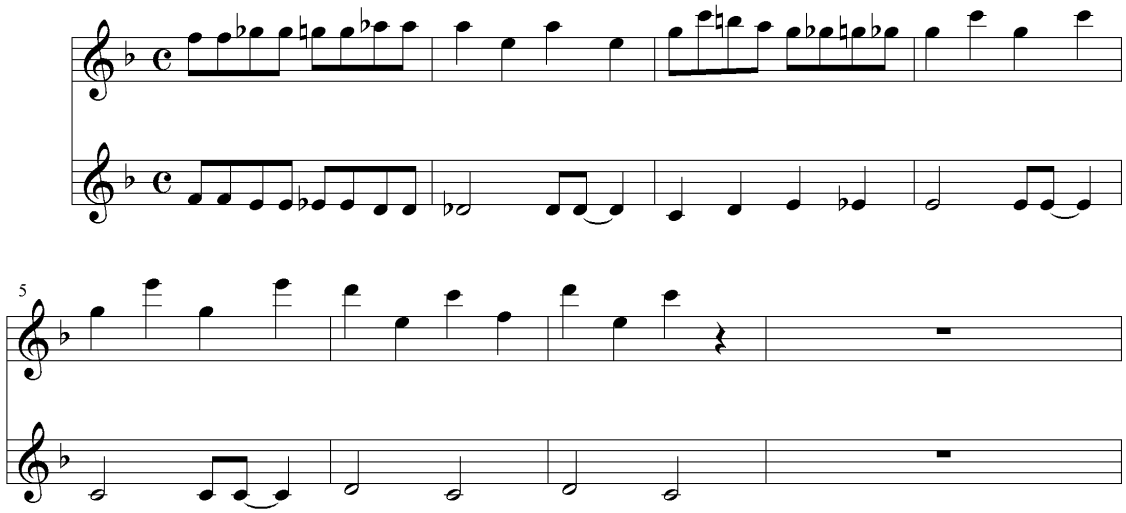

Figure 10. *Burger Time* – Arcade Version (Data East, 1982)

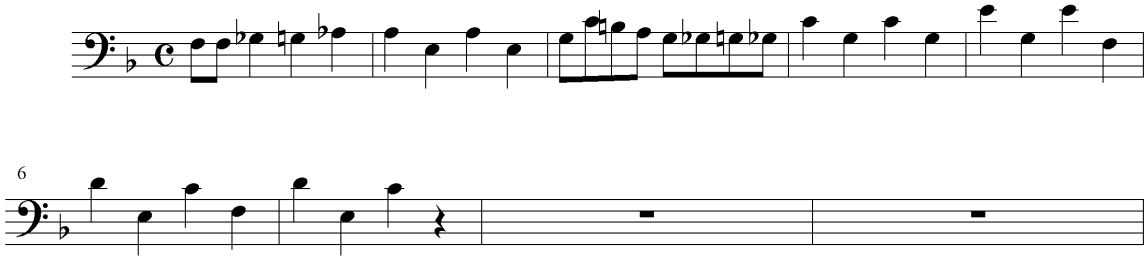

Figure 11. *Burger Time* – Atari VCS version. (M Network 1982, sound by Patricia Lewis du Long)

Three other covers, *Qbert*, *Crazy Climber*, and especially *Up n' Down* had a noticeably different flavour to the tunes, due, apparently, to the limitations of the Atari soundchip.

