Effects of the Presence of Audio and Type of Game Controller on Learning of Rhythmic Accuracy

by

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ABSTRACT

Guitar Hero III and similar games potentially offer a vehicle for improvement of musical rhythmic accuracy with training delivered in both visual and auditory formats and by use of its novel guitar-shaped interface; however, some theories regarding multimedia learning suggest sound is a possible source of extraneous cognitive load while playing so players may score higher with sound turned off. Also, existing studies have shown that differences in the physical format of interfaces affect learning outcomes. This study sought to determine whether (a) the game's audio content affects rhythmic accuracy, and (b) the type of game controller used affects learning of rhythmic accuracy. One hundred participants were randomly assigned in approximately equal numbers (ns = 25) to the four cells of a 2x2 between-subjects design. The first variable was the audio content of the game with two levels: on or off. The second variable was the type of game controller: the standard *guitar-style* controller or tablet interface. Participants across all conditions completed a pre- and post-test with a system that required them to tap along with repeated rhythmic patterns on an electronic drum pad. Statistical evidence showed better outcomes with a tablet controller with respect to input time error, reduction of extra notes played, and reduction of missed notes; however, the *guitar-style* controller produced superior outcomes in terms of avoiding missed notes and was associated with higher satisfaction by participants. When audio was present better outcomes were achieved at multiple factor-levels of reduction of missed responses, but superior outcomes in input time error were seen without audio. There was no evidence to suggest an interaction between controller type and the presence or absence of audio.

Dedicated to my little family: Cat, Twiggy, and Wawa. You are my why.

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Introduction

Contemporary research in cognitive science has shown that learning supported by video games is fundamentally sound (Gee, 2003). According to Gee, well-designed games provide information in a timely and contextually appropriate fashion, facilitating clearer understanding and better memory retention. Additionally, motivation may also be improved. Lim's 2008 paper advocating the use of games in the classroom cites *Never-Winter Nights*, *Rollercoaster Tycoon*, and *Guitar Hero II* as examples of games that achieve this goal. The next game in the *Guitar Hero* franchise, *Guitar Hero III,* features rhythm as a central component while incorporating many of the design principles upon which good games are built (Gee, 2003). Teachers of the traditional guitar emulated by the game see a clear link between *Guitar Hero III* and desire to begin playing the real instrument (Price, 2007). Conversely, Radocy and Boyle (1979) summarized traditional teaching techniques for rhythm. Historically rhythm has been taught almost exclusively in a face-to-face environment by an instructor with one or several pupils. They listed specific exercises including counting out loud, tapping or clapping rhythmic phrases, asking students to simulate conducting a piece of music, expression of rhythm through physical movements, vocalization of *rhythm syllables or words*. Additionally, they stated that rote performance of rhythmic expression can be a valuable learning aid. *Guitar Hero III* and other games of the genre employ analogous techniques such as tapping on a game controller button along with audio and a visual representation of pitch and rhythm.

Dalby (2005) argued that rhythm is the most important component of music. He states that a key goal in teaching rhythm is that students must be able to identify music by *audition*, which he defines as *the way music sounds*. Another goal is that students experience music through rhythm-syllables (sounds as symbols for rhythmic notation) because they facilitate comprehension and retention of audited rhythmic patterns. Finally, he suggests that movements based on rhythm create meaning and relevance for those rhythms. Face-to-face experiences such as audition and rhythm-syllables can be recreated or expanded with Computer Assisted Instruction (CAI) but must be tempered by research into multimedia learning theory.

Rhythm is the universal method of expressing and interpreting the human experience of a concept that stretches throughout all existence: time. Rhythm is the single essential element of music, as music is a temporal experience. Music education stands to benefit greatly by incorporating into its long-standing practices new theories and technologies like videogame-based learning. This study augments existing research by examining the effects of different types of controllers on practice and tests existing theories about multiple sensory channel learning. This study has implications well beyond music. Pushing the right button at the right time can literally be a matter of life and death in professions such as aviation and law enforcement. Even the most modest drive in a car demonstrates the need to react to sensory input with appropriately timed and selected motor responses. We can all benefit from a more intimate and accurate relationship with time.

Instructional Value of Sound: Multimedia Learning Theory

Cognitive load theory addresses the amount of workload available for utilization in working memory. Cognitive load increases with both the frequency with which information is presented to a learner and the complexity of processing such information.

When working memory is overloaded, errors related to processing information are likely to occur (Chandler & Sweller, 1991; Sweller 1999; Sweller & Pass, 1998).

Mayer (2001) applied the above theories to CAI to create multimedia learning theory, which suggests that optimal learning occurs when information is presented concurrently in both visual and auditory forms. This theory implies that games such as the *Guitar Hero* series enhance learning by providing visual timing cues indicating which button to press and when to press it as well as audio cues that also support timing of button presses. Music education literature supports this notion, as Shehan (1987) suggested that learning rhythmic concepts is best accomplished with a blending of visual and auditory strategies.

Split attention effect occurs when multiple pieces of information are presented in the same modality. As a result, extraneous cognitive load occurs (Chandler & Sweller, 1992). Early research into this effect was conducted with visual materials, but Moreno and Mayer (2000) would investigate a similar effect with audio. They found that multimedia presentations containing extraneous environmental sounds would cause students to perform worse on tests or retention and transfer. They called this *coherence effect*. Coherence effect could explain why players of the *Guitar Hero* series may possibly achieve higher scores with the audio turned off. *Guitar Hero III* audio is peppered with environmental sounds such as those from an audience as well as sounds of other instruments and vocals from the same song.

The aspects of multimedia learning theory mentioned thus far provide support both for and against including audio for instructional purposes. Generally, the addition of audio is supported if the audio is both appropriate and not so complex as to cause an overload of the aural channel; however, if the audio is unrelated to learning, distracting, or otherwise extraneous a detrimental effect could occur. This study was designed to test whether *Guitar Hero III's* audio results in improved or lessened learning outcomes.

Influence of Physical Interfaces: Novel Hardware Interfaces

It has been speculated that one of the key reasons for the popularity of the *Guitar Hero* series is the guitar shaped controller used to interact with the software (Conlon, 2008; Price, 2007). Such speculation reflects prior studies of hardware interfaces. Thompson et al. (1994) described a variety of hardware interfaces used to induce classical conditioning in humans, rabbits, and rats, indicating that multiple interface designs can be used to create the same kinds of learning. Terrenghi et al. (2006) developed a *Learning Cube* as an alternative learning appliance, which showed that a novel, *playful* interface could successfully support learning. As early as 1994, Qwek demonstrated that vision-based gestural interfaces could be intuitive and useful. Tang et al. (2009) developed a stereo-camera gestural interface and showed evidence that it was as effective as or more effective than traditional interfaces. In conclusion, evidence supports the use of specialized hardware controllers to achieve improved learning outcomes.

Literature Review

The studies used in the literature review were located via a selective search of the literature as discussed in Maxwell (2006). Highly relevant studies were included to support a fundamental basis for the study. Searches were conducted via the Arizona State University Library's search portal. Google Scholar was the primary search tool used, but searches were also conducted using Education Research Complete, ERIC, PsychInfo, and

Web of Science. Search terms included *cognitive load*, *multimedia instruction*, *computer-based teaching of rhythm*, *game controllers*, *hardware interfaces*, as well as searches for works by specific authors cited in other literature.

Multimedia learning is taking a variety of new shapes, some figuratively but many literally. The explosion of smartphone ownership brings with it the ubiquitous use of touchscreens. Devices such as Activision's *guitar-style* controller, Nintendo's *Wiimote* and *Wii U Gamepad* controller, and Microsoft's *Kinect* motion-detecting controller added new ways to interact with computers and the potential for new learning opportunities. With this in mind, this literature review will examine existing research related to multimedia learning theory as well as its historical foundations. It will next explore literature related to the use of novel hardware interfaces in learning. Both bodies of knowledge will lead to proposed research questions.

Channel Capacity

In a 1955 presentation to the Eastern Psychological Association (later published in 1956), George Miller first introduced the concept of a limited capacity of memory for immediate use (later known as *working memory*). Miller described a series of experiments that supported his claim that humans could typically work with seven pieces of information (plus or minus two) at any given time. He used the phrase *channel capacity* to describe the general concept of a limit of cognitive working capacity.

Miller described several experiments in which participants judged various unidimensional traits of stimuli. Pollack (1952) and Garner (1953) undertook studies focusing on audio that found that participants were limited to recalling 4 to 5 sounds reliably. Miller also described an experiment using taste (Beebe-Center, Rogers, &

O'Connell, 1955). Participants could judge varying saline concentrations reliably with an average of about four concentrations.

Capacity for identification of visual information seemed larger, Miller noted. Hake and Garner (1951) asked participants to interpolate the positions of markers on a scale. In one group, they allowed users to use a number between zero and 100 to identify the position of the marker, though they only presented these markers at 5, 10, 20, or 50 positions for each sub-group. The other group was only allowed to choose from values that were actually presented. The results for both groups were significantly similar. Eriksen and Hake (1955) found that participants could discern about five discreet sizes of squares. In another experiment Eriksen (1955) found similar results for judging hue and brightness. When viewed from an instructional design viewpoint, Miller's analysis indicated that there is limited room for error when choosing what information to include and exclude in multimedia instructional design.

Cognitive Load Theory

Cognitive load theory suggests that learning is most successful when cognitive resources are expended primarily on learning, rather than when expended significantly to integrate information into working memory in a cohesive fashion (Chandler & Sweller, 1991; Pass, 1992; Sweller, 1988). Chandler and Sweller (1991) summarized and provided evidence for the theory in a seminal article where they ran a series of experiments to compare traditional instructional materials, such as a diagram with a separate textual description, to instruction that integrated all information.

In Experiment 1, Chandler and Sweller (1991) employed a two-group experimental posttest-only design that compared presentation of almost identical information in conventional split-source format, which required mental integration of images and text placed below them to understand the information presented, with presentation in an integrated format with appropriate text located adjacent to the area of the image referred to by the text. Based on data generated from a written test and two practical application tests administered post-instruction, participants using the integrated format statistically significantly outperformed those using the split-format. This supports the idea that integrated-format instruction frees additional cognitive resources for more effective learning. Multimedia instruction providing visual and auditory information simultaneously instead of serially could be predicted to be effective given these findings, as explored in the Cognitive Theory of Multimedia Learning (CTML) discussed below.

Experiment 2 was also of a two-group experimental posttest-only design (Chandler & Sweller, 1991). In this experiment, conventional and integrated formats were compared; however, mental integration was not required as the text and diagrams could be understood independently of each other and both contained the same information. Three post-tests were given: a written test immediately after instruction, a practical test one week after instruction, and a re-administration of the written test 12 weeks after instruction. This experiment resulted in no statistically significant difference between the groups. These findings imply that integration does not afford a cognitive advantage when the information presented is redundant across text and images. One may infer that presenting redundant information in two visual forms may not be the most effective use of multimedia instruction.

Experiment 3 was of a two-group experimental posttest-only design (Chandler & Sweller, 1991). Two groups were given identical instructional materials with text and diagrams that could be understood independently of each other but contained redundant information. One group was asked only to study the text. A second group was asked to study the instructions, but also to ensure that the text was read and that they related it to the diagram. A post-test was given when the subjects individually decided they were done studying the materials. The first group spent less time reading the material, yet performed somewhat better when tested; statistical significance was reached for the first of three problems. The authors hypothesized that the first group avoided unnecessary mental integrations whereas the second group allocated unnecessary cognitive capacity to forming such integrations. This implies that effective multimedia instruction avoids redundancy.

Experiment 4 was a three-group experimental posttest-only design study (Chandler & Sweller, 1991). The first group only received a self-explanatory diagram with instruction about the human circulatory system. The second received conventional split-source material with the diagram and text that contained redundant information. The authors provided the third group with integrated diagram and text materials which also featured redundant information. The diagram-only group processed the information faster and performed better on test problems, indicating that redundancy may be associated with unnecessary cognitive load. This experiment again suggests that multimedia-delivered instruction may benefit from the elimination of redundancy, as work by Mayer and others will demonstrate below.

The fifth experiment was a three-group quasi-experimental posttest-only design (Chandler & Sweller, 1991). Participants were given instructional materials in diagram-only, split-source, and integrated forms. As with experiment four, the diagram-only group spent less time processing the material and performed statistically significantly better when tested. These findings reinforce the findings of the previous experiment in a very different participant group, further suggesting the need to construct multimedia instruction with as little redundancy as possible.

Finally, the sixth experiment was a two-group experimental posttest-only design (Chandler & Sweller, 1991). One group was provided a non-self-explanatory diagram with accompanying text in split-source format with instruction about the human circulatory system. The second group was given the same information in integrated format. The integrated group spent less time studying the materials and performed statistically significantly better on test problems. This result reinforces the finding that integrated-format instruction may be superior to conventional split-format instruction. This concept will prove to be critical in works later reviewed in this paper.

Pass (1992) showed a correlation between reduced cognitive load and superior knowledge transfer. He performed a three-group experimental posttest-only study with basic statistics being the material to be learned. Participants were assigned to three groups: conventional instruction, worked-examples instruction, and completion-oriented instruction. The conventional instruction group was presented with general information pertaining to solving a number of study problems and asked to solve all of these study problems. Participants in the worked-examples group were given worked examples of problems and told to study them as they would be similar to subsequent conventional problems. Finally, participants in the completion-oriented group would attempt to work on the problems and were then presented with a worked out version of the problem after three failures or five minutes had elapsed. All participants were then given a 24-problem test via computer. The software assigned values for perceived mental effort, problem solutions, and problem-solving times. The conventional instructional approach yielded statistically significantly poorer outcomes in terms of test scores and transfer performance.

