

Synesthesia for Universal Design

An exploratory thesis on synesthesia as a potential method for universal design.

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Abstract

The objective of this thesis aimed to explore a methodology in which participants pair sound to abstract paintings by extracting compositional elements in the form of color and shape from those paintings and pairing them with sound elements of pitch and timbre. The selection of sound choices were based on experiences from a select number of chromesthetes to use as a control to discover if the general public will make the same sound to color associations as those select chromesthetes in order to raise awareness of synesthesia and apply this knowledge in creating multisensory experiences and environments for universal design practice. An online testing environment was created using compositional elements (color and shape) from abstract paintings in which 5 sound options relating to pitch or instrument were provided. One of these options was used as the chromesthete control option. Based on participant responses, each question was evaluated to determine if the majority of participants chose the chromesthete control. If the chromesthete control was not the majority chosen option, additional analysis was completed to understand if there was an accord for one option over others. Ultimately, results were low, in most instances below 40% unanimity. Sound choices were dispersed for many questions, of which the highest agreement in sound choice was 20%.

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Definition of Terms

1. Synesthesia

A neurological and perceptual phenomenon in which the stimulation of one sensory cortex involuntarily triggers the perception of an additional sensory cortex. This perception can be projective or associative.

2. Projective Synesthesia

The physical reaction of synesthesia in which a person physically sees a color or shape, feels an object, or hears a sound that is not physically present in response to a stimulus.

3. Associative Synesthesia

The perceptual reaction of synesthesia in which a person very strongly and involuntarily associates a color, shape, or sound (in their mind) to a stimulus but doesn't not physically experience it.

4. Synesthete

A person with synesthesia.

5. Chromesthesia

A type of synesthesia in which sound involuntarily triggers the perception of color. Also known as *sound-color synesthesia*.

6. Chromesthete

A person with chromesthesia.

7. Synesthesia Battery Test

An approved, reliable, standardized test used by researchers to verify synesthetic participants for study created by neuroscientist David Eagleman.

8. Synesthesia Battery Test Preview Questions

A preview set of seven questions from the full Synesthesia Battery Test.

9. Universal Design

Design (products, exhibitions, environments, etc.) that is accessible to all people, regardless of age, size, ability, and disability. Also known as *inclusive design*.

10. Timbre

Distinguishable characteristic of a sound, particularly relating to tone, of a musical instrument. *Defined for the purposes of this paper.*

Introduction

Have you ever stopped to “taste” the roses, or “listen” to the color yellow? Maybe you have. However, many of us will likely raise a quizzical eyebrow as we know in physical reality that yellow, whether manifested in ink, paint, on screen, etc. doesn’t have a specific sound associated with it, in comparison to say that of a cow (“MOO!”). The purpose of this paper isn’t asking you to actually dip your ear in yellow paint. This thesis aimed to explore a methodology in which we pair sound to abstract paintings by extracting compositional elements in the form of color and shape from those paintings and pairing them with sound elements of pitch and timbre. The selection of sound choices were based on experiences from a select number of chromesthetes to use as a control to discover if the general public will make the same sound to color associations as those select chromesthetes in order to raise awareness of synesthesia and apply this knowledge in creating multisensory experiences and environments.

Visual art typically relies on our ability to see it. However, “the essence of a painting or sculpture doesn’t solely rely on our ability to physically see it, but rather our ability to create a memorable, meaningful connection with it.”² If involving multiple senses enables us to have a more memorable connection, how can we begin to understand how to pair an additional sense (*e.g.* sound) with something that is primarily visual (*e.g.* paintings), to create a memorable, meaningful experience? Film has been doing this for years, combining sound with the moving image. In video production, the videographer will capture the principle footage to tell the story (A-Roll) as well as supplemental footage (B-Roll)

to support and provide depth and context to the principle footage. B-Roll footage also includes supporting sound: a ball bouncing, birds chirping, horn blowing, etc. During my graduate studies, I studied videography for two semesters. From concept to execution, we had to continually think about not only what was going to be visually represented on screen but also what it would sound like. At first, this task seemed straightforward. Subjects with a physical presence have a physical sound. As my work became more abstract, and my visual subject lacked a physical presence, I wondered how to apply sound that the audience could connect with. My thinking expanded further into print design as the majority of my professional design career has been based in print. I started wondering what people might hear when they receive a postcard that I designed in the mail. What sounds do my designs bring to mind? What sound do all visual abstractions bring to mind? For some individuals, this mingling of senses comes naturally and involuntarily. For the rest of us, however, it is completely subjective to our own artistic interpretation and expression.

