Preferences between Acoustic and Digital Pianos

A Document

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

degree of

Master of Music in Music Technology

Production Track

By

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University of Valley Forge

Phoenixville, Pennsylvania

June 2018

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Abstract

The digital piano has become a common instrument today. However, since it's invention, musicians have argued that its acoustic counterpart has, and continues to reign superior in sound quality, feel, and expression. While early digital pianos relied on technology that was just beginning to progress, current generation instruments benefit from decades of research and development done by Yamaha, Kurzweil, Roland and others. Today's instrument look, feel, and sound more like their acoustic counterparts than any other generation of digital pianos. So, is the acoustic piano still preferred? Are there factors that influence one's preference of either an acoustic or digital sound? Can people even tell the difference between the two types of instruments?

ACKNOWLEDGEMENTS

Excerpt 1, “The Cat and the Mouse” Pianist: Margaret Zheng

Excerpt 2, “Behind the Waterfall/Desert Rain Medley” Pianist: Austen Yim

Excerpt 3, “She Cries” *from Songs for a New World* Pianist: Jared Williams

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Chapter 1 – Introduction

The 1980's were revolutionary for the digital piano. For the first time, acoustic pianos began to be challenged by digital instruments that were designed to look, sound, and feel like their acoustic counterparts. Several manufacturers began to enter the market with their version of what would become the digital piano genre. However, determining what was a digital piano was confusing at first, as different manufacturers had varying ideas on what components and hardware truly made up this new product line. Did Yamaha create the first digital piano with the introduction of the GS1 in 1981, or were the first real digital pianos Yamaha's 1983 Clavinovas? Could the reveal of the Kurzweil 250 in 1984 be the first true digital piano, or was Roland's 1986 RD1000 the first "real" digital piano? Regardless of opinion, it is clear that the initial developments of these products helped to fuel the quest to create a digital piano that looked, sounded, and played like it's acoustic equivalent. The problem, however, has always been the technology powering the instrument. The limitations of technology have always had an effect on the opinions about the final product: does a particular digital piano sound as good as its acoustic counterpart, and does the general public have as much of an opinion about acoustic or digital piano sounds as perhaps a musician would?

Current technology is overwhelming in comparison to what was available in the 1980's. Floppy disks and hard drives containing only a few hundred kilobytes of memory or a paltry 1 or 2 megabytes of space have been transformed into what are seemingly limitless storage devices that are both faster and smaller than anything that preceded it. Computers are also faster and smaller, and the ability to download updated content in literally seconds through virtual cloud services have given users of anything electronic opportunities that were unimaginable in 1981.

But, has this technology been applied to digital pianos in the same ways that it has been applied to everything else?

For years, many educated musicians have tended to argue over the perceived quality and sound of digital pianos. There are piano purists who simply think the acoustic piano will never be matched in quality, and piano innovators who push the limits of technology to produce the best possible digital counterpart. Michel Thivierge has this opinion: “Nothing can replace a real piano. A piano is something very special; it is part of a home. A piano is something you choose with your heart. Its sound touches your heart. Every piano is individual. It is something you get attached to, that you can create real music with. You don’t get attached to a TV or a CD player or a computer.” He is certainly not alone in his opinion, as many pianists and musicians in general would argue that there has yet to be an instrument that feels, plays, and sounds like a genuine acoustic piano. There are others, however, that cannot help but choose a digital piano because of the features they provide that an acoustic piano can’t: portability, the need to never tune the instrument, size, simple and complex recording, composition, and MIDI.

Regardless of one’s stance on the issue, technology has certainly aided in the overall quality of the digital piano. Kurzweil’s 250 was the first digital piano to feature digital sampling, which is a sound generation method that is still used today in most digital instruments. This technology is the process of recording a real acoustic piano into digital samples, and then assigning those sound bytes to keys on the instrument. In 1984, one could argue that it was the most realistic sounding digital piano of the day. “The Kurzweil 250 is widely considered to be the first electronic keyboard to produce a convincing piano sound” (Byrd, Yavelow, 64). But the limitations of the computer technology were not really able to capture the response, timbre, and

dynamics of an acoustic piano. Nevertheless, this was the start to what would become a revolution of digital piano making, and major manufacturers such as Yamaha, Roland, Casio, Young Chang (Kurzweil), Korg, and others are still trying to create the best digital instrument possible.

Today, most digital pianos use some type of sampling at the core of their sound creation engines. Yamaha's CVP-700 Series provide a good example of excellent sampling. The company's advanced sampling techniques take multiple levels of dynamics, hammer noise, partials, and other sounds that make up the entire quality of the piano, into consideration. This is a far cry from the simple Kurzweil sampling of the 80's. As of 2017, Roland has taken a new approach in their digital pianos: modeling. This process of digitally creating a realistic piano sound is very different than the sampling technique, as it is designed to interact with the performer and the actual instrument in a more realistic way. Rather than just playing back a variety of sampled sounds, the Roland Digital Pianos create the sounds, therefore making a rich experience in nuance and style that "models" an acoustic piano in such a way that perhaps provides the most realistic sound and authentic playing digital piano to date. Roland says this about their HP-605 Piano: "The premium HP605 is powered by the latest version of our acclaimed SuperNATURAL Piano Modeling technology. Press a key on most digital pianos and you will hear a recording of a piano note. But a SuperNATURAL Piano works differently, using the latest modeling technology to recreate, rather than replay, the sound. The unique modeling process spans the entire sound creation process of a typical piano including the combination of notes played, their resonance and the way in which the piano's many elements interact with each other. The result is a rich,

complex sound - complete with overtones - that actually changes in response to the way you play; something impossible to achieve when a piano uses samples."