Owens and Sweller (2008) conducted studies that addressed musical instruction in the context of cognitive load. One of the experiments addressed the inclusion of auditory music. A four-group posttest-only design was used. All conditions included written explanatory text and auditory musical excerpts. Musical notation was present in two of the four conditions. In two of the four conditions, all materials were temporally integrated. A temporal split-attention design was used in the other two. In summary, the goals of the experiment were to test the effect of either including or omitting written musical notation and to examine the effects of presenting the materials in a time-integrated or split format. Separate sessions of simultaneous (integrated) with notation, successive (split) with notation, simultaneous (integrated) without notation and successive (split) without notation were each administered to respective groups. Each session consisted of 15 instructional examples followed by 35 test problems. No significant effects were noted when comparing the absence or presence of musical notation but results for simultaneous (integrated) instruction were statistically significantly higher than for successive (split) instruction.

These experiments demonstrated that integrated-format instruction may be superior to a conventional split-course format when both text and images are needed to understand a concept; however, when diagrams and texts do not require mental integration this advantage is negated. Finally, an important finding of these studies is that elimination of redundancy in instructional materials tends to lead to higher performance on tests. These findings also provide a foundation for later work regarding Split-attention effect and the CTML.

Split-attention effect occurs when multiple types of information are presented in the same modality in instruction materials, causing the learner to expend extraneous cognitive load by sharing attention between information types (Sweller & Chandler, 1991; Tarmizi & Sweller, 1988; Ward & Sweller 1990). In a subsequent paper to the one detailed above, Sweller and Chandler (1991) further distilled the above results by clarifying the Split-attention effect. They cited the inability of other theories to explain why some worked examples were effective and others were not, yet Split-attention effect did yield a good basis for making comparisons. Further, they described an analogous situation in which forms of instruction can be analyzed for success by this effect when other theories were unable to do so. By providing a basis for the assessment of extraneous cognitive load, Split-attention effect showed that worked example problems could be more effective than means-end strategies.

Kalyuga, Chandler, and Sweller (1999) applied a similar research approach to multimedia design by utilizing both visual and auditory presentation. They described two experiments with a two-group experimental posttest-only design. In their first experiment information was presented with a visual diagram, but text in auditory form. It was also presented with the diagram and text in visual form as well as text in auditory form. The diagram-as-visual and text-as-audio format proved to be superior to visual-only presentation. The authors believed this was because using two sensory channels increased working memory capacity; however, when the presentation was made with diagram and text in visual form and text in audio form performance was lessened. The authors stated that the visual text was redundant and caused a cognitive overload that interferes with learning. The results imply that effective instruction cannot include information that is redundant across channels. Each channel should contain distinct but related content to avoid cognitive overload.

Dual-Coding Theory (DCT) proposes that information is processed via distinct visual and verbal/aural pathways (Clark & Pavio, 1991; Mayer, 1994; Paivio, 1991). DCT assumes that there are two distinct systems involved with learning. Information from each pathway is used to create knowledge that can be acted upon or stored in memory. The first is that which deals with symbols, which is virtually always visual in nature and typically deals with linguistics. It may come in the form of multiple modalities, such as the distinction between printed text and visual objects. The other system deals with sensorimotor input. This is often studied in the form of auditory input, but may include other non-visual/symbolic forms such as haptic feedback. Paivio (1991) noted that each channel has limitations. Visual and auditory information that are not aligned in content can make understanding material difficult by causing working memory to be overloaded. Additionally, multiple visual or auditory cues can overload a viewer's capacity to process information in a single channel. This model supports the use of multimedia as a learning tool because visual information is displayed on-screen in the form of symbols while audio representing complimentary information is heard.

Cognitive Theory of Multimedia Learning

The CTML draws on dual coding theory, cognitive load theory, and constructivist learning theory. CTML states that learners employ both a visual information processing system and a verbal information processing system (Craig, Gholson & Driscoll, 2002; Mayer & Moreno, 1998; Moreno & Mayer, 1999). Animations are processed by the visual system and auditory narration is processed by the verbal system. The cognitive processes take place when learning. *Selecting* creates an image base from visual information and a text base from verbal information. *Organizing* creates an image-based system of the new concept from the image base and verbally-based system from the text base. Finally, *integrating* takes place as the learner identifies connections between the image-based system and the text-based system.

This theory leads to many best practice principles for multimedia learning design (Mayer & Moreno, 2002). The multiple representation principle suggests that explanations are best presented with a combination of words and pictures as opposed to solely words. The contiguity principle states that presentation of corresponding words and images simultaneously yields better outcomes than presented separately. The modality principle proposes that text should be presented in an auditory fashion rather than as on-screen text. The redundancy principle dictates that a combination of animation and narration is superior to a more complicated presentation of animation, narration, and on-screen text. Finally, the coherence principle states that multimedia learning is most effective when the quantity of extraneous words and sounds is kept to a minimum.

The Coherence effect occurs when extraneous words or sounds overload working memory, thus decreasing learning outcomes (Brünken, Plass & Leutner, 2004; Craig, Gholson & Driscoll, 2002; Moreno & Mayer, 2002). Moreno and Mayer (2002) conducted two four-group experimental posttest-only design experiments to examine the Coherence effect. In both, participants viewed a multimedia presentation in four formats:

multimedia with narration, multimedia with narration and music, multimedia with narration and environmental sounds, and multimedia with narration, music, and sounds. Retention and problem-solving transfer were tested. Retention, transfer, and matching test scores showed that participants who viewed either of the versions that included music had statistically significantly poorer learning outcomes than those of the other groups. The second experiment resulted in the narration-only group having performed statistically significantly better on retention and matching tests. There were no significant differences on matching tests, but the authors felt that the instrument itself was possibly not sensitive enough and may have caused a ceiling effect.

Coherence effect is likely to occur in video games as these games tend to be saturated with extraneous visual and auditory information. Coherence effect predicts that removing all sound from the user experience would reduce cognitive overload and make for a more effective learning experience; however, the loss of information in the auditory channel could also reduce learning as suggested by the modality principle.

Modality in Rhythmic Learning

Varying modalities have been shown to affect outcomes for learners of musical rhythms (Persellin, 1992; Sadakata, Hoppe, Brandmeyer, Timmers, & Desain, 2008; Shehan, 1992). Shehan (1992) studied rhythmic learning under four sets of conditions. The first condition was an audio-rhythm mode featuring a pattern played on a woodblock. The second was an audio and audio-mnemonic mode in which various spoken syllables stood for associated note durations. The third mode, (audio) visual-mnemonic, consisted of standard Italian musical notation while the pattern was played on a woodblock. The fourth mode, (audio) visual-mnemonic, combined the notation and vocalization of patterns in the mnemonic format. Rhythms were presented to participants in each of these formats. Participants were then asked to reproduce the rhythms from memory. The number of attempts to play the pattern correctly was recorded as the criterion variable. The results showed that a combination of visual and aural cues produced the best learning outcomes.

Persellin (1992) examined the effects of modalities on rhythmic recall. In her study, rhythms were presented visually by playing the rhythm on a resonator bell, by patting the participant's hand, or by a combination of these methods. The participants were then asked to clap the rhythms presented to them. The results indicated that the combination of aural and kinesthetic presentation techniques is often superior to the use of a single modality or to a combination of visual, aural, and kinesthetic techniques.

The use of visual feedback for learning rhythms has been correlated with positive learning outcomes. Sadakata et al. (2008) developed a visual representation system for real-time feedback to teach short rhythmic phrases. The experiment was conducted with two groups of matched-pair participants and both pretests and posttests were performed. The system gave feedback on both rhythmic accuracy and loudness and was intended to increase the level of expressiveness by musicians with several years of training. Only loudness skills showed statistically significant improvement, however both rhythmic accuracy and loudness skills successfully transferred to performance of similar rhythms. These findings indicate empirically that the visual channel could have a function in learning to reproduce rhythms accurately, and anecdotal examples such as an orchestral conductor's baton or the flashing lights on metronomes abound.

Though often presented in traditional teaching settings, findings in these studies are consistent with multimedia learning theory. They therefore support the idea that the use of multimedia in the teaching of rhythm should be effective if best practices are used.

Novel Hardware Interfaces

Novel hardware computing interfaces have been shown to produce favorable learning outcomes (Lindley, Le Couteur, & Bianchi-Berthouze, 2008; Terrenghi, Kranz, & Holleis, 2006; Zuckerman, Arida, & Resnick, 2005). Zuckerman et al. (2005) developed a system of digital building blocks. These were inspired by the work of Maria Montessori. Montessori developed a set of learning toys called *Montessori Materials* as part of her overall vision of an ideal classroom. The authors considered their blocks to be in a category of learning toys they termed *Montessori-inspired Manipulatives*. The blocks were designed to model abstract concepts including mathematics of change, dynamic behavior, and probabilistic behavior, among others. They cited three advantages to the use of tangible user interfaces (TUIs) in the learning of abstract concepts: sensory engagement, accessibility, and group learning. *SystemBlocks* were created to explore concepts related to rates, accumulation, simultaneous processes, positive feedback, and negative feedback. *FlowBlocks* were designed to explore concepts related to counting, probability, looping, and branching. The moving lights and sounds in the blocks created high levels of engagement and their tangibility encouraged discussion. The children involved in testing the designs could model and show understanding of at least some of the complex concepts for which the blocks were designed.

Terrenghi, Kranz, and Holleis (2006) developed a *Learning Cube* as a TUI. It was designed to augments learning assessments that are either text or image-based. The cube was built with embedded acceleration sensors (to determine orientation), an LCD display on each face of the cube, and a speaker. These are controlled by microcontroller-driven hardware embedded within the cube. In use, the cube displays a question, four incorrect answers, and one correct answer on each of its faces. These can be in the form of text or images. The user is to select the correct answer, turn its face upward, and then shake it. If the answer is correct the next question is displayed. If the answer is incorrect, the user is given another opportunity to answer. Topics such as vocabulary and mathematics were tested among children. The authors noted high levels of engagement and social interaction among users. The authors assert that unusual physical formats (as opposed to a computer screen, mouse, and keyboard) create high levels of engagement and standalone devices such as the Learning Cube offer the benefits of multiple-user social interactions.

Lindley, Le Couteur, and Bianchi-Berthouze (2008) measured engagement and social interaction when comparing the use of *Donkey Konga* bongos to a standard controller. They hypothesized that controllers which allow natural body movement increase social interaction and engagement. Ten pairs of university-aged females played *Donkey Konga* in a co-operative two player mode. These sessions were videotaped and coded for speech, other utterances, instrumental gestures, and empathetic gestures. Participants also completed an engagement questionnaire after the sessions. Engagement and social interaction both increased with the use of a more realistic game controller.

These studies indicate that video games may be useful in a learning context, especially with respect to levels of engagement. Participants seem to readily adapt to game controllers they are unfamiliar with, or at least are not strongly deterred by them.

Touchscreens

Touchscreens are potentially easier for young children to operate, allowing them to complete simple tasks (i.e., moving a cursor) without having to achieve the level of mastery required by other input devices (Batternberg & Mebler, 1989). Touchscreens present both promise and challenges to designers.

Robinson and Burk (2013) explored in what manners and for what purposes 689 U.S. medical students used tablets. They found that positive attitudes toward tablets among these students are common, with 49% of students in the clinical portions of their programs using tablets for accessing clinical care information such as electronic medical records (e.g., radiographs and comprehensive patient history) and reference. Over 20% of students reported using these devices several times daily. These findings support attitudes favoring the use of tablets for more substantive uses than social media and gaming.

Romeo et al. (2003) examined issues and attitudes related to Australian children's use of touchscreens in a classroom environment. One setting was an independent early learning center which generated groups of about fifteen participants. One group consisted of three-year-olds and the other two groups were of age two. The other two groups were from a public primary school. One group consisted of 24 five-year-olds and the other of 26 six-year-olds. Software consisted of age-appropriate educational offerings. Data were collected qualitatively via direct observation, teacher and researcher journals, and loosely structured interviews. Findings were grouped into three main categories. Developmental issues observed included that children's proficiency and comfort with touchscreens increased over time, size and general usability of icons were key to positive learning outcomes, and individual levels of motor-skills and position of the fixed desktop monitors were major factors in touchscreen competency. Input device preference was largely based on the type of software in use but children generally preferred the mouse. Finally, social interaction among these relatively young children consisted of common but frequently unconstructive collaboration. Negative collaboration was amplified by the concurrent availability of multiple input devices. The findings of this study suggest that moveable touchscreens such as those found on tablets may enhance the user experience by allowing participants to position the tablet as they prefer. Icons should be large and responsive. Finally, touchscreens are best used by individuals and made to be the only available input device.

The literature suggests that working memory is limited in capacity (Miller, 1955). Cognitive load theory supports a need to make learning efficient so that cognitive resources are expended on learning instead of used to integrate information into working memory cohesively (Chandler & Sweller, 1991). DCT provides that information is processed in separate visual and verbal/aural pathways (Paivio, 1991). Split-attention effect occurs when information intended for the visual and aural channels is not presented in an integrated fashion and therefore is difficult to encode into memory efficiently (Sweller & Chandler, 1991). CTML (Mayer & Moreno, 1998) applies the concept of multiple information pathways to multimedia, at its highest level stating that multimedia learning is most efficient when words and pictures are presented, as opposed to solely words. Coherence effect (Moreno & Mayer, 2002) occurs when extraneous sounds and words overload working memory, thus decreasing learning. Music education literature is in agreement with the need for instruction in multiple modalities (Shehan, 1992, Persellin, 1992).