Synesthesia is a neurological phenomenon where senses naturally mingle. In a person with synesthesia, the stimulation of one sense automatically triggers the perception of a second sense.³ Chromesthesia, a type of synesthesia, involves the pairing of sound to color automatically and was used in the research study conducted for this thesis to bring awareness to the condition and also to have a starting point on how to begin pairing sound with color. A person with chromesthesia (a “chromesthete”) associates or projects a color when hearing a sound. A chromesthete can experience these sensory overlaps in the form of pitch to color (i.e. C major is red), chord to color, and/or instrument to color

(i.e. the sound of a violin is green). If chromesthetes are already doing this, making these color and sound associations inherently, I wondered how a non-synesthete would translate the color red, or yellow, to sound. I began asking myself this very same question to start experimenting.

“What sound does this painting bring to mind?” I asked myself. I wasn’t really sure where to begin. Paintings usually contain multiple compositional elements. The complexity can be overwhelming, so I began dissecting each painting, looking at those compositional elements individually. What sound does this color bring to mind? What sound does this yellow line make? Since I am not a synesthete, I thought of verbal descriptors like “melancholy.” However, what sound does the word melancholy bring to mind? I used a USB piano keyboard and played individual keys. When I played the note “D” on the piano, I felt that it sounded yellow and melancholy. I cannot explain why I feel like yellow is best represented by D major, but I discovered I was not alone in my association. Several artists have described this phenomenon of synesthesia, including Wassily Kandinsky and Alexander Scriabin, using it as inspiration for their artistic expression (*Appendix A*). Alexander Scriabin, a synesthete and composer, also heard yellow as D major. Would other people have a similar experience and associate the color yellow with “D”, in the same way Alexander (a synesthete) and I (a non-synesthete) did? I began building a testing environment that contained a synesthetic control option (a chromesthetes association of color with sound) with additional, tonally different sounds to discover if the general public (both synesthetic and non-synesthetic) would also associate sounds to color as the selected chromesthetes did. It is

important to note that there were limitations to this study by using only a select number of chromesthetes. A small selection of chromesthetes was necessary particularly because of the lack of knowledge regarding synesthesia and therefore the lack of reporting of one's condition to research and use as controls.

Two test groups were established over the course of a year. The first test group of 25 participants provided inconclusive results, so an additional test group of 105 participants was added to increase the number of responses for more concise analytics. Participants were surveyed online and asked to pair a sound with a visual color. Results were recorded in order to obtain quantitative data that would validate the chromesthetic associations from the general population to compare to the chromesthete controls. All participants completed the Synesthesia Battery Test Preview Questions designed by David Eagleman⁵ after completing the sound-pairing survey to determine their synesthetic ability. The purpose of this sound-pairing survey was to determine:

- Do people pair sound with color as select chromesthetes do?

Synesthesia is a continually growing research topic as we explore new methods of measurement and understanding. While many people, particularly the general public, may not know if its qualities and whether they possess the ability, there is definite interest in the subject and the research process. I discovered this interest in participants' comments throughout my study, with many participants remarking how "interesting" or "cool" the process was.

Additional research questions were formulated and analyzed:

- How many participants are synesthetes based on the Synesthesia Battery Test Preview?
- Is there a commonality in sound-pairings between synesthetes vs. non-synesthetes?
- Is there a commonality in any of the sound-pairings?
- Does being a musician affect participants' sound choices?