With the amount of effort and technology put into today's digital piano, the question still remains: is the sound of an acoustic piano preferred over the sound of a digital piano, or is there really not much of a difference? If given a choice to play a 9-foot Steinway D Acoustic Grand Piano or a top of the line Yamaha CVP-709 Digital Clavinova Grand Piano, most pianists would likely choose the Steinway. But, if the Steinway was substituted with a Boston UP-118S upright, would the piano player still pick the acoustic piano? The Clavinova's digital sound was sampled from a $90,000 CFX Grand Piano and a $180,000 Bosendorfer Imperial Grand. Does a $5000 Boston piano really sound as good? A pianist *may* agree that the sound of the Boston is inferior but still prefer its touch, feel, and action.

But what does the average listener think? Would they prefer to listen to an acoustic piano, or does a digital counterpart do the job? Will a listener be able to tell the difference between an acoustic and a digital piano? Does the musical style of a piece determine whether or not an acoustic or a digital piano is preferred?

Purpose of the Study

The purpose of this study is to determine if the average person who listens to music prefers the sound of a digital or an acoustic piano in a variety of musical settings. It will also examine if today's digital pianos can arguably sound "as good" as their acoustic counterparts. For this study, we will consider an "average listener" anyone above 15 years of age ranging from little to no musical experience to someone has studied or is currently studying or teaching music.

Procedure of the Study

A variety of data will be collected in order to determine whether or not a digital piano can sound as good as an acoustic piano. The study will focus on the sound of four different pianos, two acoustic and two digitals. Using all of the pianos, recordings will be made of excerpts of three stylistically different pieces. Within a specific style of a piece, the same pianist will be used on each of the different pianos to ensure that they are musically similar in quality. The recording technique will be the same for each piano in an effort to make the sound as accurate as possible. Subjects will listen to all twelve recordings and will be asked to rate the piano tone quality and their overall listening impression of each sample. At the end of the rating scales, subjects will also be asked to determine whether or not the piano heard in the recording is digital or acoustic.

Potential Outcomes of the Study

Themes that may arise from the data collected may include: preference overall in acoustic piano sound versus digital piano sound, preference overall in digital piano sound versus acoustic piano sound, certain musical styles yield a preference over a specific type of piano, the overall impression of a piece may change based on the piano used, artistic or technical merit may be more pronounced when using a specific type of piano, and/or the overall quality of a recording may be based on the type of piano.

This study offers many potential insights. For instance, if it reveals that there is a negligible difference in user experience when listening to a quality digital piano versus listening to a quality acoustic piano, the implications include that in certain situations, purchasing and using a digital piano versus purchasing and using an acoustic piano is as good or better. The study may also be

able to determine if an acoustic piano or a digital piano is preferred in specific musical genres. The study might also reveal that the sound of a piano is completely subjective, and that the impression it leaves on the listener has little to do with anything other than personal preference.

Chapter 2 – Literature Review

Arguments over perceived digital and sampled piano quality versus acoustic pianos have occurred since the creation of the first digital pianos. It seems to be very important that a digital piano has good tone quality regardless of other advantages it may have over an acoustic piano. This was especially the case in early comparisons. Wapnick and Rosenquist in their study of preferences of undergraduate music majors for sequenced versus performed piano music found that although "sequenced (and sampled) excerpts of piano performances were rated higher with regards to the quality of recording, the tone quality of the piano was rated significantly lower in the majority of those recordings." (Wapnick & Rosenquist, 1991) Of course, one must consider the state of sequencing and sampling technologies used at that time. However, it is important to note that they found that the overall impression of sequenced excerpts rated significantly higher in the majority of the recordings. This may have suggested that in the early days sampling, piano quality was only one aspect of what is paid attention to when listening to music. In a related study, Price discovered that if given a choice between a sampled piano tone or a synthesized random "piano-like" tone, musicians and non-musicians in general preferred the piano sound. Interestingly enough, "Significant ($p<.008$) timbre by non-musician interactions were found for artistic merit and overall impression, with musicians reacting more negatively to the synthesizer timbre than non-musicians." (Price, 1996) The question remains, does the general public have as much of an opinion about acoustic or digital piano sounds as perhaps a musician would? Can either group identify the differences with today's technology?

It is important to consider the development of the digital piano. Each of the major companies have spent millions of dollars and decades of time in research and development of their products.

It is clear that the evolution of the digital piano is the result of a process that has yet to be perfected.

Byrd and Yavelow suggested in 1986 that the Kurzweil 250 is "widely considered to be the first electronic keyboard to produce a convincing piano sound." Their suggestion that "technology imitates reality" was shown at the 1984 NAMM (National Association of Music Merchants) show.

> "At the June, 1984 NAMM convention in Chicago, a top of the line 9-foot concert grand piano and a Kurzweil 250, were both played through the same very high quality $40,000 sound system. There was a general agreement that it was not possible to tell the difference between the piano and the K250." (Kurzweil, 1984)

The Kurzweil K250 was one of the first digital pianos, but it had its competition. Leggitt suggests that the Yamaha YP-40 Clavinova is often cited as the first digital piano. While Kurzweil introduced the world to sampling, Yamaha was creating piano sounds with FM (Frequency Modulation) Synthesis. "The YP models were presented as piano-oriented keyboards, with their FM architecture geared specifically towards piano-family simulation." (Leggitt, 2014) He went on to say "FM synthesis was really a general-purpose system of sound generation, but it was better at creating percussive attack and more elaborate harmonic structures than traditional analogue, which meant it was better equipped for simulating the upper harmonics of acoustic pianos."

"Roland's quest to build the ultimate electronic piano started soon after the company was founded in 1972. Back then, much of the technology didn't exist so we had to invent it" (Roland Online, www.roland.com). Their journey included creating keyboards in the 1970's that featured innovations such as touch-sensitive keyboards and oscillation-based electronic piano engines. By

1986, Roland introduced their best attempt at a digital piano with the RD-1000. “They set about creating a much more sophisticated system of dynamic modeling. Known as Structured Adaptive Synthesis, Roland’s new concept completely abandoned existing techniques.” (Leggitt, 2014) Their success was by far the most recognized in the early days, likely because the instrument was built from the ground up as a piano.