With respect to hardware interfaces, purpose-built handheld user interfaces have been shown to be effective (Lindley, Le Couteur, & Bianchi-Berthouze, 2008; Terrenghi, Kranz, & Holleis, 2006; Zuckerman, Arida, & Resnick, 2005). The latter study further examined engagement and social interaction when comparing *Donkey Konga* and standard game controllers, finding that both increase with the use of a more realistic game controller.

The Present Study

This study was designed to address important gaps in existing educational technology literature. First, multimedia learning theory studies generally address the learning and application of procedural and conceptual knowledge, such as how lighting is formed (Mayer & Moreno, 2002), as opposed to psychomotor learning, which is the focus of the present study. Second, such studies typically provide learners with control over the pace of instruction (Mayer, 1991, 1994, 1996, 1998; Mayer & Moreno 1998). In contrast, this study examined situations in which a few discrete events occur in rapid succession and learning takes place via iteration, resulting in schemata requiring automaticity. Third, little educational technology literature addresses learning with novel hardware interfaces such as the one used in *Guitar Hero III.* Touchscreens are becoming extremely common among users in the United States. Every major smartphone manufacturer produces smartphones with touchscreens (Henze, 2011). According to a Pew Internet survey (Smith, 2012) usage of smartphones among adults in the U.S. grew from 35% in May 2011 to 46% in February 2012. Touchscreen-based, gesture-driven tablets are becoming ubiquitous. The Apple iPad alone sold 17 million units in the first quarter of 2012. These sales came as the iPad’s market share dropped from 72% to 50%

with Amazon's low-priced Kindle Fire accounting for most of the difference (Netburn, 2012). Even traditional desktop computing is embracing touchscreen-based gesture control. Microsoft touted the new Metro Windows user interface as having a novel touch interface, departing from a decades-long paradigm of keyboard and mouse control (Microsoft, 2012).

This study was intended to complement and add to the existing body of knowledge by examining the effect of the absence or presence (dual-modal) of audio combined and differing types of game controllers to the learning of rhythmic accuracy. For the purposes of this study, *rhythmic accuracy* is defined as the degree of ability to play a note at the same time a note is produced by the testing software. This definition includes notes that were missed entirely and notes added extraneously.

The popular game *Guitar Hero III* was selected for use as the rhythmic accuracy training environment for this study. Participants were sought who were experienced, but not masters of the game, to attempt to control for the expertise reversal effect (Kaluga, Ayres, Chandler, & Sweller, 2003).

All four conditions in this study provided training in this environment. This game was selected because it embodies many of Gee's (2003) traits that suggest its value as learning tool. It is highly interactive, allows players to take risks without real-world consequences, is highly customizable to a player's skill level, provides feedback in a "just-in-time" fashion, is challenging, and most importantly to this study, builds competence through performance. *Guitar Hero III* players typically use a guitar-shaped controller to simulate playing guitar in a variety of popular songs. The game provides two sets of cues for the player in a dual-modal format: audio cues in the form of popular music and visual cues in the form of colored bars on a representation of a guitar fret board (see Figure 1).

In this study, one factor was the presence of sound, with levels of *present* or *absent*. Participants in the audio conditions were provided a dual mode format, whereas their peers in the no audio condition were just provided visual feedback.

The second factor in this study was the type of interface used to play the game. Participants were provided either the standard *Guitar Hero III* interface or a tablet in which to interact with the game. The standard *Guitar Hero III* interface (see Figure 2) is designed to resemble a guitar, though only about two-thirds the size of an actual guitar (about 29 in. or 74 cm at its maximum length) and much lighter (about 28 oz. or 800g; see Figure 2). Instead of strings, players pressed one or more colored buttons (1 in. or 2.54 cm wide, ¾ in. or 1.91 cm long, 1/8 in. or 0.38 cm tall at the top of its arched shape) located near the top of the fret board in conjunction with a strum bar (2 ¾ in. or 5.72 long) *flicked* by players toward the bottom of the controller. A *whammy bar* is present but was not used in this study. The interface also houses controls for navigating the game's menus but these controls were not used in this study. The *Guitar Hero III* guitar is equipped with a strap that allows players to operate the device with a body stance such as one would use when playing a real guitar. The *Explorer* model was used in this study. It was connected to a PC via USB.

Participants in the table conditions were provided an Android 7-in. touchscreen tablet. The GUI chosen for this study consisted of five colored rectangles (each 1 in. or 2.54 cm wide by 3 in. or 7.62 cm tall) which corresponded to the colored buttons on the *Guitar Hero III* guitar (see Figure 3). It had an additional white rectangle equivalent to the *strumming bar*. When tapped, the rectangles flashed brightly and haptic feedback was generated. The hardware consisted of an Acer Iconia Tab A100 Android tablet connected to the PC via WiFi. The *Guitar Hero Server* app software translated data from the tablet into a format usable by the game. *Guitar Hero III* supports standard computer keyboards allowing for conversion of the tablet's data into a keystroke format.

Two types of analyses were conducted. Primary analyses addressing the research questions with the dependent variables were conducted. Secondary analyses were also performed on survey data on an exploratory basis, searching for clues that might suggest further research.

Ten rhythmic patterns were created to provide varying levels of difficulty to participants, each more difficult than the last. Each pattern was a one measure rhythmic phrase repeated sixteen times. Patterns became more difficult as the number of notes in each pattern increased as well as an increase in syncopation (notes played varying from the main beat or pulse). The first pattern was simply quarter notes played on the beat. This progressed to the last pattern containing many notes and a high level of syncopation. Participants attempted to play along with these beats by tapping the input pad. Each tap generated a timestamp, creating a set of timestamps for each pattern. Tempo remained consistent across all patterns at 120 beats per minute. Tempo was not increased for two reasons. This study intended to measure learning of rhythmic accuracy in a cognitive sense, not virtuosity in motor control which would have been required at higher tempos. Also, increasing tempos for each pattern would have greatly accelerated the increase in difficulty from one pattern to the next. Testing revealed that floor and ceiling effect avoidance had most likely been achieved without varying tempo so it was decided to avoid an additional confounding factor.

Analysis of each of the 10 rhythmic patterns individually increased the risk of Type I statistical error. To reduce this risk multiple patterns were considered in groups. The patterns became progressively more difficult from the first to the tenth. The first three patterns as a group are referred to as *easy*, the fourth through seventh patterns group as *medium*, and the final three patterns group as *hard*.

Three music-relevant dependent variables were used in this study. Time error is the difference between when a note should have been played and was played by participants. Extra notes were notes played in addition to notes participants were prompted to play. Missing notes are notes that should have been played but weren't. These variables were selected to reflect the importance of accuracy of timing and identification of when a note should or should not be played. These variables were selected for use in this study because they are crucial to performing music cohesively. Music is largely a temporal experience; therefore, notes must be performed at the correct time to reflect the intentions of the composer. Similarly, extraneous or missing notes will also alter the expression of the composition.

In summary, this study sought to address the following research questions:

1. Does the game's audio content affect learning of rhythmic accuracy?
2. Does the type of game controller affect learning of rhythmic accuracy?
3. Is there an interaction between the presence of audio content and the type of controller on learning of rhythmic accuracy?

To address these questions, a 2x2 between-subjects design was conducted and the dependent measures analyzed. A series of ANOVAs were used to examine each of the research questions. For each dependent measure, the main effect for presence of audio, main effect for type of controller, and the interaction of these factors were analyzed. The three statistical analyses afforded in a 2x2 factorial design—the two main effects and the 2x2 interaction—were conducted to answer the study's three research questions on each dependent measure.

Method

Participants and Design

One hundred participants (N = 100) were recruited from a large university in the southwestern United States and the neighboring vicinity. These participants were recruited from education classes by participating instructors, flyers posted on campus and in the community (especially at community colleges), posts to mail lists and forums, a departmental subject pool, and word of mouth. The participants were primarily enrolled at the university, a near-by community college, or were college-bound graduating high-school seniors. Ages ranged from 18 to 45 with a mean average age of 21.1. Fifty-one females and forty-nine males participated. Participants were paid $10 for their participation.

The experiment was a 2x2 between-factors design, with the first factor being the presence or absence of audio during game play, and the second factor being the type of game controller used: the standard *guitar-style* controller or a tablet controller. Each group (i.e., *Audio*/*Guitar-style* controller, *Audio*/*Tablet* controller, *No Audio*/*Guitar-style* controller, *No Audio*/*Tablet* controller) had 25 participants. Twenty-five participants per cell assumed a medium to large effect size and power of about 0.80. Recruitment materials advised readers that the study sought participants who had played any of the *Guitar Hero* series but were not *masters of the game* to attempt to control for the expertise reversal effect (Kaluga, Ayres, Chandler, & Sweller, 2003). The *Guitar Hero* franchise is noted for its extremely high level of popularity and devoted enthusiasts. As a result, expert players abound. Expertise reversal effect suggests that when such experts receive information that is redundant to extant schema-based knowledge, increased cognitive load can occur. This can result in lessened performance than without new guidance, producing inaccurate measurement of learning outcomes.

Treatment

All of the conditions were presented with *Guitar Hero III* on Windows PCs. They all participated in the *Basic Lessons* tutorial. They then completed four songs in *Practice* mode. This mode was chosen for two reasons. First, it reduced (but did not eliminate) extraneous noises by removing many of the extraneous sounds found in the main game such as those produced by the crowd. Also, the game displays useful data after a practice song is completed. This includes percentage of notes played correctly, actual number of notes played correctly, attempted notes, and *streak*, a measure of the greatest number of notes played correctly concurrently.

The *Audio*/*Guitar-style* controller group played *Guitar Hero III* in its stock configuration. Participants heard audio through headphones and used the *guitar-style* controller supplied by the manufacturer with the game that connected to the PC via USB. The game ran on PC desktops equipped with typical monitors to display visual elements of the game. Participants' game scores were recorded as in the Procedure section that follows.

The *Audio*/*Tablet* group heard audio through headphones. Instead of the *guitar-style* controller supplied by the manufacturer with the game, they controlled the game via a 7-in. touchscreen on an Acer A100 Android tablet with rectangles colored to correspond with the *guitar-style* controller buttons (see Figure 3). Haptic feedback was generated when any of the color bars were tapped. The tablets sent input to the PC via a peer-to-peer IP network connection. Peer-to-peer was selected to reduce latency and other issues endemic to router-based networks.

The *No Audio*/*Guitar-style* controller group played *Guitar Hero III* with the *guitar-style* controller but did not hear audio. They wore headphones with no audio to replicate the physical distraction caused by wearing headphones and to help muffle extraneous noises. Similarly, the *No Audio*/*Tablet* group played *Guitar Hero III* a tablet controller did not hear audio but also wore headphones with no audio.

Assessments

Rhythmic Accuracy Assessment System. The pre/post-test assessment software was designed and constructed in conjunction with a percussionist who has earned a Doctor of Musical Arts. The hardware included an Alesis electronic drum pad with a piezo transducer connected to a Line 6 Tone Port DI Gold and a Dell PC laptop running Windows. When struck, the pad produced electrical current that produced a click when connected to the audio interface. The software sensed any such click louder than an adjustable lower-end threshold then wrote a time in milliseconds to a file. It was written in Pure Data. The user viewed instructions and a large circle that flashed when a note was played on a separate LCD monitor. Instructions were added in a narrated audio format after feedback from pilot users.

The program played a pre-determined sequence of rhythmic patterns for the user to tap along with on the drum pad while recording the user's performance in a list of event times. The reference patterns were in MIDI format in separate files and called by the software from a *qlist* file. The *qlist* file also included events such as playing audio files (with textual instructions), pauses, and sensing taps that were part of the user interface navigation.

The user experience with the instrument began with text asking the user to tap the drum pad to begin training on use of the drum pad. Instructions were given as text and narration that summarized the test and gave examples of patterns and the *count-offs* that preceded each pattern to prepare the user to play along. The user proceeded from screen to screen by tapping the drum pad (see Figure 4). If the user had difficulty in consistently tapping with enough force to control the software, a VU meter was toggled by the researcher to help the user self-assess the amount of pressure with which they tapped (see Figure 5). After the introductory portion, the user was given 10 patterns to play along with, each pattern more difficult than the last. A large circle blinked on-screen with each tap (see Figure 6). Each pattern was preceded by a demonstration of the pattern during which the user was asked to memorize the pattern. The user was then prompted to tap along with the pattern, which was repeated 16 times. The program wrote user event time data to a separate file for each pattern. After the last pattern, the user was thanked for their participation by the software.

The test was given before and after the *Guitar Hero III* treatment. User time data from the respective tests was compared with time data from the preset patterns, and pre- and post-test scores were used to create difference scores as well as to compute missed and extra notes.

The apparatus was pilot tested by 10 people, ranging from a female sixth-grade student to a male Doctoral-level percussionist. Feedback from users resulted in the addition of audio narration of instructions as well as adjustment to wording of the instructions. Pilot testers took an average of approximately five minutes to complete the test. Users with little musical experience completed several of the simpler patterns, whereas even the Doctorate-level percussionist had a mild degree of difficulty with the more complex patterns, which indicated it was likely that ceiling and floor effects were adequately controlled.