It was important to understand how many participants could be synesthetic since having synesthesia, particularly chromesthesia, can affect how one experiences color and sound together. It was also important in raising awareness of the condition to the general public and introducing identifiers of synesthesia to them for potential diagnosis. Through my research, I discovered that out of 130 total participants, not one self-identified as a synesthete. A little more than half of the participants self-identified as a non-synesthete, with nearly half of participants unsure if they possess the condition, leading me to conclude that many people today are still relatively unaware of the condition known as synesthesia and more importantly, whether they possess it or not.

Documenting participants' musical background was of interest to this survey in order to understand if having a musical ear affects their choices of sound and color together. Many famous recording artists over the last few years (i.e. Lorde, Pharell Williams, Billy Joel) have come forward stating they have this condition of synesthesia, and in many instances, the type of synesthesia they have is chromesthesia. Musicians have also been used in the creation of multisensory exhibitions

that pair sound with other sensory stimuli (vision, smell, touch, taste). Based on my own findings, participants who currently play an instrument more frequently agreed on particular sound choices to colors as opposed to those who do not currently play an instrument or have never played an instrument.

This thesis combined several areas of research together (exhibition design, design and art theory, neurology, psychology, multisensory design, music and sound theory, and more) with a focused center on synesthesia in order to further understand the phenomenon and formulate a methodology that can be used by researchers moving forward in the design and implementation of multisensory experiences and environments, and to also understand and add to the progress of synesthesia research. Multisensory exhibitions today often attempt to evoke a sense of synesthesia by pairing visual artists and sound artists together to create a new art form for exhibition display (an *ekphrasis*, art inspired by art), which is often interactive through motion or touch. Suzanne MacLeod, Professor of Museum Studies at the University of Leicester, believes visitor-centered exhibition and museum design enhances the visitor experience. In adding a multisensory component (e.g., sound) to an exhibition that would include visitor research, I feel that a more memorable, meaningful experience could be achieved if the visitors experienced the same associations to sound and visuals paired together, rather than experiencing someone else's interpretation (an *ekphrasis*). The information obtained from visitor research could help create more unique, individualized experiences for each visitor. Additionally, the data obtained from participants who registered for the

Synesthesia Battery Test are accessible to researchers at the University of Sussex and could be used in their research in hopes of “speed(ing) scientific progress in synesthesia research.”⁶

Interdisciplinary Approach to Multisensory Design

INCLUSIVE DESIGN

Multisensory experiences in the arts have been used as a tool for universal design, also known as inclusive design, which makes design (products, exhibitions, environments, etc.) accessible to all people, regardless of age, ability, etc. Recent examples can be seen across the globe in multisensory museum exhibitions such as *Collide, Design for the Senses*, and *Multisensory Met*. Multisensory artistic expression has been used by painters, sculptors, musicians, and more who either wish to evoke a multisensory reaction and sense of synesthesia or use their neurological condition of synesthesia to express their abilities through art.

In the sciences, particularly but not limited to neurology and psychology, multisensory experience has been explored as the neurological phenomenon synesthesia, as a learning tool, and as potential for mental health treatment. A multisensory experience involves the triggering of multiple senses, which stimulates multiple cortexes of the brain. Jinsop Lee, an industrial designer, and Dr. Max Cynader, a neuroscientist, believes that as multiple senses are stimulated, the better we are able to create a memorable experience.¹ Multisensory research and experiences are interdisciplinary and therefore include many areas of study and collaborative efforts.

The Senses: Design Beyond Vision, a book based off of the exhibition *The Senses: Design Beyond Vision* held at the Cooper Hewitt Museum in New York in April 2018, describes contributions and research to the exhibition by “designers, architects, scientists, engineers, manufacturers, and users engaging in sensory design practice.”⁴ Inclusive design not only offers accessibility but also diversely includes many skill sets. Inclusive (universal) design is interdisciplinary. Interdisciplinary studies provides a foundation, if not *the* foundation, for new ideas, and as Lupton and Lipps state in *The Senses: Design Beyond Vision*, “we are designing the invention of a new medium... all senses design.”⁹

One particular exhibit at *The Senses: Design Beyond Vision*, titled “Taste of Music,” evoked synesthesia based on research collected from jazz musicians. The exhibit consisted of four buttons, each playing short musical compositions meant to evoke a particular taste (salty, sour, sweet, bitter) (*Appendix B*). The exhibit is based on research by Bruno Mesz, a pianist and mathematician from the MUNTREF Center for Art and Science at the National University of Tres de Febrero, Argentina, and Marcos A. Trevisan and Mariano Sigman, physicists from the Laboratory of Dynamic Systems at the University of Buenos Aires, University City, Argentina.