By the early 1990’s, improvements in digital pianos were seen in many of the instruments. “(Yamaha’s) CLP-760 gave me a pleasant touch and a reasonable sound.” (Jacobs, 1992) Another company, Wersi, also entered the digital piano market. Jacobs continues with an all-in review:

> “Here is a truly remarkable digital instrument designed to a specification beyond the standards I had previously experienced. The natural piano sound quality is derived from the ability of this design to accurately respond to changing harmonic patterns as notes interact when they are played.”

Instruments have continued to improve as synthesis, sampling, and modeling technology have become better. By 2015, even companies such as Casio were making digital pianos with detailed, rich, sampled piano sounds. Radio & Music suggested in 2015 that the “(Casio) GP-500BP and GP-300 feature a Grand Acoustic System that faithfully represents the sound of a grand piano as in emanates from above and below the soundboard.” And while many regard today’s Yamaha Clavinovas as the best digital pianos on the market, Praskins believes that the 2017 Roland Pianos may really change the entire digital piano market.

> “In the final analysis, I believe Roland has finally hit the ‘sweet spot’ in its quest for a great line of digital pianos by producing instruments that focus on recreating a more authentic piano playing experience. (They have) incorporated new

> technology in an attractive, well-built cabinet at affordable price points, especially compared to some other digital piano brands and regular acoustic pianos." (Praskins, 2017)

Opinions have abounded on whether or not digital pianos can take the place of acoustic pianos. Eve McBride suggested in 1995 that "Acoustic pianos are serious musical instruments. Digital pianos are musical toys – and I mean that in a complimentary way. They are spontaneous, playful, and challenging. I'd like to have both." Today, there are many bloggers, teachers, and pianists who repeatedly make their positions clear whenever they can. In 2015, piano dealers were taking a different thought on the situation. Robert Lowrey suggests "(The acoustic piano) is certainly not going to disappear, but the place it's going to have in people's homes has still yet to be determined." (Kennedy, 2015) Doreen Hall (2017) pens another opinion. "As for the digital piano, how can it be described? In a word, dead. It's not a piano at all, it is a computer, a sampling of sounds represented by binary code. It is limited in the ways it can be played. I believe acoustic pianos are better for students in most cases." But Alex Marten said this in 2012, "There are four reasons why digital pianos are better than acoustic pianos: they are more versatile, you never need to tune them, you can play in silence, and they don't take up much room."

The improvement of digital piano in regards to tone quality, touch, feel, versatility, and overall construction has unquestionably happened, and this definitely helps to feed arguments like those mentioned earlier. But the challenges of nuance, expression, hammer sound, and sound reproduction have always been a reality with the instrument. Advances in technology have made things faster, easier, and in general better, but what drives opinions on digital pianos? Is it just the sound, or do these other elements enter in to the picture? Richard Moore suggested in

1988 that there were many dysfunctions of MIDI (Musical Instrument Digital Interface) that create poor performances and undesirable results. He suggests that regardless of the quality of the sound, MIDI lacks the robustness of expression, control intimacy, the inability to perceive millisecond delays, delay uncertainties, sluggish channels, information bursts, and smearing. "The principal effect of having a sluggish channel between the performer's actions and the synthesized sound is to decrease the sonic identity of each performed note. The result of this process is that triggered synthesized sounds seem rich but repetitive, while smeared synthesized sounds (the result of triggered information that is faster than the MIDI transmission rate) are not intimately controllable by the performer." (Moore, 1988) Van den Berghe, De Moor, and Minten believe that a better digital piano includes a better grand piano key action. "The traditional keyboard, which existed in essentially the same form for the last several centuries, is not yet found in electric pianos." (Van den Berghem De Moor, and Minten, 1995) They go on to conclude:

> "The actual scan system used in most synthesizer keyboards today is not capable of predicting the hammer velocity with any accuracy. It has been shown that the scan system must track the key displacement. Using a detailed mathematical model, we can improve the sensitivity of electric pianos. To do this, the model must be reduced, the parameters must be trained from experiments, and the algorithm must be implemented in an ASIC."

Rauhala, Laurson, Valimaki, Lehtonen, and Norilo explored piano synthesis in 2008. They note "sound synthesis of the piano is a great challenge. The piano sound is difficult to synthesize mainly because it has a rich, somewhat inharmonic spectrum, and the decay characteristics of its partials vary significantly over time." The researchers created a parametric model that they

conclude “is an excellent tool for perceptual experiments in which the perception of specific parameter values is investigated; the results from these experiments can provide information on how to further develop the model to produce perceptually ‘good’ piano tones.” It appears that Roland’s 2017 digital pianos have attempted to do so. The current instruments feature piano modeling rather than a playback of samples. The idea is that the piano model can replicate the nuances of tone interaction, hammer noise, and harmonics in a more realistic way if the algorithms are good enough.

There has been much interest in the digital piano and how to develop it in such a way that it is a true replication of an acoustic piano. Research and development from major manufacturers as well as educational institutions have produced instruments that are some of the most powerful pianos to date. Although opinions exist on multiple ends of the spectrum, the goal of this research project is to determine if we have grown to a point where digital pianos and acoustic pianos are similar enough that using either does not matter in to the average listener. Simply put, does it sound like a piano, regardless of whether or not it is digital? Is there still a preference in the majority of consumers? This study hopes to shed some light on the subject of whether or not the opinions of an acoustic or digital piano actually matter in today’s technological world.

Chapter 3 – About the Study

In designing data collection tools for the study, it was important to consider what factors may or may not have an effect on the listener. It was imperative to test different types of both acoustic and digital pianos of varying quality, as well as present the pianos in contrasting styles of music. Within a stylistic sample, the piano performances needed to be performed as similarly as possible across the selection of pianos so that artistic impression and technical skill had little to do with the outcome of the survey results.