Rhythmic accuracy assessment system was designed to produce three dependent measures: average errors for each pattern, a count of extra notes, and a count of missed notes. These were selected because accuracy of timing, avoidance of unintended notes, and performance of all notes (avoiding missed notes) are essential to conveying the expression of music. Misplaced, unwanted, or missing notes create a deviation in the flow of music that creates what is essentially a type of cognitive dissonance for the listener.

User Experience Questionnaire. The Questionnaire for User Interaction Satisfaction (QUIS; Chin, 1988) is a fully validated subjective assessment that measures user satisfaction with a human-computer interaction. It has been continuously updated since 1988. It measures eleven areas of interface factors. These include system experience (to measure their familiarity with the *Guitar Hero* series and similar games), past experiences (general computing experience), overall user reaction, screen layout, terminology and system information, learning, system capabilities, technical manuals, on-line tutorials, multimedia, and teleconferencing. A nine-point scale is used by participants to score levels of satisfaction. The QUIS is designed to be adapted for the needs of specific human-computer interactions and as such was modified for this study, with sections reworded or eliminated as appropriate with the text as shown in Appendix B. The QUIS was delivered to participants via computer.

The QUIS was selected for a variety of reasons. Its impact as a fully-validated instrument added gravitas to the data it gathered. It includes items querying previous usage of a wide variety of computer-oriented technologies. Of special interest to this study were items that were a part of the study, such as touchscreens, or other hardware interfaces that could be considered novel, such as *pen-based computing*, *graphics tablet*, and *trackball*. These items provided an opportunity to compare users' previous use of novel controllers with measured learning outcomes achieved with the *guitar-style* novel controller or the common tablet used in a novel way in this study.

Instructional Satisfaction Survey. This study also included an instructional satisfaction survey (see Appendix F). These included topics including software appearance, relevance of knowledge, and attitudes about the treatment. Items were generated by the researcher and were intended to enhance continuity with similar studies. These were Likert scale items with values ranging 1 = *not true* to 5 = *very true*. These items were aggregated by calculating a mean value of scores to produce the Instructional Satisfaction Survey used in data analysis.

Procedure

A demographic survey was administered prior to the procedure. Each participant was then administered the pretest instrument. This consisted of audio playback of a series of taps on a drum trigger pad for each rhythmic pattern. Those taps were also represented visually by a large flashing circle on screen. The participants first listened to the rhythm then tapped along with it as prompted. The subject's performance was recorded as timestamps in a data file.

The subject then played *Guitar Hero III* according to the experimental group conditions randomly selected for him or her. The participants completed the short in-game tutorial (all with audio) with their assigned controller to assure a baseline level of familiarity with the game. The game was played as a practice treatment. This was done with sound or without sound (always with visuals however), and with one of the game interfaces (guitar or video-gestural) randomly selected. Participants using the *Touch/Gesture-based* controller were told to tap the appropriate colors with one hand (instead of clicking the buttons on the guitar) and tap the white bar to *strum,* causing the tapped color bars to flash and haptic feedback to occur on the tablet. A packet with text and photos describing how to play the game with the assigned controller and steps for recording scores was given to each participant. Participants were encouraged to ask questions about any aspect of their controller or the game. The songs were performed at *Normal* difficulty in *Practice* mode. These include "Slow Ride" by Foghat, "Talk Dirty to Me" by Poison, "Hit Me with Your Best Shot" by Pat Benetar, and "Story of My Life" by Social Distortion. At the end of each song *Guitar Hero III* displayed the percentage of notes played correctly, the number of notes attempted versus the actual number of notes, and the longest *streak* of sequential correctly played notes. Participants recorded these scores on a scoring sheet and a screenshot was taken as a backup measure. Next, they completed a posttest identical to the pretest. Finally, the participants completed the QUIS and instructional satisfaction items. The QUIS included semantic differential items recorded as scores of 0-9 corresponding to the level of agreement for each set of terms and items averaged for participants in each treatment condition. Mean averages were computed for the hardware use-history, learning and user reaction sections. The instructional satisfaction items generated by the researcher and presented at the same time were Likert scale items on a 1-5 scale.

Coding

A second program was written in Node JS that calculated the difference in milliseconds for each note between the source list of event times and the user's actual performance to calculate an average error in milliseconds. If a participant played an extra note or omitted one no comparison was made for the source note. Instead, extra and missed notes were recorded for use as additional dependent variables. For each participant, this resulted in a list of average errors for each pattern, a count of extra notes, and a count of missed notes.

Time error was computed by comparing the timestamps of events recorded during test administrations against times listed for notes to be sounded in the source file for the assessment program. Participant responses that were within +/-250ms of notes in the source file were considered to be an attempt to play that particular note and the difference in times was recorded. The mean average of all attempted notes was computed for each pattern and recorded for each participant in both the pre-test and post-test. If two participant responses were detected within +/-250ms of a source note a value of one was added to a count of extra notes. If no note was detected within +/-250ms of a source note a value of one was added to a count of missed notes. Counts of extra and missed notes were recorded for each pattern and recorded for each participant in both the pre-test and post-test.

Results

A pretest/posttest two (inclusion of audio) by two (type of hardware interface) factorial design was employed. Multiple 2x2 ANOVAs were performed to compare pretest and posttest scores on subcomponents of the rhythmic accuracy assessment including the three groups of patterns, averages of each of the 10 patterns completed by the participant, total extra notes for each assessment pattern, and total missed notes for each assessment pattern. The (a) type of controller used and (b) presence of audio conditions were compared to reveal differences in outcomes and any possible interactions. Simple main effects test would have been used to follow up any significant interactions but none were found. ANOVAs were also used to explore for differences on the instructional satisfaction survey and QUIS across conditions.

Supplemental analyses were also conducted. Select items from the pretest, QUIS, and instructional satisfaction survey were used to create a number of bi-variate factors that were analyzed along with the study's original factors, presence of audio and controller type. Participants' responses to the satisfaction were aggregated into low and high satisfaction groups and analyzed in conjunction with, presence of audio and controller type in a series of 2x2 ANOVAS.

Time Error

As Table 1 shows, a 2x2 ANOVA assessing time error at *Easy* difficulty level (Patterns 1 through 3) with controller (*Guitar-style controller*/*Tablet*) and presence of audio (*Audio/No Audio*) revealed a main effect of presence of audio, $F(1, 96) = 5.21$, $MSE = 305.94$, $p = .03$, $\eta_p^2 = .05$. No interaction between controller and presence of audio was detected. Table 2 contains descriptive information regarding this analysis.

As Table 3 shows, a 2x2 ANOVA assessing time error at *Difficult* difficultly level (Patterns 8 through 10) with controller (*Guitar-style controller/Tablet*) and presence of audio (*Audio*, *No Audio*) revealed a main effect of controller, $F(1, 96) = 6.81$, $MSE = 8.39$, $p = .01$, $\eta_p^2 = .07$. No interaction between controller and presence of audio was detected. No significant effect was found at the *Moderate* difficulty level (Patterns 4 through 7). Table 4 contains descriptive information regarding this analysis.

Extra Notes

As Table 5 shows, a 2x2 ANOVA assessing extra notes at *Difficult* difficulty level with controller (*Guitar-style controller/Tablet*) and presence of audio (*Audio*, *No Audio*) revealed a main effect of controller, $F(1, 96) = 5.56$, $MSE = 394.21$, $p = .02$, $\eta_p^2 = .06$. No interaction between controller and audio state was detected. No significant differences were detected at the *Easy* or *Moderate* difficulty levels. Table 6 contains descriptive information regarding this analysis.

Missing Notes

As Table 7 shows, a 2x2 ANOVA assessing missing notes at *Easy* difficultly level with controller (*Guitar-style controller/Tablet*) and presence of audio (*Audio*, *No Audio*) revealed a main effect of audio state, $F(1, 96) = 4.34$, $MSE = 2.35$, $p = .04$, $\eta_p^2 = .43$. No interaction between controller and presence of audio was detected. Table 8 contains descriptive information regarding this analysis.

As Table 9 shows, a 2x2 ANOVA assessing missing notes at *Moderate* difficultly level with controller (*Guitar-style controller/Tablet*) and presence of audio (*Audio*, *No Audio*) revealed a main effects of controller, $F(1, 96) = 4.74$, $MSE = 6.04$, $p = .03$, $\eta_p^2 = .05$, and presence of audio, $F(1, 96) = 6.27$, $MSE = 37.82$, $p = .01$, $\eta_p^2 = .06$. No interaction between controller and presence of audio was detected. No significant differences were found at the *Difficult* Difficulty level. Table 10 contains descriptive information regarding this analysis.

Instructional Satisfaction Survey

As Table 11 shows, a 2x2 ANOVA showed a main effect of the Instructional Satisfaction Survey on *Moderate* difficulty level missed notes, $F(1, 98) = 7.86$, $MSE = 6.26$, $p = .01$, $\eta_p^2 = .07$. To measure user satisfaction, a set of instructional satisfaction questions were administered during the final survey (see Appendix F). These 1-5 scaled agree/disagree items were averaged and grouped into low (less than three) and high (not less than 3) groups. Participants whose aggregate instructional satisfaction score was low missed a mean of 1.97 notes, whereas those in the high category missed 3.38 notes. No significant difference was found at the *Easy* or *Difficult* levels. Table 12 contains descriptive information regarding this analysis.

As Table 13 shows, a 2x2 ANOVA showed a main effect of controller type on the Instructional Satisfaction Survey. This aggregate is composed of eight semantic differential and agree/not agree statements on a one to nine scale, $F(1, 99) = 33.75$, $MSE = 2.16$, $p < .01$, $\eta_p^2 = .26$. Participants assigned the *guitar-style* controller had a mean aggregate of 6.70, whereas tablets users had a mean of 5.00. Table 14 contains descriptive information regarding this analysis.

As Table 15 shows, a 2x2 ANOVA showed a main effect of presence of audio on the Instructional Satisfaction Survey, $F(1, 99) = 4.51$, $MSE = 2.78$, $p = .04$, $\eta_p^2 = .04$. Participants who heard audio had a mean aggregate of 6.20, whereas those without audio had a mean of 5.50. Table 16 contains descriptive information regarding this analysis.

Questionnaire for User Interaction Satisfaction Results

As Table 17 shows, 2x2 ANOVA showed a main effect of age on *Difficult* level reduction in time improvement, $F(1, 99) = 5.26$, $MSE = 8.46$, $p = .02$, $\eta_p^2 = .05$. Participants over 21 years regressed by a mean of -.93ms, whereas those 21 or under improved by a mean of .63ms. Ages of participants were very strongly skewed toward those of traditional college-age students. In addition, there tended to be clusters of participants at the ages associated with beginning college and ending college. This provided an opportunity to examine the effect of the college experience on performance. Participants' ages were analyzed as groups of over 21 and not over 21.No significant difference was found at the *Easy* or *Moderate* levels. Table 18 contains descriptive information regarding this analysis.

As Table 19 shows, a 2x2 ANOVA showed a main effect of age on *Difficult* level missed notes, $F(1, 99) = 5.59$, $MSE = 101.93$, $p = .02$, $\eta_p^2 = .05$. Participants over 21 years missed a mean of 10.78 notes, whereas those 21 or under missed a mean of 5.20 notes. No significant difference was found at the *Easy* or *Moderate* levels. Table 20 contains descriptive information regarding this analysis.

Supplemental Analyses

A survey consisting of items related to musical experience, organized movement, and preliminary instructional expectations was administered at the start of each session. The QUIS, measuring past computing experience, general demographics, and learning self-evaluation was administered with a survey measuring instructional satisfaction at the end of each session. Those with apparent differences in group means were compared with the study's original main factors. These items were not part of the original research questions and are subject to inflated Type I error rate as many tests were performed.

Preliminary expectations survey items were administered as shown in Appendix G. These items were averaged to form a two-level (low and high) *Preliminary Expectations* factor. The aggregate was divided into a low group (mean average of items less than 3) and a high group (mean not less than 3). These results were analyzed with a 2x2 ANOVA to investigate the effect of expectations of performance. As Table 75 shows, an analysis of variance showed a main effect of preliminary expectations score on *Moderate* level time improvement, $F(1, 98) = 4.80$, $MSE = 16.28$, $p = .03$, $\eta_p^2 = .05$. Participants with low expectations regressed by a mean of .90ms, whereas those with high expectations improved by a mean of .87ms. No significant results were found at the *Easy* or *Difficult* levels. Table 76 contains descriptive information regarding this analysis.

As Table 77 shows, a 2x2 ANOVA showed a main effect of *Guitar Hero III* game play score on *Difficult* level time improvement, $F(1, 98) = 4.54$, $MSE = 64.17$, $p = .04$, $\eta_p^2 = .04$. *Guitar Hero III* game play scores were analyzed to look for overall effect on outcomes. Mean averages of percentages of correct notes played during gameplay consisting of four songs were used. Participants whose mean overall *Guitar Hero III* score was above the mean of all participants (49% correct notes played) improved by a mean of .96ms, whereas those below the aggregate mean regressed by .29ms. No significant difference was found at the *Easy* or *Moderate* levels. Table 78 contains descriptive information regarding this analysis.

As Table 79 shows, a 2x2 ANOVA showed a main effect of *Guitar Hero III* game play score on *Moderate* level extra notes, $F(1, 98) = 6.89$, $MSE = 442.0$, $p = .01$, $\eta_p^2 = .07$. Participants whose mean overall *Guitar Hero III* score was above the mean of all participants (49% correct notes played) missed a mean of 27.38 notes, whereas those below the aggregate mean missed a mean of 31.61 notes. No significant difference was found at the *Difficult* or *Easy* levels. Table 80 contains descriptive information regarding this analysis.