The research involved a group of jazz musicians who were asked to individually create short improvisations in response to basic taste words (salty, sour, sweet, and bitter).⁷ Patterns evolved throughout the results in associating taste with music: short, high pitched notes that were dissonant represented sourness; slow and low notes that were *legato* —

smooth and without breaks — represented bitterness; long, low, and soft notes were sweet; and *staccato* — quick, sharply separated — notes were salty.⁴ These musical compositions were then presented to listeners with no musical training. The task was to pair one taste word to each musical piece, with the results at over 70% affirming the same associations as the musicians.⁸

In listening to the compositions, myself, I felt changes occur in my mouth as I played each piece. My mouth puckered as I listened to the sour composition, slightly inciting an inward chill as if I had just bit into a pickle. The lingering of dark chocolate melting in my mouth was tasted as my ears listened delicately to the bitter composition. However, the research conducted for this particular experiment (“Taste of Music”) did not state reasoning for choosing individuals with “no extensive musical or culinary background” only stating that these factors “could have moderated the effects.”¹¹ It is also unknown if any of the jazz musicians or individuals selected for the second phase of the “Taste of Music” experiment were synesthetic. This information could have also affected their results.

In *Multisensory Met* at the Met Media Lab Expo held in 2015 created by Ezgi Ucar, ideas for a more accessible, engaging, and welcoming museum experience were exhibited. Scratch-and-sniff booklets were provided alongside famous paintings, such as Claude Monet's *Garden at Sainte-Adresse* (Appendix C). Meant to stimulate the sense of smell, these books displayed scents of the paintings as they would represent in real life (for Claude Monet's *Garden at Sainte-Adresse*: florals, saltwater, spicy-cocoa). Sound paintings were also created based on real life sense

responses, for instance, *Jean Monet (1867–1913) on His Hobby Horse* (Appendix D) was presented alongside four sounds including “an ambient nature sound for the bushes, a child talking, a horse neighing, and the sound of moving carriage wheels.”¹⁰ However, it’s important to take into account the representational, or figurative, nature of these artworks and positioning them with their real life counterparts. Since elements of nonrepresentational, abstract art don’t have specific real-life counterparts, how do we choose sounds for those paintings in order to create an inclusive experience for everyone? There is a lack of methodology on how to apply sound to nonrepresentational, abstract art in order to create a multisensory (exhibition) experience that incorporates synesthetic research, so I attempted to create one. Since synesthesia is a phenomenon in which senses are activated for generally non-physical things (the color red is C major, or a thin line represents the sound of a violin), it was hypothesized that it’s qualities, particularly those associated with chromesthesia, could be used for pairing sound with nonrepresentational art to create a visitor-centered and visitor-inclusive gallery experience for both synesthetes and non-synesthetes.

Collide, an installation for Dolby Laboratories by Onformative digital art and design studio, transformed motion data into abstract visuals that were then interpreted by three cellists, of unknown synesthetic ability, into a musical composition (another *ekphrasis* experience).²⁷ The video composed of the abstract visuals and musical composition was displayed on a 62-foot long screen to create an immersive experience inspired by chromesthesia for visitors. This new work of art by Onformative is beautifully crafted, modern, technology

driven, and collaborative but was not constructed from visitor experience. While these exhibitions I've listed in this section are multisensory, they are essentially an *ekphrasis* experience, one artist's work inspired by another artist's work presented to visitors for a general experience, rather than an individualized, uniquely tailored experience.

Lupton and Lipps' encourage us to "design for synesthesia" as a component for universal design. Designing and evoking a sense of synesthesia is different than actually having the condition synesthesia. In order to design for it, and particularly with it, I believe it's relevant to understand it both as a neurological phenomenon and as a multisensory tool into perception. Participants in my study were documented as potentially synesthetic versus non-synesthetic. Their responses were analyzed as an overall group but also separated into synesthetes versus non-synesthete comparisons. This was to understand if people with some form of synesthesia perceive certain sounds to color similarly as a collective.