Participants were 15 years of age or older and were either high school students, college students, or adults, with varying amounts of musical knowledge. They were asked to listen to three excerpts from a variety of pieces each played on four different pianos. The first excerpt was from Aaron Copland's "The Cat and the Mouse." It features a robust piano part that uses a large range of the piano with very intense dynamics. The second piece was a very soothing, gentle song called "Behind the Waterfall/Desert Rain Medley." Composed by David Lanz, the intention of this choice was to be in stark contrast with the first excerpt. It has a "pop" feel, but could easily be thought of as background piano easy listening music. Finally, the third piece, "She Cries" from Jason Robert Brown's *Songs for a New World* again shows intense dynamics in a popular, musical theater style. While the pieces used maybe be unknown to most, the styles are easily recognizable as piano-centered. This might have allowed the listener to identify the piano sound with songs of similar styles outside of the survey. The listener may unconsciously ask, "Does the piano in this recording sound like another song I know?" It should be stated that individual participants of the survey may or may not have had knowledge or recollection of the pieces presented to them.

The recordings were made using four different pianos. Two were acoustic instruments, while the remaining two were digital. Within each category, both high and low budget instruments were used, representing pianos across the quality spectrum of both the acoustic and digital world. The first piano was Roland's new HP-605 Digital Piano and retails for $3,899. This digital piano uses a technique called "modeling" in which the sounds are created by synthesis. The sound engine is the most advanced Roland has ever created and does not rely on sampling like most other digital pianos. Roland says this about the technology:

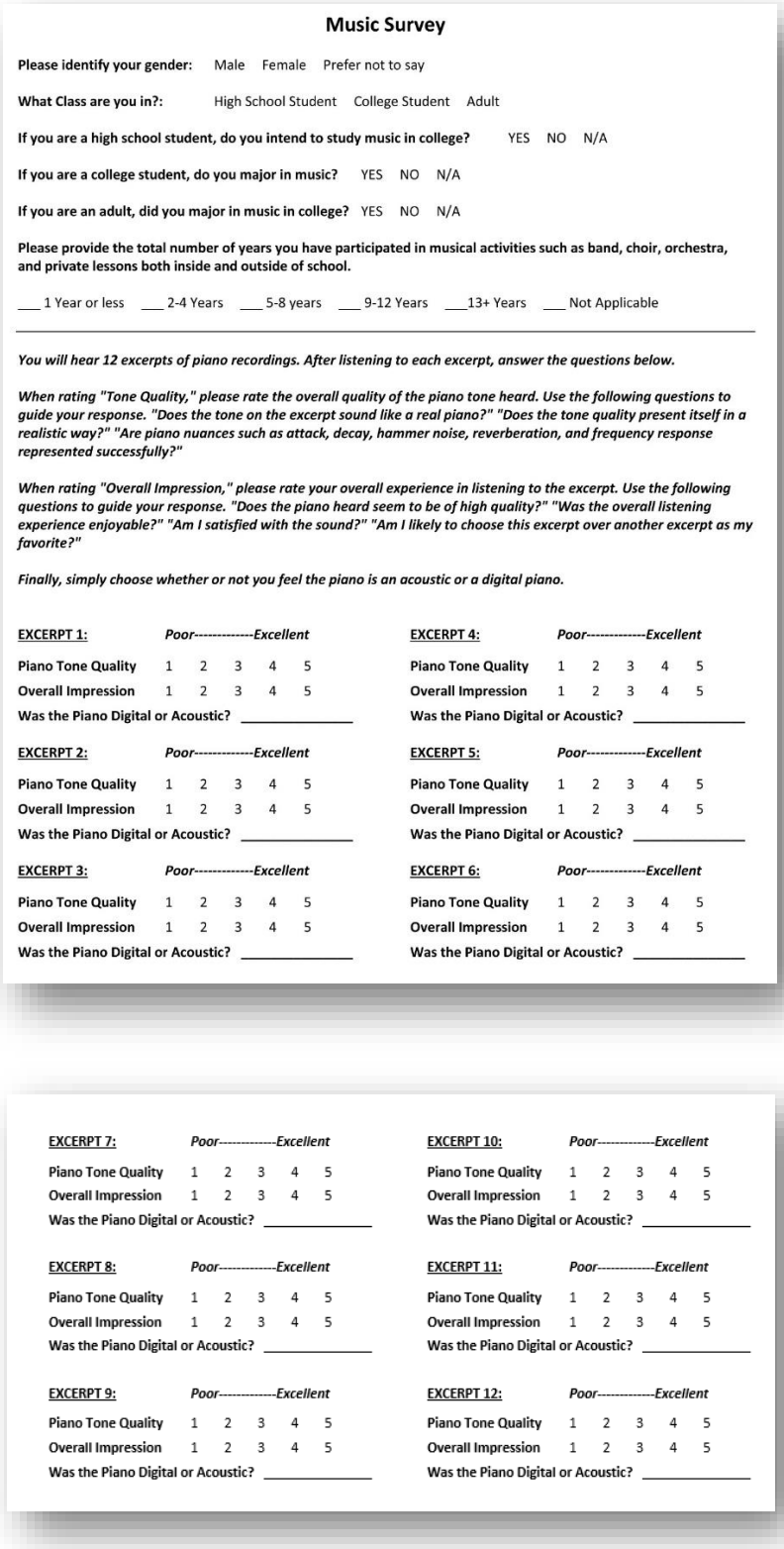
> "Press a key on most digital pianos and you'll hear a recording of a piano note. But a SuperNATURAL Piano works differently, using the latest modeling technology to recreate, rather than replay, the sound. The unique modeling process spans the entire sound creation process of a typical piano including the combination of notes played, their resonance and the way in which the piano's many elements interact with each other. The result is a rich, complex sound - complete with overtones - that actually changes in response to the way you play; something impossible to achieve when a piano uses samples. It's the difference between just listening back to a recording or actually being there yourself." (www.roland.com)

The other digital piano represented was Yamaha's top of the line CVP-709 Clavinova. While the piano does use sampling at its core, it does so with realism and nuance, using a large number of samples per note to create the most realistic sampled piano sound possible. The instrument retails for about $9,500. The first acoustic piano was a 9-Foot Acoustic Baldwin Concert Grand Piano. It was built in the 1960's and was in good condition. If purchased new, the piano would retail around $103,500. Finally, the second acoustic piano was a Boston UP118S. This model is

frequently specified for schools and retails for around $6,500. At the time of recording, this piano was approximately one year old.