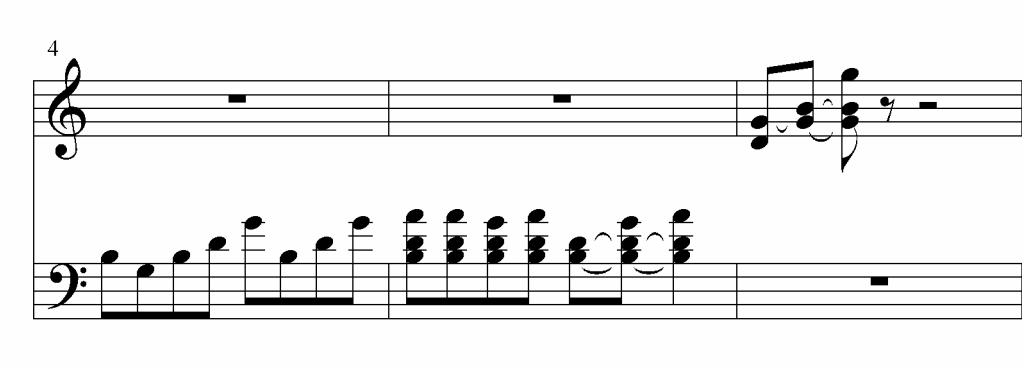

Figure 12. *Qbert* – Arcade Version (D. Gottlieb and CO. 1982)

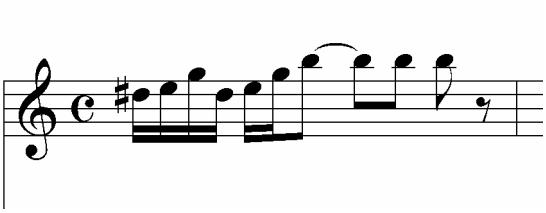

Figure 13. *Qbert* – Atari VCS Version (Parker Bros/Atari 1983)

Up n' down in particular suggests the Atari's tunings may have had a significant role to play in the prominence of flat seconds, as the tune changes from a bluesy F# minor groove to an almost psychotic sounding version based in C minor.

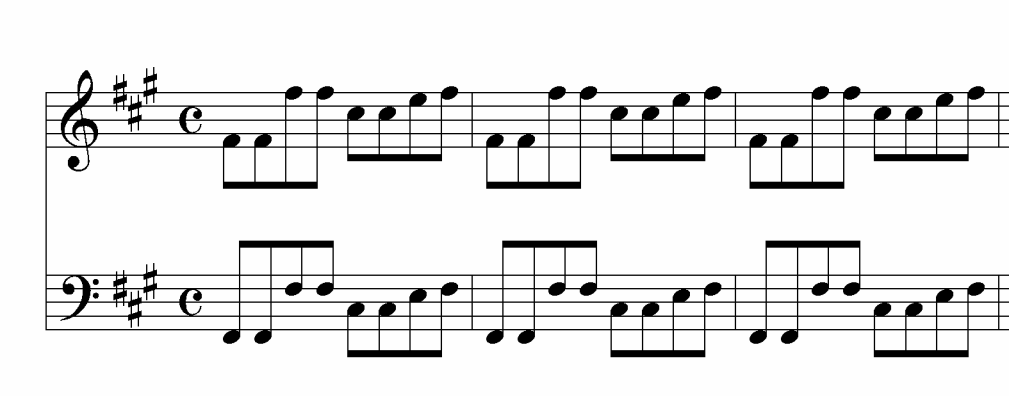

Figure 14. *Up N Down* - Arcade Version (Sega 1983)

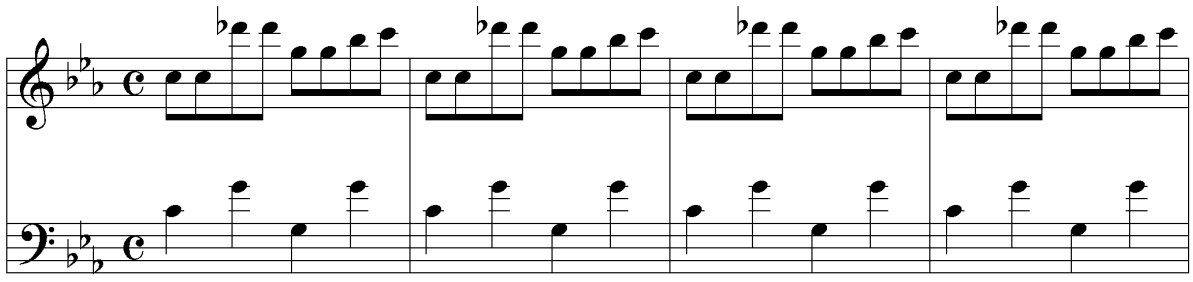

Figure 15. *Up N Down* - Atari VCS Version (Sega 1983)

It seems fair to say, then, that the prominence of minor seconds is to a large extent dependent on the tuning limitations of the TIA soundchip. But this still fails to explain why the other four arcade songs originally contained minor seconds, at a time when these were uncommon in Western music, and most of the games companies in this early period were US American. Could it be that, since most composers at the time were programmers rather than musicians, they just didn't "know any better"? Or could it be that by the time these games came out—1982 and 1983—the Atari aesthetic had already been absorbed into game programmers' consciousness?