SYNESTHESIA, TESTING, AND QUASI-SYNESTHESIA

Synesthesia is an involuntary, neurological phenomenon in which one sense that is triggered by stimuli involuntarily triggers another sense [*unidirectional synesthesia*] or multiple senses [*bidirectional synesthesia*] to react. It is estimated that 4% of the population have this capability.¹⁵ Documentation of synesthesia experiences date as far back as the 1800s, with the first documented case being Georg Tobias Ludwig Sachs in 1812. In his medical dissertation, Georg describes experiences he has that are defined today as chromesthesia and grapheme-color synesthesia. Research and general interest in synesthesia has grown in recent years in the news, media, scientific, and creative communities as research and testing has become available to validate the neurological condition. Several present-day, popular musicians have spoken publicly about their own synesthesia, including Lady Gaga, Beyoncé, and Lorde. Additionally, new scientific testing has been made available on the subject. Before this, most people were unaware of their ability as a synesthete, either believing themselves to be strange or that everyone else also had this ability.¹²

The Synesthesia Battery Test was developed by David Eagleman and a team of researchers from the University of Texas Health Science Center. It is a standardized testing method for various types of synesthesia, the first of its kind, and is available for free at synesthete.org. Before beginning the battery test, visitors are encouraged to answer a short preview questionnaire (*Appendix E*) if they are unsure if they possess the ability. If the visitor answers “yes”

to any of the generalized questions, they are then prompted to register an account and go through the battery test. The battery test begins with offering additional varieties of synesthesia to choose from with descriptions and examples. Participants are then tested based on their selected type(s) of synesthesia.

The synesthesia battery test is able to calculate synesthesia based on two of the most commonly reported types of synesthesia: grapheme-color and chromesthesia. Grapheme-color synesthesia is the association of color to letters, numbers, days of the week, and/or months. A person with grapheme-color synesthesia may see the letter “L” as inherently blue, or the number 3 as yellow. Recording artist Lorde sees days of the week in color, with Friday consistently being green.¹³ Chromesthesia is the association of color to either to pitch, chords, and/or instruments. Russian composer Alexander Scriabin saw C major as red.

Additional testing for synesthesia can include fMRI, functional magnetic resonance imaging, but was not a resource available for this thesis. fMRI is a brain imaging technology that enables us to see the sensory cortexes in use. When our sensory organs come into contact with sensory stimuli, signals are sent to the coordinating sensory cortex of the brain (e.g. food to gustatory cortex, music to auditory cortex) that “light up” under brain imaging.

In non-synesthetes, only the corresponding sensory cortex is activated when the matching sensory organ is stimulated. However, in synesthetes, multiple sensory cortexes react – “light-up” – when only one sensory organ is stimulated. For example, when a non-synesthete hears the word “jail” under fMRI, only the auditory cortex of the brain