The recordings were made in a large high school auditorium that seats approximately 1,300 people. Acoustically, the space was fairly dry. Bass tones tended to dissipate quickly while higher frequency sounds moved rapidly and very directionally. However, it was possible for each of the pianos to be heard throughout the space in an even way. During the actual recording, other than the musicians, no one was in the auditorium. Recordings were captured in stereo using two high quality large diaphragm Shure KSM42 microphones, Presonus Audiobox USB audio interface, and Pro-Tools digital audio workstation software. Editing was also performed in Pro-Tools. Other than simple fade in's and out's, no processing was used on the recordings. The pianist was the same for all four recordings of a particular excerpt so that the musical attributes of the piano technique used within the excerpt were the same or similar among all of the pianos recorded.

Each of the participants were asked to complete a survey based on the recordings that were made. (Figure 3.1)



Music Survey

Please identify your gender: Male Female Prefer not to say

What Class are you in?: High School Student College Student Adult

If you are a high school student, do you intend to study music in college? YES NO N/A

If you are a college student, do you major in music? YES NO N/A

If you are an adult, did you major in music in college? YES NO N/A

Please provide the total number of years you have participated in musical activities such as band, choir, orchestra, and private lessons both inside and outside of school.

___ 1 Year or less ___ 2-4 Years ___ 5-8 years ___ 9-12 Years ___13+ Years ___ Not Applicable

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You will hear 12 excerpts of piano recordings. After listening to each excerpt, answer the questions below.

When rating "Tone Quality," please rate the overall quality of the piano tone heard. Use the following questions to guide your response. "Does the tone on the excerpt sound like a real piano?" "Does the tone quality present itself in a realistic way?" "Are piano nuances such as attack, decay, hammer noise, reverberation, and frequency response represented successfully?"

When rating "Overall Impression," please rate your overall experience in listening to the excerpt. Use the following questions to guide your response. "Does the piano heard seem to be of high quality?" "Was the overall listening experience enjoyable?" "Am I satisfied with the sound?" "Am I likely to choose this excerpt over another excerpt as my favorite?"

Finally, simply choose whether or not you feel the piano is an acoustic or a digital piano.

EXCERPT 1: *Poor----------Excellent*
Piano Tone Quality 1 2 3 4 5
Overall Impression 1 2 3 4 5
Was the Piano Digital or Acoustic? _____

EXCERPT 2: *Poor----------Excellent*
Piano Tone Quality 1 2 3 4 5
Overall Impression 1 2 3 4 5
Was the Piano Digital or Acoustic? _____

EXCERPT 3: *Poor----------Excellent*
Piano Tone Quality 1 2 3 4 5
Overall Impression 1 2 3 4 5
Was the Piano Digital or Acoustic? _____

EXCERPT 4: *Poor----------Excellent*
Piano Tone Quality 1 2 3 4 5
Overall Impression 1 2 3 4 5
Was the Piano Digital or Acoustic? _____

EXCERPT 5: *Poor----------Excellent*
Piano Tone Quality 1 2 3 4 5
Overall Impression 1 2 3 4 5
Was the Piano Digital or Acoustic? _____

EXCERPT 6: *Poor----------Excellent*
Piano Tone Quality 1 2 3 4 5
Overall Impression 1 2 3 4 5
Was the Piano Digital or Acoustic? _____

EXCERPT 7: *Poor----------Excellent*
Piano Tone Quality 1 2 3 4 5
Overall Impression 1 2 3 4 5
Was the Piano Digital or Acoustic? _____

EXCERPT 8: *Poor----------Excellent*
Piano Tone Quality 1 2 3 4 5
Overall Impression 1 2 3 4 5
Was the Piano Digital or Acoustic? _____

EXCERPT 9: *Poor----------Excellent*
Piano Tone Quality 1 2 3 4 5
Overall Impression 1 2 3 4 5
Was the Piano Digital or Acoustic? _____

EXCERPT 10: *Poor----------Excellent*
Piano Tone Quality 1 2 3 4 5
Overall Impression 1 2 3 4 5
Was the Piano Digital or Acoustic? _____

EXCERPT 11: *Poor----------Excellent*
Piano Tone Quality 1 2 3 4 5
Overall Impression 1 2 3 4 5
Was the Piano Digital or Acoustic? _____

EXCERPT 12: *Poor----------Excellent*
Piano Tone Quality 1 2 3 4 5
Overall Impression 1 2 3 4 5
Was the Piano Digital or Acoustic? _____

Figure 3.1 – *Paper copy of the survey. Most participants used the online version.*

The participants were first asked to identify their gender. Then, they were asked to identify what "class" they were in, specifically high school student, college student, or adult. High School Students were then asked if they intend to study music in music in college, while college students were asked if they studied music in college. Similarly, adults were asked if they majored in music in college. Participants were also asked about the number of years they have participated in music. This was to include a combined number of years of private instruction, secondary school ensemble participation, and college ensemble participation.

Next, the participants listened to the four recordings of each excerpt and rated the categories subjectively on a scale from 1 (Poor) to 5 (Excellent). The excerpts were played one recording at a time, and were only played once. Excerpt one was "The Cat and the Mouse," excerpt two was "Behind the Waterfall/Desert Rain Medley," and excerpt three was "She Cries." The piano recordings were randomized within the excerpts so that there was not a predictable pattern of pianos played or that the same piano was always featured in excerpt 1, recording 1; excerpt 2 recordings 1; etc…Excerpt 1 recording 1 featured a different piano than excerpt 2 recording 1 and so on. The categories that were rated included piano tone quality and overall impression. These were defined to the participants using the following descriptors and questions:

- **Piano Tone Quality:** When rating "Tone Quality," please rate the overall quality of the piano tone heard. Use the following questions to guide your response. "Does the tone on the excerpt sound like a real piano?" "Does the tone quality present itself in a realistic way?" "Are piano nuances such as attack, decay, hammer noise, reverberation, and frequency response represented successfully?"