Discussion

This study found statistically significant results with both audio and controller-type factors. Following discussion of these findings with regards to the research questions, the limitations of the study will be addressed. Finally, the discussion will conclude with implications of the study on future research and practical applications.

Research Question 1: Does the game's audio content affect learning of rhythmic accuracy?

Presence or absence of audio produced statistically significant results but these differed according to which factors were compared. Participants who heard audio on the *Easy* and *Moderate* patterns missed fewer events than those with no audio but both groups had improved scores, consistent with DCT (Clark & Pavio, 1991; Mayer, 1994; Paivio, 1991). This would seem to add evidence to support the modality principle researched by Persellin (1992) and others (e.g., Sadakata, Hoppe, Brandmeyer, Timmers, & Desain, 2008; Shehan, 1992), as shown by improved outcomes with both audio and visual information present, utilizing both channels. This adds further weight to DCT and CTML theories and practices suggesting multiple modalities as most effective for instruction.

Nonetheless, participants with no audio had improved timing on the *Easy* patterns whereas participants with audio present regressed. Tablet users without audio also showed improvement in timing on the *Difficult* patterns. These results support the theory of coherence effect (Brünken, Plass & Leutner, 2004; Craig, Gholson & Driscoll, 2002; Moreno & Mayer, 2002). In these instances, it may have been that audio had become extraneous and therefore “incoherent.” Advanced students may benefit from practice with only visual references. We already see this as a common practice with the use of sheet music; however, the “down the neck” point-of-view, just-in-time delivery of timing information in *Guitar Hero III* may eliminate the instructional bottle-neck of the lengthy process of learning to read sheet music. “Playing by ear” is another common approach that uses only one sensory channel. Its prevalence taken with the prevalence of sheet music as serial instructional styles may show that for demanding performances the use of multiple sensory channels for input may be less efficient than use of a single channel.

Players at typical ages (reported on the QUIS) for participants in the midst of their college experience had a reduced time error at the *Difficult* level more than those of age typically approaching or beyond completion of their undergraduate studies. Younger participants may have had more recent and frequent gaming experience and music lessons.

QUIS data were analyzed by creating Novel Interface, User Reaction, and Learning aggregates via mean averages of items in those sections. The 2x2 ANOVAs were run comparing these to audio and controller-type factors but no significant results were observed (see Tables 21-74).

In summary, this study found that the presence of audio produced results that varied by factor. Groups with audio showed superior outcomes in reduction in missed notes at the *Easy* and *Moderate* levels; however, time error was reduced significantly more by the audio-absent group at the *Easy* level and also reduced at the *Difficult* level. These findings help to inform educators of how to best achieve specific desired outcomes, rather than simply increasing rhythmic accuracy learning outcomes as a whole.

Research Question 2: Does the type of game controller affect learning of rhythmic accuracy?

Statistically significant evidence favors the tablet controller over the *guitar-style* controller. Tablet users reduced time error at the *Difficult* level, whereas guitar users regressed. When considering the reduction in extra events at the *Difficult* level both groups regressed but the tablet condition’s regression was statistically significantly less; however, reduction of missed events at the *Moderate* level provided evidence showing the *guitar-style* controller produced better outcomes, though both groups improved. This may imply that more advanced music students may benefit from use of the tablet, whereas beginners may achieve better outcomes from the *guitar-style* controller. It’s possible that the larger format of the *guitar-style* controller may make gameplay easier for beginning and intermediate students, allowing them to concentrate on learning rather than using the controller; however, advanced students with improved motor skills may be able to leverage the smaller format and associated smaller motions required to produce better outcomes.

Both controllers show good potential for aiding in the evolution from STEM to STEAM curricula. As both produced generally positive outcomes, practical issues may outweigh performance advantages in the K-12 classroom. Specifically, tablets have myriad potential uses in most subject areas whereas a guitar controller is much more specific in function; however, the greater user satisfaction revealed by the study may justify the use of the *guitar-style* controller to maintain interest. The lower initial investment and ease of setup (USB for the *guitar-style* controller vs. WiFi for the tablet) are important factors as well.

This study produced results that show statistically significantly strong outcomes for *tablet* users with respect to the three musical factors of time error, avoidance of missed notes, and reduction of extra notes. The tablet's potential for multiple uses in the classroom should be noted as well; however, the statistically strong evidence that learner satisfaction is increased by the *guitar-style* controller should not be dismissed as it may create enthusiasm in learners not present with the tablet.

The skeuomorphicly designed *guitar-style* controller shows much promise based on comparisons with the Instructional Satisfaction Survey. Statistically significant evidence showing a strong connection between instructional satisfaction and the *guitar-style* controller could indicate potentially improved outcomes. This could be due to reduced human-machine workload compared to the tablet. For example, the buttons on the *guitar-style* controller provide strong kinesthetic clues as to where the buttons are located compared to the smooth surface of the tablet, which requires a glance away from the GUI to confirm button position. Such workload detracts from performing any task at peak efficiency, including learning. If the notion that the satisfaction associated with the *guitar-style* controller is correct, results from a study with more sessions might yield better outcomes for *guitar-style* controller users as that satisfaction may sustain continued improvement throughout further practice sessions. This is consistent with work done by Lindley, Le Couteur, and Bianchi-Berthouze (2008) and others (Terrenghi, Kranz, & Holleis, 2006; Zuckerman, Arida, & Resnick, 2005). No evidence was found to indicate an interaction between the presence of audio content and the type of controller.

Research Question 3: Is there an interaction between the presence of audio content and the type of controller when learning of rhythmic accuracy?

No evidence was found to indicate an interaction between the presence of audio content and the type of controller. Though the literature on novel hardware interfaces is still evolving, no findings in previous studies suggested that such an interaction might occur; however, clues to this lack of interaction may exist in the music literature. Persellin’s (1992) study introduced kinesthetic feedback as a sensory mode in addition to aural and visual cues for learners. The study tested all three modes separately, together as a trio of modes, and in pairs. The study achieved results that varied by condition, implying that the kinesthetic factor is a third, discrete mode of sensory input. In the case of this study, the *guitar-style* controller provided no feedback to the user at all. The *tablet* controller provided haptic and visual feedback (if the user looked at it instead of the screen) but no audio feedback. It is possible that the lack of interaction could be explained by the fact that the audio conditions took place in a completely discrete, “walled off,” channel and therefore didn’t interact with sensory input from the controllers. Significant future research would clearly be required to substantiate this possibility.

Players at typical ages (reported on the QUIS) for participants in the midst of their college experience had a reduced time error at the *Difficult* level more than those of age typically approaching or beyond completion of their undergraduate studies. Younger participants may have had more recent and frequent gaming experience and music lessons.

In summary, this study found that the lack of interaction between presence of audio and controller type is not well accounted for in current literature. There are hints that a third channel sensory channel might exist and account for the lack of interaction but much further research would be required to make that assertion.

Supplemental Analyses

A survey was administered consisting of items related to musical experience, organized movement, and preliminary instructional expectations at the start of each session. A second set of surveys measuring past computing experience, general demographics, learning self-evaluation and instructional satisfaction (a second survey) were given at the end of each session. The following discussion stems from these surveys.

Participants with high preliminary expectations (as measured by an aggregate of 10 survey items on a 1-5 scale) reduced time error at the *Moderate* level. This is consistent with concept of *outcome expectancy* (Moreno, 2009), which suggests that students will perform with greater diligence if they expect a positive learning outcome.

Players with *Guitar Hero III* practice scores above the mean of 49% improved in time accuracy at the *Moderate* difficulty level, whereas those scoring below the mean regressed. Higher scoring *Guitar Hero III* players improved statistically significantly more than low scoring players in reduction in extra notes at *Moderate* difficulty. Better players may be intrinsically more skilled in rhythmic skill acquisition, but higher scores may increase or signal higher levels of interest.

Implications

Overall, all music students may be well served by a skeuomorphicly derived controller whereas advanced students may be better served by a tablet-based controller. This study showed that positive learning outcomes and improved instructional satisfaction were widely present when the *guitar-style controller* was used. Skeukomorphic/novel controllers may be preferred by users and lead to greater engagement (Terrenghi, Kranz, and Holleis, 2006); however, tablet-based controllers are easier and less-expensive to develop and have other applications beyond teaching music skills. Statistically significant results showed greater learning outcomes associated with the difficult patterns advanced users would be more likely to practice. Use of audio appears to produce better outcomes and provides users with greater satisfaction with their instruction (Clark & Pavio, 1991; Mayer, 1994; Paivio, 1991).

Pushing the right button at the right time has a myriad of applications outside of music, such as in aviation, military and law enforcement, and even more mundane applications like driver’s education. For example, according to Fender Musical Instruments Corporation, 90% of new guitar players give up on the instrument within one year of purchasing it (Bhasin, 2016), greatly affecting profitability. Training tools like

Guitar Hero III, including skeuomorphicly designed controllers, could lower that number significantly for guitar and other instruments. Such controllers and their adjunct software could be designed in a way to gradually introduce new skills via the *second channel* (i.e., not the visual channel) potentially resulting in better learning outcomes and thus retaining many customers that would have otherwise given up after losing interest in video, online, or traditional lessons. Similarly, potentially life-saving measures could be employed with less response time in situations where time is a critical life-or-death factor.

This study has shown that *Guitar Hero III* can provide an effective learning environment for teaching rhythmic accuracy skills. All but a single statistically significant result of analyses of major factors in this study suggest that *Guitar Hero III* is an effective tool that provides positive learning outcomes with regard to musical rhythmic accuracy. Time error, extraneous notes, and missing notes all showed statistically significant improvement post-treatment.

Groups with either controller reduced the occurrence of missed notes at the Moderate level and by the guitar-style controller group at the *Difficult* level. Only the Difficult level showed regression with extra notes by both the tablet and guitar groups. These results support *Guitar Hero III* as an effective tool for increasing rhythmic accuracy.

The supplemental analyses also revealed additional evidence supporting positive learning outcomes as a result of playing *Guitar Hero III*. All participants showed reduction of extra notes at the Moderate difficulty level when analyzed against their mean *Guitar Hero III* scores. The analysis of missed notes at the Moderate level compared to the Instructional Satisfaction Survey, as well as at the *Difficult* level compared to college experience showed positive outcomes for both group as well.

Time error was improved by at least one group improved at the Moderate difficulty level compared to preliminary expectations, as well as at the *Difficult* level when compared to mean *Guitar Hero III* scores and college experience. None of the statistically significant secondary analyses showed regression in both groups in any test.

Guitar Hero III provides a socially-interactive and fun gaming environment that has proven by its enormous sales to be an activity many people seek out for their own pleasure. It is to the great benefit of educators that it also provides a successful learning environment for acquiring essential rhythmic accuracy skills.

Limitations

Music skills are traditionally practiced on a regular basis over months, years, or lifetimes. A single session of practice is much less likely to reveal changes due to factors such as familiarity with the controllers, repetition of practice materials, and improvement due to repeated test-taking. Limiting the study to one session per participant may have lowered outcomes significantly. Each participant had an initial survey, a pre-test, a practice session, a post-test, and a final survey. The overall workload and loss of focus is likely reflected in the regressions noted from pre- to post-test as well as informal comments by the participants themselves at the end of sessions.

Guitar Hero III was considered to be old, if not obsolete, by many participants. Experienced players may simply have been bored with the game. Lower levels of satisfaction among some participants may have been present due to a perception of irrelevance, based on survey comments reflecting the game’s age. Although general familiarity with the game among most participants probably reduced cognitive workload, a newer game may have afforded higher levels of interest.

The *No Audio* condition wasn't entirely without audio. Participants wore headphones with no audio signal but could still hear background noises such as the clicking sounds of *guitar-style* controllers, noise made by movement of other persons, and general background noise. Budget-permitting, noise cancelling headphones would have greatly enhanced the validity of the *No Audio* concept. A *dummy* audio signal such as white noise might have been suitable and but may also have had unexpected effects of its own.

This study is also subject to the cliché of being labeled "The Science of College Students" as the participants were ASU students, community-college students, or college-bound high-school graduates. The participants were also highly homogenous in age. Beyond the physiological ramifications of age, there still exists a significant technological experience gap between participants of this age and older potential participants. Younger participants have most likely grown up with the Internet and historically massive computing power at their disposal ubiquitously, whereas those at or beyond middle age may or may not have had access to a home computer of any kind during their youth, potentially making the game more difficult and frustrating. This situation would create an innate advantage for the younger group in playing, as opposed to a state of distraction that could be caused by unfamiliar technology. With this in mind, the results of this study may not generalize to an older population.

The tablets used were older and relatively bulky for their size. The age of the tablets could have conceivably affected networking latency as well, though this issue did not appear in any obvious way.

Future Research

Guitar Hero III and similar games provide practice beyond rhythmic skills. They also provide practice in selecting the correct physical response to on-screen and audio events. Assessment could be modified to include a choice of pads to tap for each event in the same way that a *Guitar Hero III* player must activate the correct switches at the correct time. The assessment could be validated in the current video-plus-audio with the addition of audio-only forms. Addition of an eye tracker would add great insight into the hardware user experience (HUX) of controllers. Hardware that requires users to look away from the screen is innately less usable than hardware that allows the user to maintain eye contact with the display. Supplemental analyses revealed that controller type plays a significant role in user satisfaction. Controllers that require the user to look away from the screen to find switches and other items cause distractions that impair performance. Additionally, haptic feedback prompting the user to play a note could be incorporated into one level of a controller factor in future studies.