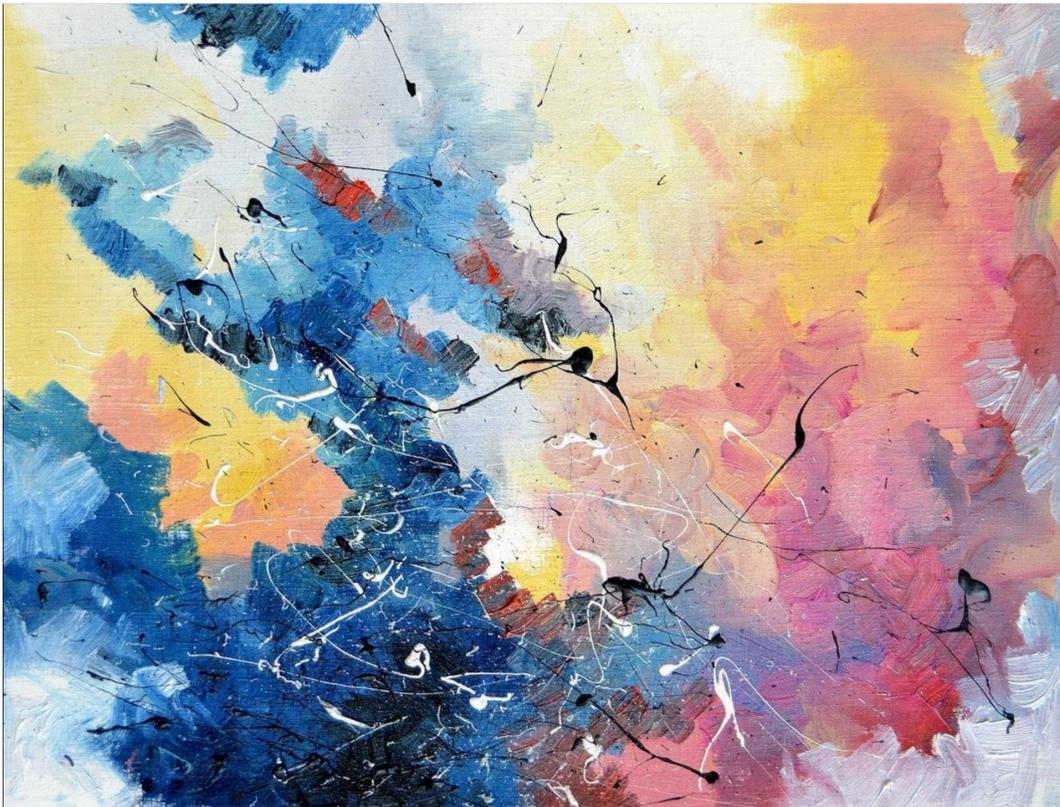
activates. However, in a study conducted by Dr. Julia Simner from the University of Edinburgh, a lexical-gustatory synesthete hears the word “jail,” and in response under fMRI, their auditory and gustatory (taste) cortex activate (“light-up”) as they associate the word “jail” with the taste of “cold hard bacon”.¹⁶ Because of this ability to connect multiple sensory cortexes of the brain involuntarily, synesthetes have heightened brain plasticity, or neuroplasticity. Neuroplasticity is the brain’s ability to “rewire” itself by making new neural connections.¹⁷ Several researchers, including Dr. Max Cynader, director of the Brain Research Centre at Vancouver Coastal Health, and Berit Brogaard, professor and director of the Brogaard Lab for Multisensory Research at the University of Miami, believe we have the potential to strengthen these connections and practice the qualities of synesthesia.¹² In designing for synesthesia, it could be that there are neurological benefits to using synesthetic qualities for universal design; however, additional research would need to be conducted on the topic.

Synesthesia is a continually growing research topic as we explore potential methods of measurement and understanding. Although synesthesia presents in many different forms, there is one consistent factor among them — the senses. Our senses are the affordances that begin perception processes for how we process sense data and make meaning and memories.

Sound, Color, and the Testing Environment

Sound is synesthetic. As Ellen Lupton describes, it “primes us to see” and makes us “think and feel, listen... touch... imagine.”⁴ As one of the sound-pairing survey participants shared with me during the experiment, sound “engulfs” her, especially when attending raves. The loud music of concerts and clubs pulsates through her body. “Whether heard with the ears or felt with the body, sound envelops us in the rich murmur of being.”⁴ But what does sound look like, what color is it? To musicians and audio engineers, the overall frequency can be described as “bright” or “dull.” These same descriptors were used by researchers at the University of California Berkeley in an experiment that paired lively music with bright tones of yellow and sad music to dull blues and grays.²⁰ However, these color pairings were for the overall perception of the song itself, not for the individual components that make a musical composition (instruments, key/chords). For instance, in the study, participants listened to *Brandenburg Concerto No 2* by Johann Sebastian Bach which demonstrates vivid timbres of a trumpet and oboe. The color most often associated with the entire composition in this study was yellow. However, it is unknown if the reason for this color choice was in fact due to the timbre sounds of the oboe and trumpet, or because of the overall pitch/frequency of the piece. A few participants chose greens and blues, which raises the question as to whether they’re perception of the composition was perhaps based on their perceptual relation to the timbre of the string instruments in the piece (violins, violas, etc.).