CONCLUSIONS

The Atari aesthetic is still going strong, as "micro musicians" have worked out how to record and play songs through the old VCS. In 2000, the band Golden Shower won "Best Electronic Music Video at the MTV Brazil Video Music Awards, for their video for a song called 'Video Computer System', written using entirely Atari VCS game sounds.[12] But is the Atari responsible for a much larger shift in tonal sensibilities in the 1980s?

Philip Tagg suggests

> "… European and North American techno-rave seems to go in a big way for the aeolian and phrygian modes, not as harmonic padding for blues pentatonicism, but as straight sets of minor mode triads or bare fifths without much trace of a seventh, let alone ninth, eleventh or thirteenth."

And asks,

> "Why phrygian? Have British rave musicians taken a stand for the new-age travellers and gypsies? Have European and North American bedroom boffins started to support the pan-Islamic movement or is the phrygian thing a musical 'up yours' to the powers that sent the Nintendo missile through the Iraqi bomb silo window and smashed the lives of thousands of civilians in Baghdad, i.e. the same powers that condemn half the rave-going youngsters to unemployment? Or has everyone been listening to raj music? Or is the phrygian mode just new and different? If so, why that particular difference and not another? What about the lydian mode? It's just as rare in pop as the phrygian."

Tagg uses a few examples of Euro House—BMQ's 'Mastermind' and Capella's 'U Got 2 Know' (both 1993, but the Capella melody is based on the Siouxie & The Banshees 'Happy House' of 1980) to illustrate his point, and there are certainly many house and techno tunes using the flat second, particularly those using an E tonic. Heavy metal and industrial songs in the 1980s and early 1990s likewise ended up frequently using flat seconds (see Collins 2002).

While the prominence of flat seconds in electronic music could be down to any or all of Tagg's suggestions, or could have something to do with the setup of programming in tracker sequencers, could it also be that the acceptance of this modal element—particularly in genres that were based on synthesizer music, such as techno, house, and industrial—was influenced by the hearing of Atari VCS songs hundreds of times over in the formative years of these musicians and their fans?

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[1] Hunter, William. 2000. 'Videogame History 101' http:// www.emuunlim.com/doteaters/play3sta1.htm. All web dates accessed on October 17, 2004.
[2] Eckhard Stolberg has put together a list of possible VCS tunings, available on http://home.arcor.de/estolberg/texts/freqform.txt.
[3] Slocum, Paul, 2003. 'Atari 2600 Music And Sound Programming Guide' http://qotile.net/files/2600_music_guide.txt.
[4] All VCS games songs are shown in closest approximate pitches.

[5] Tagg, 1997. "From Refrain to Rave: The Decline of Figure and the Rise of Ground" *Popular Music*, vol. 13/2 (1994), pp. 209-222.

[6] Cooke, Deryck. 1989. *The Language of Music*. Oxford: Oxford University Press p. 78.

[7] For examples, type in "phrygian" and "dark" as search terms in Google.
[8] Cited in William H. Rosar, "The *Dies Irae* in *Citizen Kane*: Musical Hermeneutics Applied to Film Music" in Kevin J. Donnelly (ed.), *Film Music: Critical Approaches* (Edinburgh: Edinburgh University Press, 2001), p. 110.

[9] Frazier, Charles. 1997. *Cold Mountain*. New York: Atlantic Monthly Press p. 232.

[10] Manuals are available for some games on Atari Age http://www.atariage.com
[11] The use of flat seconds was also popular in horror themes of the era—such as *Nightmare on Elm Street*.
[12] http://www.srcf.ucam.org/~hmw26/join-the-dots/2004/03/11/atari-audio
hear the song on: http://www.bizarremusic.com.br/bz/mp3/golden_shower-videocomputersystem.mp3