- **Overall Impression:** When rating "Overall Impression," please rate your overall experience in listening to the excerpt. Use the following questions to guide your response. "Does the piano heard seem to be of high quality?" "Was the overall listening experience enjoyable?" "Am I satisfied with the sound?" "Am I likely to choose this excerpt over another excerpt as my favorite?"

After rating those categories, particpants were then asked to identify whether or not they felt the piano in the recording was a digital piano or an acoustic piano.

Analysis to be done after the survey portion has been completed included:

- Did participants correctly identify the acoustic pianos and the digital pianos?
- If they did identify the pianos correctly, was there a higher percentage of correct responses from people with more musical background?
- Does the age of the participant affect the ability to identify the pianos correctly?
- Does the gender of the participant affect the ability to identify the pianos correctly?
- What pianos and/or recordings had the best and the worst perceived tone quality?
- What pianos and/or recordings had the best and the worst percieved overall impressions?

The data collected from the surveys is what was used to generate the results and conclusions of the study.

Chapter 4 – The Results

The primary purpose of this study was to see if participants could correctly identify acoustic and digital pianos. It focused on four different pianos, two acoustic and two digitals. Recordings were made of excerpts of three stylistically different pieces on each piano. Subjects listened to all 12 recordings and were asked to rate the piano tone quality and their overall listening impression of each sample. Finally, subjects were asked if the piano heard in the recording was digital or acoustic.

Additionally, this study examined if musical background, age, or gender had any significant correlation in identifying the pianos correctly. Finally, the study identified which pianos had the best perceived tone quality and left the best overall impression on the listener. The (null) hypothesis is that there will be no significant difference in the ability of the participants to identify acoustic pianos versus digital pianos.

Figure 4.1 represents which piano was used in the recording, the piece recorded, and the style of the piece. Figure 4.2 represents the number of subjects that correctly identified the piano from the sample of 305 responses (n=305). While many of the recordings yielded similar results, Excerpt 2, Piano 1 and Excerpt 3, Piano 2 seemed to be more difficult to identfy correctly, only yielding 144 and 148 correct responses respectively. Excerpt 1, Piano 3 yielded the best results, with 204 correct responses (66.9%). On average, the correct answer was given 59.4% of the time.

Excerpt	Piano	Piece	Style
Excerpt 1, Piano 1	ACOUSTIC: Baldwin Concert Grand Piano	**"The Cat & The Mouse"** Aaron Copland	Classical Piano
Excerpt 1, Piano 2	DIGITAL: Yamaha CVP-709 Clavinova		
Excerpt 1, Piano 3	ACOUSTIC: Boston UP118S Upright Piano		
Excerpt 1, Piano 4	DIGITAL: Roland HP695		
Excerpt 2, Piano 1	ACOUSTIC: Boston UP118S Upright Piano	**"Behind the Waterfall/Desert Rain Medley"** David Lanz	Ballad
Excerpt 2, Piano 2	DIGITAL: Roland HP695		
Excerpt 2, Piano 3	ACOUSTIC: Baldwin Concert Grand Piano		
Excerpt 2, Piano 4	DIGITAL: Yamaha CVP-709 Clavinova		
Excerpt 3, Piano 1	DIGITAL: Roland HP695	**"She Cries"** *from Songs for a New World* Jason Robert Brown	Musical Theater Pop
Excerpt 3, Piano 2	ACOUSTIC: Baldwin Concert Grand Piano		
Excerpt 3, Piano 3	DIGITAL: Yamaha CVP-709 Clavinova		
Excerpt 3, Piano 4	ACOUSTIC: Boston UP118S Upright Piano		

Figure 4.1 – *Correct Responses & Recording Descriptions*

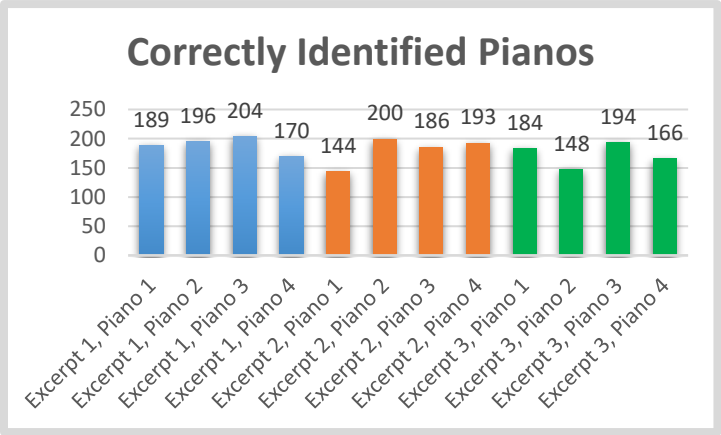

Figure 4.2 – *Correctly Identified Pianos*

The R value .846 indicates a strong correlation between the years of experience and the percentage of correct responses. The r-squared value 0.715 indicates that the 71.5% of variance in the data between the years of experience and the percentage correct can be explained by the linear relationship of years of experience. Thus, it appears that a person's musical experience does influence the ability to correctly identify the pianos. (Figure 4.3)

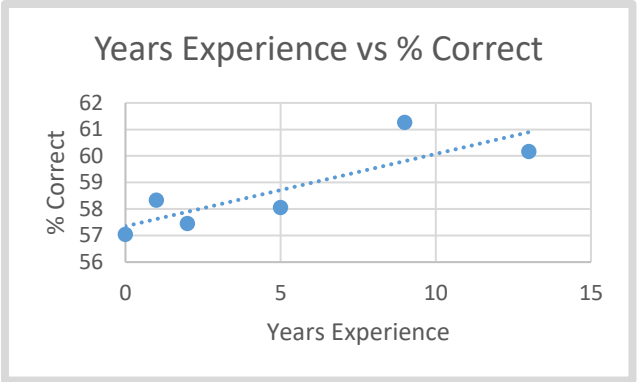

Figure 4.3 – *Years Experience vs % Correct*

The data also suggests that the style of song may influence an individual's abiility to distinguish between the types of pianos. However, the percent correct decreased from excerpt 1 to excerpt 3 in all experience categories except 2-4 years. (Figure 4.4) This could indicate that a participant's interest in the study or listening fatigue may also have influenced the results. A future study could examine the fatigue issue by randomly placing the pieces in the order of which they are heard. A much larger sample size would be needed, in this case, to ensure that the other areas of the study are evenly investigated as well.