Melissa McCracken is a painter, and synesthete, who sees color in music and paints what she hears. “Guitars are generally golden and angled, and piano is more marbled and jerky because of the chords,” McCracken told Jess Denham in a 2017 interview in *Broadly*.¹⁴



Melissa McCracken

David Bowie, “Life on Mars”

In her painting *David Bowie, “Life on Mars”*, McCracken displays her synesthetic reaction to the marbled, jerkiness of the piano in David Bowie’s hit song *Life on Mars* with the marbling of blues, and yellow-gold shades representing the guitar and splattered lines, as I interpret the work, a visualization of the string orchestral units. “Life on Mars” is heavily individual note based aside from the main chorus which is more

chord based. Therefore I believe her visualization of marbled being a metaphor for black and white piano keys and essentially scaling up and down the piano, playing each key individually and distinctly separate from the other keys is represented by the square brush strokes that separate the shades of yellow and blue.

In order to determine whether we hear color as synesthetes do and potentially use it for universal design, a testing environment was designed for participants to pair sound with a color visual. An online, cross-sectional survey was created for Test Group A: Spring 2019 using Tumult Hype, an HTML and Javascript software at the web address: layladesigns.com/thesis/survey.html. This testing was administered in person for tracking and consistency purposes and consisted of 25 participants with a creative background. After results proved inconclusive, a replica of the original testing environment (Test Group B: Spring 2020) was coded using the responsive framework Bootstrap, along with PHP for form application processing. Test Group B completed their survey at the web address “<http://layladesigns.com/thesis-survey/index.php#>.” The survey was opened to the general public to obtain data and was shared around various channels (social media, professional, educational). Test Group B obtained 105 new participants and 5 returning participants from Test Group A.

The testing environment consisted of twelve questions that offered five tonally different options for participants to choose from and one “none” option for participants who felt that none of the sounds applied to the color visual. Tonality differences were determined by scale. If the presenting synesthetic key, for instance was C, options supplied in

conjunction were to be tonally different from the scale of C, either by relative key or an alternate key not within the scale of C. Relative keys have different tonal centers.

Six questions were presented in association with pitch-color chromesthesia and six questions in association with instrument-color chromesthesia. Pitch-pairing questions were followed by instrument-pairing questions and vice versa in order to provide distinctively different sounds between questions so as not to fall repetitive on the ear.

Pitch-pairing sounds were created using a USB LaunchKey49 Novation keyboard and the software GarageBand on a MacBook Pro laptop. Keys were struck and recorded on the keyboard for a duration average of 4 seconds and included the following notes: C, C#/D \flat , D, D#/E \flat , E, F, F#/G \flat , G, G#/A \flat , A, A#/B \flat , and B. Instrument-pairing sounds were acquired from pre-recorded video instrument guides made available by the Philharmonia Orchestra. These sounds excerpts included an oboe, clarinet, cor anglais, cello, violin, harp, French horn, and trumpet. The choice to use pre-recorded sound from video was to present a more authentic sampling of those instruments that synthetization couldn't provide. In addition to these instruments from the Philharmonia Orchestra, a piano chord was created using the USB keyboard to provide an additional tonal choice of instrument. Each sound was an average of 2 seconds in length.

Color was presented to participants in forms obtained from abstract, minimalist paintings. Shape, as Rudolf Arnheim states in *Art and Visual Perception*, is a "better means of identification than color not only because it offers many more kinds of qualitative difference, but also

because the distinctive characteristics of shape are much more resistant to environmental variations.” The second reason being that the overarching premise of this study is to understand how one could potentially apply sound to a painting, using aspects of synesthetic experiences. Therefore, color elements (or shapes) were taken from abstract, minimalist art to be paired with chromesthetic experiences. The sound-color options used pitch-color chromesthesia and instrument-color chromesthesia of two well-known synesthetic artists in addition to other chromesthetes.