Musical learning is traditionally observed as a result of many learning and practice sessions. Multiple sessions were not feasible in this study due to time, budget, and participant constraints. If resources were available, a more robust protocol would be to measure initial aptitude, repeat practice sessions on different days regularly for several sessions with no more than a few days between sessions for perhaps one month, then administer the rhythmic accuracy test again. Each session could possibly include pre- and post-tests but care must be taken to prevent loss of interest and general participation due to the resulting length of each overall session. The initial survey could be taken online at a time of the participant’s choice previous to the first session; however, it would be best to capture post-treatment survey data directly after the post-test for best participant recall. The number of practice sessions and time per practice session would be a very useful factor to examine. It is likely that the significant increase in satisfaction among *guitar-style* controller users could better maintain interest over many sessions and thus provide significantly better learning outcomes than with just a single session.

Practice software could concentrate specifically on rhythm instead of vocal/song-oriented material. Vocal and song-oriented material consist of many combined musical elements. Additional elements beyond rhythm could be potentially distracting to learners. Instead of the current popular songs used in *Guitar Hero III*, songs that are simpler and more rhythmically driven could be used. Similarly, one could compare the two genres.

A younger sample of participants would be a critical next step. Supplemental analyses revealed that even the small gap in age between early- and late-college-experience users produced significant differences. They may be more engaged regardless of the vintage of practice software. To adapt for younger users the existing surveys would be simplified and likely only the *Easy* and *Medium* level patterns would be tested. The current four song practice session would probably be adequate for older children but may need to be fewer for younger children. A study could be done with aspiring musicians to compare practice like this study to simply practicing their instruments during practice sessions.

The assessment tool created for this study could potentially be used in a variety of other applications with only simple modifications to its hardware interface. The hardware, an electronic drum pad, is essentially a piezo element encased in rubber. It does nothing more than produce a short electrical pulse that is detected by the audio interface as a click. Piezo elements are inexpensive and durable by nature, allowing them to be attached to virtually any surface to detect an impact. With simple electrical design skills the piezo element could be replaced with many other simple devices such as light and proximity sensors. STEM/STEAM applications could include the construction of new sensors and their incorporation into student-generated projects. Human Performance Technology could benefit from simple analysis of manual factory processes to improve efficiency. Though the *Guitar Hero III* practice is designed to provide a musical experience the skills learned, pushing the right button at the right time could be tested in many ways that apply to many fields, and possibly save lives as a result. For instance, in aviation, reaction time and appropriate initial response to an alarm is invaluable. Similarly, speed of identification of specific *error chains* is critical as pilots can usually circumvent these error chains be selecting the correct pre-produced checklist of actions to follow. These activities could be measured in a flight cabin simulator with little modification.

Time-based practice as used in this study could also be applied to military and law enforcement where identification and reaction to potential targets is literally a life-and-death matter when deadly force is in play. Existing *shoot houses* already measure the same events as this study. In this instance, an *extra* event would be firing on a target that is not a threat. When a threat does arise, reaction time is tested. Additional minor modifications may be needed to record exact reaction times but they could be developed inexpensively and quickly. Missed events are also measured. Targets could be set to not *return fire* or the number of times the participant is *shot* can be counted as well.

Hand-eye coordination is a phrase used often when discussing sports and games like *Guitar Hero III* provide training in this area. Assessment could be done in American football by measuring reaction time to a virtual quarterback's yell of "Hike!" In baseball the participant could view an on-screen pitcher and press a control at the appropriate moment and the appropriate direction to swing. A soccer (world football) goalie could be tested for reaction time and jump direction to penalty kicks. Many sports games simulating these events exist already and could likely be modified to report results in a time-based format.

More pervasive and practical environs such as *Driver's Ed* classes may also benefit from reaction time training. Using existing skeuomorphic controllers simulating steering wheels and other vehicle controls virtual *drives* could be assessed. Reactions to events such as avoiding pedestrians in the road or other cars swerving out of their lanes could be measured with such a system.

In conclusion, this study suggests that *Guitar Hero III* is an effective tool that provides positive learning outcomes with regard to musical rhythmic accuracy. Time error, extraneous notes, and missing notes all showed statistically significant improvement post-treatment. Consistent with prevalent theories, in most cases the inclusion of audio is a best practice for educators. Controller choice is more nuanced, as it may be influenced by learner satisfaction, previous proficiency of learners and practical considerations like cost, ease of setup, and usefulness for other applications.

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Table 1

Reduction in Time Error with Easy *Difficulty Level*

	df	*F*	η_p^2	*p*
Controller Type (C)	1	.18	.00	.67
Audio (A)	1	5.21^*	.05	.03
C X A	1	.06	.00	.80
Error	96			

Note. $^*p < .05$

Table 2

Descriptive Statistics for Reduction in Time Error Analysis with Easy *Difficulty Level*

Controller Type	*M*	*SD*	*N*
Guitar			
Audio	-4.50	17.17	25
No Audio	2.61	16.78	25
Tablet			
Audio	-3.88	23.10	25
No Audio	4.98	10.76	25

Table 3

Reduction in Time Error with Difficult *Difficulty Level*

	df	*F*	η_p^2	*p*
Controller Type (C)	1	6.81*	.07	.01
Audio (A)	1	.73	.01	.40
C X A	1	.59	.01	.45
Error	96			

Note. $^{*}p < .05$

Table 4

Descriptive Statistics for Reduction in Time Error Analysis with Difficult *Difficulty Level*

Controller Type	*M*	*SD*	*N*
Guitar			
Audio	-.03	3.07	25
No Audio	-.97	2.92	25
Tablet			
Audio	1.04	3.41	25
No Audio	.99	2.00	25

Table 5

Reduction in Extra Notes with Difficult *Difficulty Level*

	df	*F*	η_p^2	*p*
Controller Type (C)	1	5.56*	.06	.02
Audio (A)	1	1.06	.01	.31
C X A	1	1.33	.01	.25
Error	96			

Note. $^{*}p < .05$

Table 6

Descriptive Statistics for Reduction in Extra Notes Analysis with Difficult *Difficulty Level*

Controller Type	*M*	*SD*	*N*
Guitar			
Audio	-15.93	17.33	25
No Audio	-15.43	17.37	25
Tablet			
Audio	-1.99	22.97	25
No Audio	-10.65	21.15	25

Table 7

Reduction in Missed Notes with Easy *Difficulty Level*

	df	*F*	η_p^2	*p*
Controller Type (C)	1	.11	.00	.74
Audio (A)	1	4.34*	.43	.04
C X A	1	.13	.01	.72
Error	96			

Note. $^{*}p < .05$

Table 8

Descriptive Statistics for Reduction in Missed Notes Analysis with Easy *Difficulty Level*

Controller Type	*M*	*SD*	*N*
Guitar			
Audio	3.67	5.01	25
No Audio	1.59	4.96	25
Tablet			
Audio	3.08	3.27	25
No Audio	1.61	3.48	25

Table 9

Reduction in Missed Notes with Moderate *Difficulty Level*

	df	*F*	η_p^2	*p*
Controller Type (C)	1	4.74*	.05	.03
Audio (A)	1	6.27*	.06	.01
C X A	1	2.79	.28	.10
Error	96			

Note. $^{*}p < .05$

Table 10

Descriptive Statistics for Reduction in Missed Notes Analysis with Moderate *Difficulty Level*

Controller Type	*M*	*SD*	*N*
Guitar			
Audio	4.25	3.29	25
No Audio	2.20	2.99	25
Tablet			
Audio	2.36	1.24	25
No Audio	1.95	1.68	25

Table 11

Reduction in Missed Notes with Moderate *Difficulty Level by Instructional Satisfaction Survey*

Difficulty Level	*df*	*F*	η_p^2	*p*
Moderate	1	7.86*	.07	.01
Error	98			

Note. $^*p < .05$

Table 12

Descriptive Statistics for Reduction in Missed Notes Analysis with Moderate *Difficulty Level by Instructional Satisfaction Survey*

Instructional Satisfaction Survey (< 6 = low)	*M*	*SD*	*N*
Low	1.97	2.01	49
High	3.38	2.90	51

Table 13

Instructional Satisfaction Analysis by Controller Type

Controller Type	*df*	*F*	η_p^2	*p*
Controller	1	33.75*	.26	< .01
Error	98			

Note. $^*p < .05$

Table 14

Descriptive Statistics for Instructional Satisfaction Analysis by Controller Type

Controller Type	*M*	*SD*	*N*
Guitar	6.70	1.29	50
Tablet	5.00	1.63	50

Table 15

Instructional Satisfaction Analysis by Presence of Audio

Controller Type	*df*	*F*	η_p^2	*p*
Controller	1	4.51*	.04	.04
Error	98			

Note. $^{*}p < .05$

Table 16

Descriptive Statistics for Instructional Satisfaction Analysis by Presence of Audio

Presence of Audio	*M*	*SD*	*N*
Audio	6.20	1.62	50
No Audio	5.50	1.71	50

Table 17

Reduction in Time Error at Difficult *Difficulty Level by Age*

Difficulty Level	*df*	*F*	η_p^2	*p*
Difficult	1	5.26*	.05	.02
Error	98			

Note. $^{*}p < .05$

Table 18

Descriptive Statistics for Reduction in Time Error Analysis with Difficult *Difficulty Level by Age*

Age	*M*	*SD*	*N*
Over 21	-.93	3.24	24
21 or Under	.63	2.80	76

Table 19

Reduction in Missed Notes at Difficult *Difficulty Level by Age*

Difficulty Level	*df*	*F*	η_p^2	*p*
Difficult	1	5.59*	.05	.02
Error	98			

Note. $^*p < .05$

Table 20

Descriptive Statistics for Reduction in Missed Notes Analysis with Difficult *Difficulty Level by Age*

Age	*M*	*SD*	*N*
Over 21	10.78	10.20	24
21 or Under	5.20	10.06	76

Table 21

Reduction in Time Error with Easy *Difficulty Level by Novel Interface*

Difficulty Level	*df*	*F*	η_p^2	*p*
Easy	1	.18	.00	.07
Error	98			

Note. $^*p < .05$

Table 22

Descriptive Statistics for Reduction in Time Error Analysis with Easy *Difficulty Level by Novel Interface*

Novel Interface Experience (Low < 3)	*M*	*SD*	*N*
Low	-.80	18.95	61
High	.75	15.76	39

Table 23

Reduction in Time Error with Moderate *Difficulty Level by Novel Interface*

Difficulty Level	*df*	*F*	η_p^2	*p*
Moderate	1	1.27	.01	.26
Error	98			

Note. $^*p < .05$

Table 24

Descriptive Statistics for Reduction in Time Error Analysis with Moderate *Difficulty Level by Novel Interface*

Novel Interface Experience (Low < 3)	*M*	*SD*	*N*
Low	.43	4.28	61
High	-.52	3.82	39

Table 25

Reduction in Time Error with Difficult *Difficulty Level by Novel Interface*

Difficulty Level	*df*	*F*	η_p^2	*p*
Difficult	1	1.25	.01	.55
Error	98			

Note. $^*p < .05$

Table 26

Descriptive Statistics for Reduction in Time Error Analysis with Difficult *Difficulty Level by Novel Interface*

Novel Interface Experience (Low < 3)	*M*	*SD*	*N*
Low	.52	2.85	61
High	-.16	3.14	39

Table 27

Reduction in Time Error with Easy *Difficulty Level by User Reaction*

Difficulty Level	*df*	*F*	η_p^2	*p*
Easy	1	.66	.01	.42
Error	98			

Note. $^*p < .05$

Table 28

Descriptive Statistics for Reduction in Time Error Analysis with Easy *Difficulty Level by User Reaction*

User Reaction (Low < 6)	*M*	*SD*	*N*
Low	.32	16.69	85
High	4.79	17.14	15

Table 29

Reduction in Time Error with Moderate *Difficulty Level by User Reaction*

Difficulty Level	*df*	*F*	η_p^2	*p*
Moderate	1	.14	.00	.78
Error	98			

Note. $^{*}p < .05$

Table 30

Descriptive Statistics for Reduction in Time Error Analysis with Moderate *Difficulty Level by User Reaction*

User Reaction (Low < 6)	*M*	*SD*	*N*
Low	.06	4.12	85
High	-.42	3.93	15

Table 31

Reduction in Time Error with Difficult *Difficulty Level by User Reaction*

Difficulty Level	*df*	*F*	η_p^2	*p*
Difficult	1	.68	.01	.41
Error	98			

Note. $^*p < .05$

Table 32

Descriptive Statistics for Reduction in Time Error Analysis with Difficult *Difficulty Level by User Reaction*

User Reaction (Low < 6)	*M*	*SD*	*N*
Low	.15	2.74	85
High	.83	2.97	15

Table 33

Reduction in Time Error with Easy *Difficulty Level by Learning*

Difficulty Level	*df*	*F*	η_p^2	*p*
Easy	1	1.81	.00	.59
Error	98			

Note. $^*p < .05$

Table 34

Descriptive Statistics for Reduction in Time Error Analysis with Easy *Difficulty Level by Learning*

Learning (Low < 6)	*M*	*SD*	*N*
Low	-3.50	18.84	34
High	1.51	16.99	66

Table 35

Reduction in Time Error with Moderate *Difficulty Level by Learning*

Difficulty Level	*df*	*F*	η_p^2	*p*
Moderate	1	2.57	.03	.11
Error	98			

Note. $^*p < .05$

Table 36

Descriptive Statistics for Reduction in Time Error Analysis with Moderate *Difficulty Level by Learning*