Experience	n	Excerpt 1, % Correct	Excerpt 2, % Correct	Excerpt 3, % Correct	% Average All Excerpts
1 Year or Less	7	60.7	53.6	60.7	58.3
2 to 4 Years	47	55.9	60.6	55.9	57.4
5 to 8 Years	90	60	58.6	55.6	58.1
9 to 12 Years	59	64.3	61.9	57.6	61.3
13+ Years	84	63.8	59.2	57.4	60.2
N/A	18	61.4	52.8	56.9	57.0

Figure 4.4 – *Correctly Identified Pianos in Regard to Musical Experience*

The data regarding matriculation status is statistically indifferent. (Figure 4.5) It appears that college students seem to have a better chance at selecting the correct response, but the small sample size of that group (n=11) isn't enough data to compare to the adults (n=140) and high school students (n=154). If you compare the percentage correct between adults and high school students (similar sample sizes), there is only a 0.1% difference, interestingly enough, favoring high school students. A better sample spread among populations would be needed to determine anything from this data.

Matriculation Status	n	Excerpt 1, % Correct	Excerpt 2, % Correct	Excerpt 3, % Correct	% Average All Excerpts
Adult	140	63.0	57.1	56.4	59.4
College Student	11	65.9	63.6	63.6	64.4
High School Student	154	61.2	60.9	56.5	59.5

Figure 4.5 – *Correctly Identified Pianos in Regard to Matriculation Status*

The difference of mean scores between men and women overall (% average, all excerpts) is between -0.0335 and -0.0145. Using a standard deviation of .438 for men and .372 for women, with a 95% confidence interval, it can be stated that men are able to select the correct answer more often than women. (Figure 4.6) Of most interest is that a particular musical style could effect the ability to identify the piano correctly. The difference of mean scores among men and women for excerpt 1 is between -0.0124 and 0.00644 and is between -0.0006 and 0.01864 for excerpt 3. This suggests that there is no real statistical difference amid men and women, but excerpt 2 yielded a difference of means between -0.0875 and -0.0685, suggesting that gender does influence the ability to determine piano types. More testing would need to be completed

to further this hypothesis. Participants who opted not to specify gender were not included in these calculations.

Gender	n	Excerpt 1, % Correct	Excerpt 2, % Correct	Excerpt 3, % Correct	% Average All Excerpts
Female	175	62.0	55.7	57.6	58.4
Male	124	62.3	63.5	56.7	60.8
Prefer Not to Say	6	66.7	75.0	33.3	58.3

Figure 4.6 – *Correctly Identified Pianos in Regard to Gender*

Perhaps of most interest was the overall perceived quality of each piano. In regards to tone quality, every excerpt with an acoustic piano scored higher than digital pianos, with the exception of the acoustic grand piano recording in excerpt 3. The highest rated tone qualities were for the Acoustic Upright recordings in excerpt 1 and excerpt 2, both receiving a rating of 4.1. The lowest tone quality rating was for the digital clavinova recording in excerpt 3, receiving a rating of 3.3 However, it is interesting to note that in some cases, the quality of the acoustic and digital pianos were the same or similar. For example, the digital Roland in excerpt 1 scored the same (3.7) as the acoustic upright recording in excerpt 3. (Figure 4.7)