Learning (Low < 6)	*M*	*SD*	*N*
Low	.97	4.09	34
High	-.4133	4.08	66

Table 37

Reduction in Time Error with Difficult *Difficulty Level by Learning*

Difficulty Level	*df*	*F*	η_p^2	*p*
Difficult	1	.246	.00	.62
Error	98			

Note. $^*p < .05$

Table 38

Descriptive Statistics for Reduction in Time Error Analysis with Difficult *Difficulty Level by Learning*

Learning (Low < 6)	*M*	*SD*	*N*
Low	.46	3.09	34
High	.15	2.92	66

Table 39

Reduction in Missing Notes with Easy *Difficulty Level by Novel Interface*

Difficulty Level	*df*	*F*	η_p^2	*p*
Easy	1	.53	.05	.47
Error	98			

Note. $^*p < .05$

Table 40

Descriptive Statistics for Extra Notes Analysis with Easy *Difficulty Level by Novel Interface*

Novel Interface Experience (Low < 3)	*M*	*SD*	*N*
Low	-.89	3.45	61
High	-.44	2.13	39

Table 41

Reduction in Extra Notes with Moderate *Difficulty Level by Novel Interface*

Difficulty Level	*df*	*F*	η_p^2	*p*
Moderate	1	2.30	.02	.13
Error	98			

Note. $^*p < .05$

Table 42

Descriptive Statistics for Reduction in Extra Notes Analysis with Moderate *Difficulty Level by Novel Interface*

Novel Interface Experience (Low < 3)	*M*	*SD*	*N*
Low	28.76	8.42	61
High	31.01	8.25	39

Table 43

Reduction in Extra Notes with Difficult *Difficulty Level by Novel Interface*

Difficulty Level	*df*	*F*	η_p^2	*p*
Difficult	1	.01	.22	.93
Error	98			

Note. $^{*}p < .05$

Table 44

Descriptive Statistics for Extra Notes Analysis with Difficult *Difficulty Level by Novel Interface*

Novel Interface Experience (Low < 3)	*M*	*SD*	*N*
Low	-11.14	21.24	61
High	-10.79	19.14	39

Table 45

Reduction in Extra Notes with Easy *Difficulty Level by User Reaction*

Difficulty Level	*df*	*F*	η_p^2	*p*
Difficult	1	.39	.04	.54
Error	98			

Note. $^{*}p < .05$

Table 46

Descriptive Statistics for Extra Notes Analysis with Easy *Difficulty Level by User Reaction*

User Reaction (Low < 6)	*M*	*SD*	*N*
Low	-.63	3.13	85
High	-1.16	3.00	15

Table 47

Reduction in Extra Notes with Moderate *Difficulty Level by User Reaction*

Difficulty Level	*df*	*F*	η_p^2	*p*
Moderate	1	.08	.00	.78
Error	98			

Note. $^{*}p < .05$

Table 48

Descriptive Statistics for Extra Notes Analysis with Moderate *Difficulty Level by User Reaction*

User Reaction (Low < 6)	*M*	*SD*	*N*
Low	29.85	8.09	85
High	29.20	9.37	15

Table 49

Reduction in Extra Notes with Difficult *Difficulty Level by User Reaction*

Difficulty Level	*df*	*F*	η_p^2	*p*
Difficult	1	.00	.00	.97
Error	98			

Note. $^*p < .05$

Table 50

Descriptive Statistics for Extra Notes Analysis with Difficult *Difficulty Level by User Reaction*

User Reaction (Low < 6)	*M*	*SD*	*N*
Low	-11.04	19.07	85
High	-10.80	27.29	15

Table 51

Reduction in Extra Notes with Easy *Difficulty Level by Learning*

Difficulty Level	*df*	*F*	η_p^2	*p*
Easy	1	1.04	.01	.31
Error	98			

Note. $^{*}p < .05$

Table 52

Descriptive Statistics for Extra Notes with Easy *Difficulty Level by Learning*

Learning (Low < 6)	*M*	*SD*	*N*
Low	-.28	3.70	34
High	-.93	2.57	66

Table 53

Reduction in Extra Notes with Moderate *Difficulty Level by Learning*

	df	*F*	η_p^2	*p*
Moderate	1	.00	.00	.99
Error	98			

Note. $^{*}p < .05$

Table 54

Descriptive Statistics Extra Notes Analysis with Moderate *Difficulty Level by Learning*

Learning (Low < 6)	*M*	*SD*	*N*
Low	29.74	8.58	34
High	29.76	8.14	66

Table 55

Reduction in Extra Notes with Difficult *Difficulty Level by Learning*

Difficulty Level	*df*	*F*	η_p^2	*p*
	1	.01	.21	.93
Error	98			

Note. $^*p < .05$

Table 56

Descriptive Statistics for Extra Notes with Difficult *Difficulty Level by Learning*

Learning (Low < 6)	*M*	*SD*	*N*
Low	-10.75	24.00	34
High	-11.00	20.34	66

Table 57

Reduction in Missing Notes with Easy *Difficulty Level by Novel Interface*

Difficulty Level	*df*	*F*	η_p^2	*p*
Easy	1	.01	.00	.92
Error	98			

Note. $^{*}p < .05$

Table 58

Descriptive Statistics for Missing Notes Analysis with Easy *Difficulty Level by Novel Interface*

Novel Interface Experience (Low < 3)	*M*	*SD*	*N*
Low	2.45	4.05	61
High	2.54	4.29	39

Table 59

Reduction in Missing Notes with Moderate *Difficulty Level by Novel Interface*

Difficulty Level	*df*	*F*	η_p^2	*p*
Moderate	1	.496	.01	.48
Error	98			

Note. $^*p < .05$

Table 60

Descriptive Statistics for Reduction in Missing Notes Analysis with Moderate *Difficulty Level by Novel Interface*

Novel Interface Experience (Low < 3)	*M*	*SD*	*N*
Low	2.84	2.68	61
High	2.46	2.45	39

Table 61

Reduction in Missing Notes with Difficult *Difficulty Level by Novel Interface*

Difficulty Level	*df*	*F*	η_p^2	*p*
Difficult	1	.628	.01	.43
Error	98			

Note. $^*p < .05$

Table 62

Descriptive Statistics for Missing Notes Analysis with Difficult *Difficulty Level by Novel Interface*

Novel Interface Experience (Low < 3)	*M*	*SD*	*N*
Low	7.19	9.60	61
High	5.50	11.42	39

Table 63

Reduction in Missing Notes with Easy *Difficulty Level by User Reaction*

Difficulty Level	*df*	*F*	η_p^2	*p*
Difficult	1	2.23	.02	.14
Error	98			

Note. $^*p < .05$

Table 64

Descriptive Statistics for Missing Notes Analysis with Easy *Difficulty Level by User Reaction*

User Reaction (Low < 6)	*M*	*SD*	*N*
Low	2.76	4.51	85
High	.96	4.29	15

Table 65

Reduction in Missing Notes with Moderate *Difficulty Level by User Reaction*

Difficulty Level	*df*	*F*	η_p^2	*p*
Moderate	1	.365	.00	.58
Error	98			

Note. $^*p < .05$

Table 66

Descriptive Statistics for Missing Notes Analysis with Moderate *Difficulty Level by User Reaction*

User Reaction (Low < 6)	*M*	*SD*	*N*
Low	2.76	2.70	85
High	2.32	2.59	15

Table 67

Reduction in Missing Notes with Difficult *Difficulty Level by User Reaction*

Difficulty Level	*df*	*F*	η_p^2	*p*
Difficult	1	.12	.00	.73
Error	98			

Note. $^{*}p < .05$

Table 68

Descriptive Statistics for Missing Notes Analysis with Difficult *Difficulty Level by User Reaction*

User Reaction (Low < 6)	*M*	*SD*	*N*
Low	6.38	10.89	85
High	7.40	6.51	15

Table 69

Reduction in Missing Notes with Easy *Difficulty Level by Learning*

Difficulty Level	*df*	*F*	η_p^2	*p*
Easy	1	.08	.24	.80
Error	98			

Note. $^*p < .05$

Table 70

Descriptive Statistics for Missing Notes with Easy *Difficulty Level by Learning*

Learning (Low < 6)	*M*	*SD*	*N*
Low	2.64	3.25	34
High	2.41	4.76	66

Table 71

Reduction in Missing Notes with Moderate *Difficulty Level by Learning*

	df	F	η_p^2	p
Moderate	1	.474	.49	.49
Error	98			

Note. $^*p < .05$

Table 72

Descriptive Statistics for Missing Notes Analysis with Moderate *Difficulty Level by Learning*

Learning (Low < 6)	*M*	*SD*	*N*
Low	2.44	2.20	34
High	2.81	2.77	66

Table 73

Reduction in Missing Notes with Difficult *Difficulty Level by Learning*

Difficulty Level	*df*	*F*	η_p^2	*p*
	1	.01	.000	.91
Error	98			

Note. $^*p < .05$

Table 74

Descriptive Statistics for Missing Notes with Difficult *Difficulty Level by Learning*

Learning (Low < 6)	*M*	*SD*	*N*
Low	6.37	10.12	34
High	6.61	10.51	66

Table 75

Reduction in Time Error with Moderate *Difficulty Level by Preliminary Expectations*

Difficulty Level	*df*	*F*	η_p^2	*p*
Moderate	1	4.80*	.05	.03
Error	98			

Note. $^*p < .05$

Table 76

Descriptive Statistics for Reduction in Time Error Analysis with Moderate *Difficulty Level by Preliminary Expectations*

Preliminary Expectations (< 3 = low)	*M*	*SD*	*N*
Low	-.90	4.12	46
High	.87	3.96	54

Table 77

Reduction in Time Error with Difficult *Difficulty Level by Mean* Guitar Hero III *Score*

Difficulty Level	*df*	*F*	η_p^2	*p*
Difficult	1	4.54*	.04	.04
Error	98			

Note. $^{*}p < .05$

Table 78

Descriptive Statistics for Reduction in Time Error Analysis with Difficult *Difficulty Level by Mean* Guitar Hero III *Score*

Time Error Change	*M*	*SD*	*N*
Above	.96	3.20	44
Below	-.29	2.68	56

Table 79

Reduction in Extra Notes with Moderate *Difficulty Level by Mean* Guitar Hero III *Score*

Difficulty Level	*df*	*F*	η_p^2	*p*
Moderate	1	6.89*	.07	.01
Error	98			

Note. $^{*}p < .05$

Table 80

Descriptive Statistics for Reduction in Extra Notes Analysis with Moderate *Difficulty Level by Mean* Guitar Hero III *Score*

Average Score (49.09%)	*M*	*SD*	*N*
Low	31.61	8.32	56
High	27.38	8.25	44

Figure 1. *Guitar Hero III* gameplay.

Figure 2. Standard *Guitar Hero III* hardware interface.

Figure 3. Screen from Touch/Gesture interface.

Figure 4. Home-brew assessment tool drum pad for uses including *Guitar Hero III*.

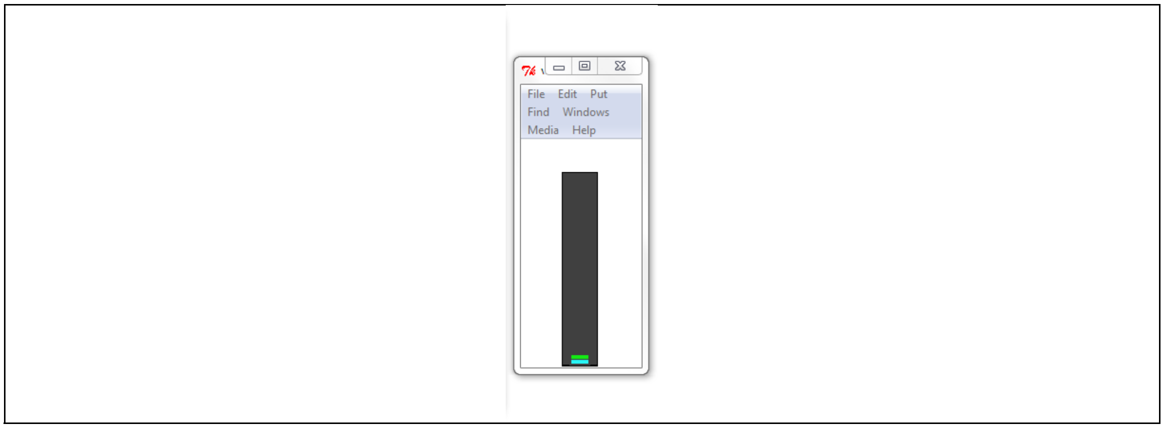


Figure 5. Screen capture of *Guitar Hero III* VU meter.

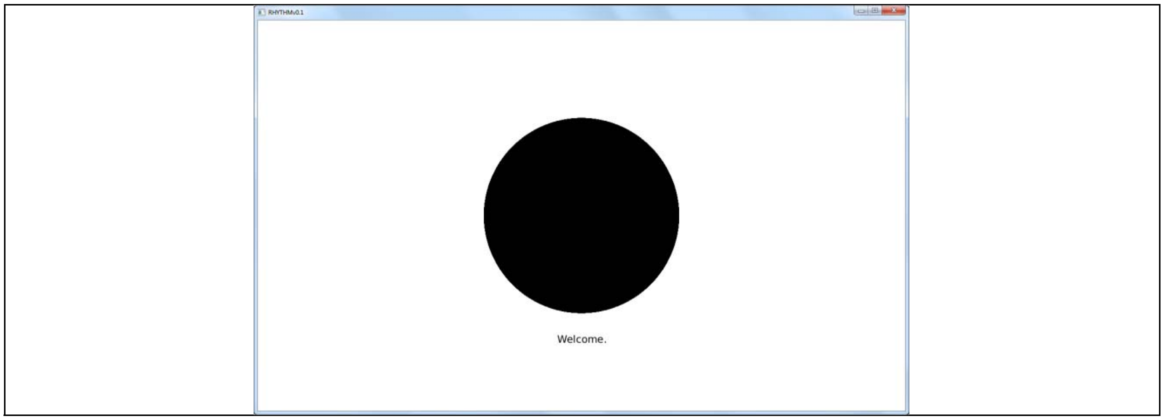


Figure 6. Screen capture of study pretest/posttest visuals.

APPENDIX A

KEYBOARD CONTROLS FOR *GUITAR HERO III*

CONTROLS	
QWERTY KEYBOARD AS GAME CONTROLLER	
Esc Key	cancel, pause
F10, F11, F12, Up Arrow or Down Arrow Key	menu
Backspace Key	start
Enter Key	confirm
Shift, Z, X, C or V Key	fret
? or/ Key or Left Mouse Button	strum down
Shift Key or Right Mouse Button	strum up
Spacebar Key or Mouse Wheel	star power
Alt Key or Move Mouse Left or Right	whammy bar

APPENDIX B

USER INTERACTION SATISFACTION QUESTIONNAIRE

Identification number: ______________________
System code: ______________________
Age: ______
Gender: ____ **male**
____ **female**

PART 1: *Guitar Hero* Experience

1.1 How long have played Guitar Hero?

__ less than 1 hour
__ 1 hour to less than 1 day
__ 1 day to less than 1 week
__ 1 week to less than 1 month
__ 1 month to less than 6 months
__ 6 months to less than 1 year
__ 1 year to less than 2 years
__ 2 years to less than 3 years
__ 3 years or more

1.2 On the average, how much time do you spend per month playing Guitar Hero?

__ less than one hour
__ one to less than 4 hours
__ 4 to less than 10 hours
__ over 10 hours

PART 2: Past Computing Experience

2.1 How many computer operating systems have you worked with?

__ none
__ 1
__ 2
__ 3-4
__ 5-6
__ more than 6

2.2 Of the following devices, software, and systems, check those that you have personally used and are familiar with:

__ computer terminal
__ personal computer
__ lap top computer
__ color monitor
__ touch screen
__ floppy drive
__ CD-ROM drive
__ keyboard
__ mouse
__ track ball
__ joy stick
__ pen based computing
__ graphics tablet
__ head mounted display
__ modems
__ scanners
__ word processor
__ graphics software
__ spreadsheet software
__ database software
__ computer games
__ voice recognition
__ video editing systems
__ CAD computer aided design
__ rapid prototyping systems
__ e-mail
__ internet

PART 3: Overall User Reactions

Please circle the numbers which most appropriately reflect your impressions about using this computer system. Not Applicable = NA.

3.1 Overall reactions to the system:	terrible	wonderful	
	1 2 3 4 5 6 7 8 9		NA
3.2	frustrating	satisfying	
	1 2 3 4 5 6 7 8 9		NA
3.3	dull	stimulating	
	1 2 3 4 5 6 7 8 9		NA
3.4	difficult	easy	
	1 2 3 4 5 6 7 8 9		NA
3.5	inadequate power	adequate power	
	1 2 3 4 5 6 7 8 9		NA

3.6		rigid	flexible	
		1 2 3 4 5 6 7 8 9		NA

PART 4: *Guitar Hero* Screen

4.3	Screen layouts were helpful	never	always	
		1 2 3 4 5 6 7 8 9		NA
4.4	Sequence of screens	confusing	clear	
		1 2 3 4 5 6 7 8 9		NA

Please write your comments about the screens here:

____

____

____

PART 5: *Guitar Hero* Terminology and System Information

5.1	Use of terminology throughout system	inconsistent	consistent	
		1 2 3 4 5 6 7 8 9		NA
5.2	Terminology relates well to the task you are doing	never	always	
		1 2 3 4 5 6 7 8 9		NA
5.3	Messages which appear on screen	inconsistent	consistent	
		1 2 3 4 5 6 7 8 9		NA
5.4	Messages which appear on screen	confusing	clear	
		1 2 3 4 5 6 7 8 9		NA
5.5	Computer keeps you informed about what it is doing	never	always	
		1 2 3 4 5 6 7 8 9		NA
5.6	Error messages	unhelpful	helpful	
		1 2 3 4 5 6 7 8 9		NA

Please write your comments about terminology and system information here:

____

____

____

PART 6: Learning

6.1	Learning to operate the *Guitar Hero*	difficult	easy	
		1 2 3 4 5 6 7 8 9		NA
6.2	Exploration of features by trial and error	discouraging	encouraging	
		1 2 3 4 5 6 7 8 9		NA
6.3	Remembering use of controller	difficult	easy	
		1 2 3 4 5 6 7 8 9		NA
6.4	Tasks can be performed in a straight-forward manner	never	always	
		1 2 3 4 5 6 7 8 9		NA

Please write your comments about learning here:

____

____

____

PART 7: *Guitar Hero* System Capabilities

7.1 System speed	too slow	fast enough	
	1 2 3 4 5 6 7 8 9		NA
7.2 The system is reliable	never	always	
	1 2 3 4 5 6 7 8 9		NA
7.5 Ease of operation depends on your level of experience	never	always	
	1 2 3 4 5 6 7 8 9		NA

Please write your comments about system capabilities here:

____

____

____

PART 8: *Guitar Hero* Tutorials

9.1 Tutorial was	useless	helpful	
	1 2 3 4 5 6 7 8 9		NA
9.2 Maneuvering through the tutorial was	difficult	easy	
	1 2 3 4 5 6 7 8 9		NA
9.3 Tutorial content was	useless	helpful	
	1 2 3 4 5 6 7 8 9		NA
9.4 Tasks can be completed	with difficulty	easily	
	1 2 3 4 5 6 7 8 9		NA
9.5 Learning to operate the system using the tutorial was	difficult	easy	
	1 2 3 4 5 6 7 8 9		NA

Please write your comments about the tutorial here:

____

____

____

PART 10: Multimedia

10.2 Quality of video	bad	good	
	1 2 3 4 5 6 7 8 9		NA
10.3 Sound output	inaudible	audible	
	1 2 3 4 5 6 7 8 9		NA
10.4 Colors used are	unnatural	natural	
	1 2 3 4 5 6 7 8 9		NA

Please write your comments about multimedia here:

____

____

____

APPENDIX C

INITIAL SURVEY

Participants chose one of these statements for the below items: Not true, Slightly true, Moderately true, Mostly true, Very true

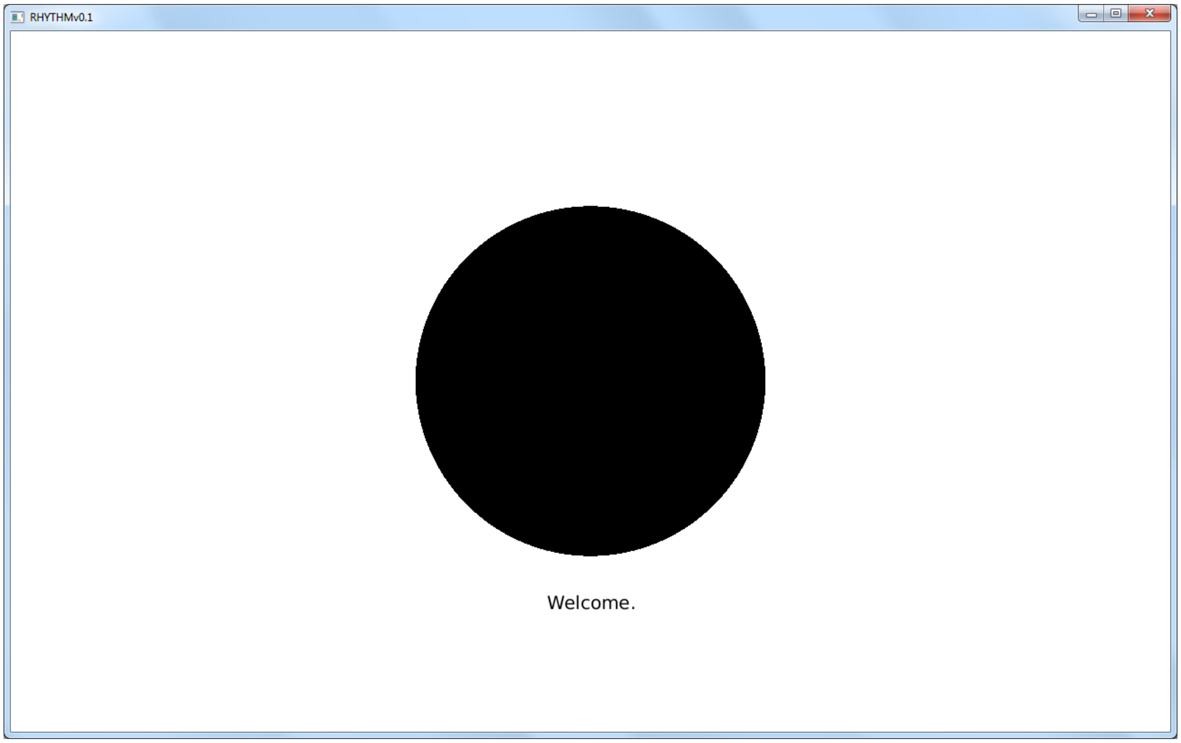
- I have had a lot of musical instrument instruction.
- I have had a lot of vocal instruction.
- I have had a lot of organized movement experience (dance, martial arts, marching, flag & rifle squad, etc.).
- I have spent a lot of time playing competitive sports.
- I am NOT very coordinated.
- I learn well by seeing.
- I do NOT learn well by hearing.
- When listening to music in the car I tap along or sing along.
- My sense of hearing is good.
- I am a good listener.
- I expect that the instructor will do unusual or surprising things that are interesting.
- The things I learn in this instruction will be useful to me.
- I expect to find the challenge level in this instruction to be about right: neither too easy nor too hard.
- I expect that a person has to be lucky to get good scores in this instruction.
- I expect that the amount of work I will have to do will be appropriate for this type of instruction.

Other questions:

- Are you (choose)
  - Left handed
  - Right Handed
- Types of music I enjoy (check all that apply):
  - Rock
  - Jazz
  - Classical
  - Blues
  - R&B
  - Country
  - Reggae
  - Hip Hop
  - Electronic
  - Latino

APPENDIX D

ASSESSMENT TOOL SCREENSHOTS AND SCRIPT



Example of screen from assessment. The circle flashed to yellow when a note should be played and red for the count-off tones.

These instructions were given to participants in text and audio form:

- Welcome to the test. Tap the drum to go to the next step. (Tap/next)
- This test evaluates your rhythmic accuracy. (Tap/next)
- You will hear a pattern once then you will tap along with it. (Tap/next)
- There will be a 4 beat countdown before any pattern begins like this... (Tap/next)
- You are about to hear an example of a pattern. Memorize (don't tap) the pattern that plays after the countdown. (Tap/next)
- Listen closely because you'll only hear the example once. You'll tap each pattern many times. Don't stop if you make a mistake. Keep playing. (Tap/next)
- (Ask any questions now before you begin!) Listen to (but don't tap along with) the pattern. (Tap/next)

For each pattern the participants received this instruction before the pattern:

- Listen to (but don't play along with) the pattern. (Tap/next)
- Tap along with the pattern after the 4 3 2 1 cowbell countdown. (Tap/next)

After each pattern:

- Stop tapping now. Done with the pattern. (Tap/next)

After the last pattern:

- Finished! Please see the researcher to continue.

APPENDIX E

GUITAR HERO III SCREENSHOTS

Guitar Hero Screenshots

Gameplay from Guitar Hero III practice songs.

Example results screen from practice songs.

APPENDIX F

INSTRUCTIONAL SATISFACTION SURVEY

The following items were aggregated to form the *Instructional Satisfaction Survey*. Scores for negative statements were adjusted to positive as appropriate.

- The way that the information is arranged on the pages got my attention.
- The pages of this lesson looked interesting.
- This lesson made me curious.
- Finishing this lesson successfully was important to me.
- I can see how the content of this lesson is related to things I already know about.
- The knowledge in this lesson is NOT useful to me.
- The exercises in this lesson were too hard.
- I felt rewarded for my work because of the way that the answers to the exercises were given.
- I was happy about finishing this lesson successfully.
- I liked studying this lesson.

APPENDIX G

PRELIMINARY EXPECTATIONS AGGREGATE

The following items were aggregated to form the *Preliminary Expectations Aggregate*. Scores for negative statements were adjusted to positive as appropriate.

- This instruction will have many things in it that will capture my attention.
- I expect that the instructor will do unusual or surprising things that are interesting.
- The things I learn in this instruction will be useful to me.
- I do NOT see how the content of this instruction relates to anything I already know.
- I feel confident that I will do well in this instruction.
- I expect to find the challenge level in this instruction to be about right: neither too easy nor too hard.
- I expect that a person has to be lucky to get good scores in this instruction.
- Whether or not I will succeed in this instruction is up to me.
- I expect to feel satisfied with what I will get from this instruction.
- I expect that the amount of work I will have to do will be appropriate for this type of instruction.