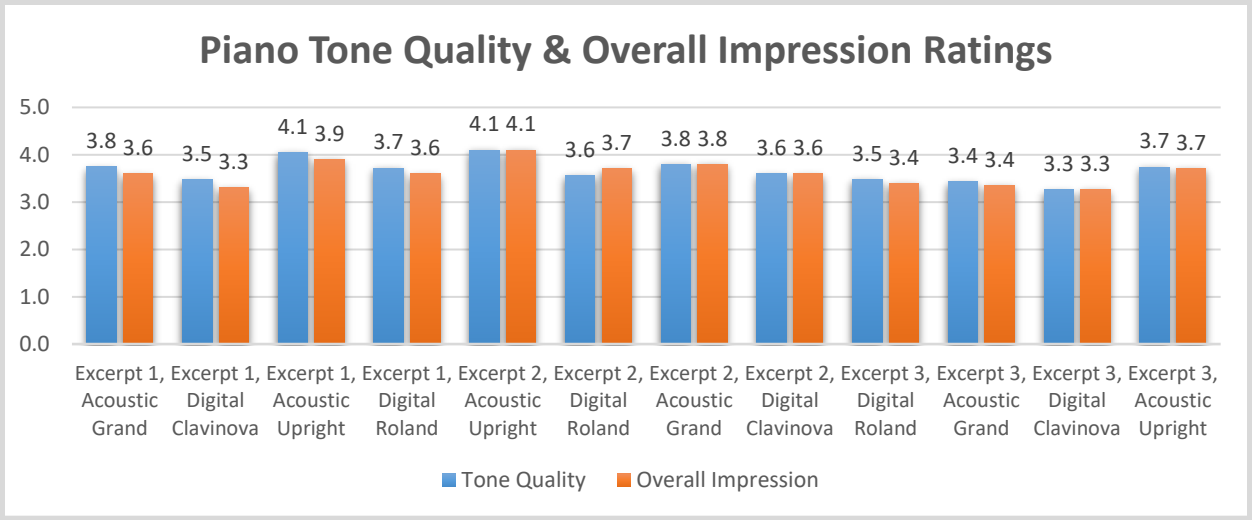

Figure 4.7 – *Piano Tone Quality & Overall Impression Ratings*

Amongst the digitals, the Yamaha Clavinova received a rating of 3.4 overall, while the Roland received a rating of 3.6. When comparing acoustics, the Baldwin Grand received a rating of 3.7 overall, while the Boston upright piano received a rating of 4.0. We can conclude that, in general, people preferred the tone quality of acoustic pianos over digital pianos. It is interesting to note, however, that the Roland digital piano scored similarly to the Baldwin Grand and overall, the preferred tone quality was that of the Boston upright. This might suggest that the most commonly heard piano is an upright piano. (Figure 4.8)

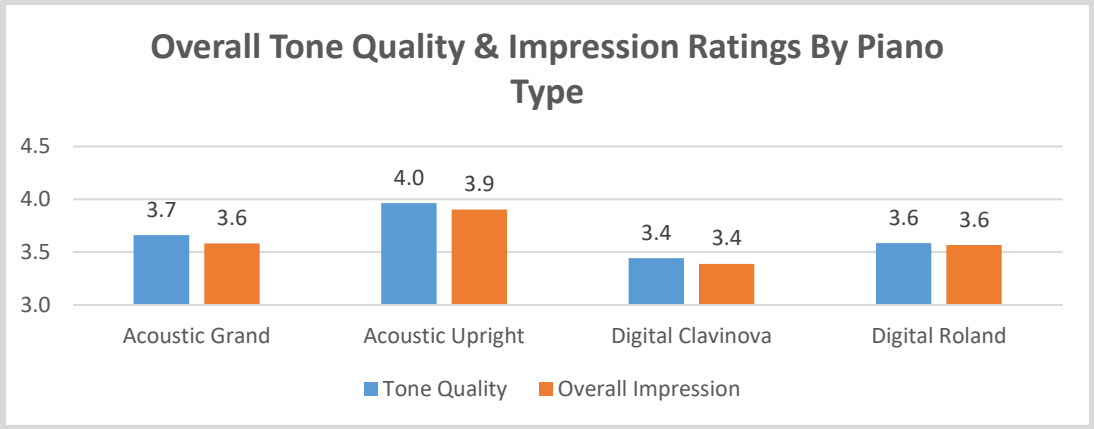

Figure 4.8 – *Piano Tone Quality & Overall Impression Ratings*

The results were similar with the Overall Impression category. The pianos scored 3.4, 3.6, 3.6, and 3.9 for the Digital Clavinova, Digital Roland, Baldwin Grand, and the Boston Upright respectively. Of most interest, the digital Roland and the Baldwin Grand left the same impression on listeners, suggesting that the null hypothesis, at least among those two pianos, is true. The data also seems to suggest that the style of the piece also factors into what the listener perceives. For example, the overall impression in excerpt 3 was the same for the Digital Roland (3.4) and the Baldwin Grand (3.4), but in excerpt 2, the Digital Roland scored a 3.7 while the Baldwin Grand scored a 3.8. Both pianos scored the same in excerpt 1 (3.6).

Overall, 59.38% of the population was able to accurately determine whether or not the audio excerpt was generated by a digital or acoustic piano. The (null) hypothesis is that there will be no significant difference in the ability of the participants to identify acoustic pianos versus digital pianos. Since there were two options, participants had a 50% chance of providing the correct answer even if they were unable to identify the type of piano. Using the sample mean of 59.38 and a standard deviation of .826, with 95% confidence, the confidence interval is 59.37 to

59.43. Since the 50% does not lie within the confidence interval, the null hypothesis must be rejected, as there is statistical evidence supporting the participant's ability to correctly identify the piano type.

Chapter 5 - Conclusion

The results of the study show that, on average, listeners can determine whether or not a piano is digital, despite the excellent technologies that are in place today. However, it appears that musical experience is a factor in determining whether or not someone can correctly identify the piano type. This study was unable to determine if matriculation status has anything to do with one's ability to select the correct piano; however, it might be able to be determined if this study had a larger sample size. In general, men were able to identify the correct piano more often than women, and it appears that the style of the piece may affect one's abilty to determine the correct piano. This could be tested in a study with random placements of the excerpts. It can also be said that an acoustic piano is still preferred over a digital one, but, at least in this study, an acoustic grand piano was not the preferred piano. Instead, an upright piano was the most pleasing. In the end, that is surprising, given the strong opinions people have of specific piano types.

There are still other factors to consider that were beyond the scope of this study. For instance, does the concert hall itself effect the perceived sound of the piano? If the four pianos were moved to a small room, would the results have been the same? If a different microphone was used for the recordings, would the results change? The underliying issue of listener fatigue is also not addressed. Would the results be different if there were fewer excerpts? Since the study also seems to point to musical styles playing a factor in one's ability to determine the piano type, more genres of music should be considered in future. Finally, the study was dependent on the pianos themselves. Would other acoustic pianos garner different ratings? Would other digital

pianos rate better or worse than those used in this study? Do brands themselves have anything to do with perceived sound quality?

While we cannot answer these questions, the study does suggest that some digital pianos are thought to be "as good" as some of their acoustic counterparts. Perhaps of most interest, participants rated the overall impression of the Roland Digital Piano (3.6) the same as the Baldwin Concert Grand Piano (3.6). Although the tone quality was rated slightly higher for the Baldwin (3.7 vs. the Roland's 3.6), it is quite remarkable that a digital piano costing $3899 seemed to rival the sound of an acoustic piano that cost $103,500. So, does a particular digital piano sound as good as its acoustic counterpart? Statistical evidence shows that someone can correctly identify the piano *type,* but, a digital piano may certainly sound as good as *some* acoustic pianos.

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