Alexander Scriabin was a composer who saw color in pitches and keys. For example, he saw C as red and D as yellow. Wassily Kandinsky was an abstract painter who correlated musical instruments with color and shape, as described in his book *Concerning the Spiritual on the Art*. Table I breaks down the two artists and the synesthetic pairings.

TABLE 1.***Synesthete Pitch-Color and Instrument-Color Pairings***

Alexander Scriabin <i>Pitch-Color Chromesthesia</i>		Wassily Kandinsky <i>Instrument-Color Chromesthesia</i>	
Color	Key	Color	Instrument
Red	C	Red	Trumpet
Violet or Purple	C#	Violet	Cor Anglais or bassoon
Yellow	D	Yellow	Trumpet
Green	A	Green	Violin
Blue	B	Blue	Cello
Orange	G	Orange	Church bell or old violin

It can be observed the duplication of colors to instruments for Kandinsky, in that red and yellow were heard by Kandinsky as a trumpet. To allow for more comparison across instruments and synesthetic associations, two additional chromesthete observations were incorporated as replacements for these duplications. Joachim Raff was a music composer who saw yellow in the sound produced by an oboe. In “A Colorful Report: Color Associations in Synesthesia” by Chan, Wang Chak a synesthete correlates the sound of a French horn with the color orange. With the addition of the oboe and French horn, a greater spectrum of woodwind and brass instruments was made available for participant selection.

TEST GROUP A: SPRING 2019

The beginning of the survey introduced participants to the purpose and topic of the survey with a brief description. *See Figure 1.*

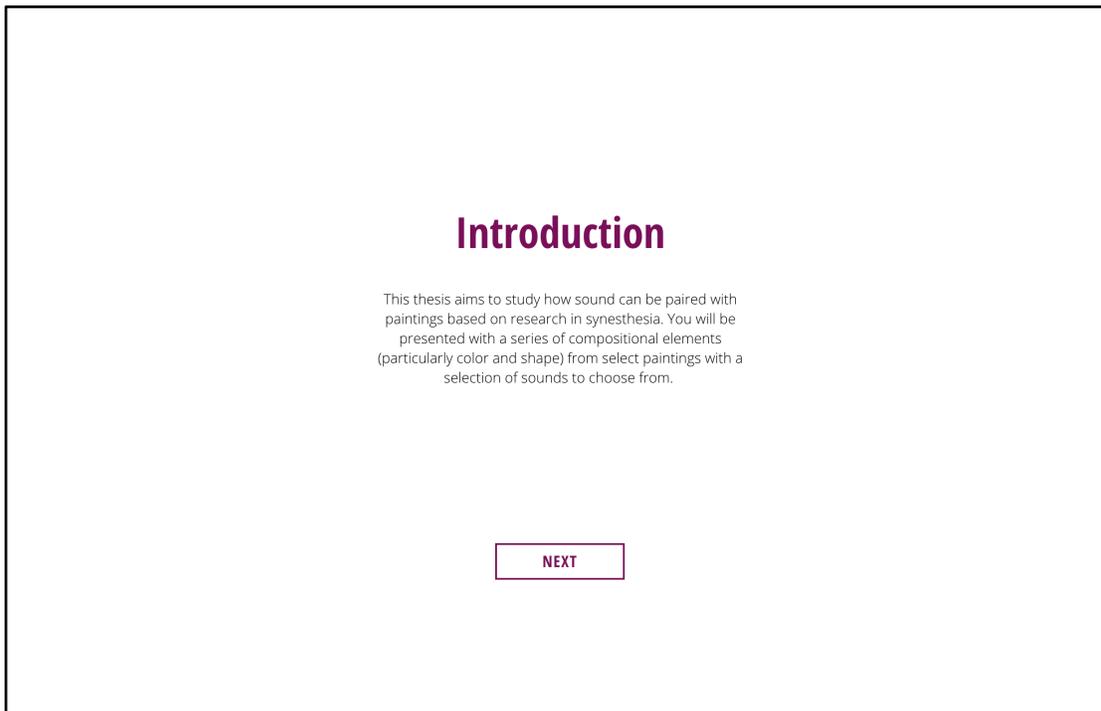
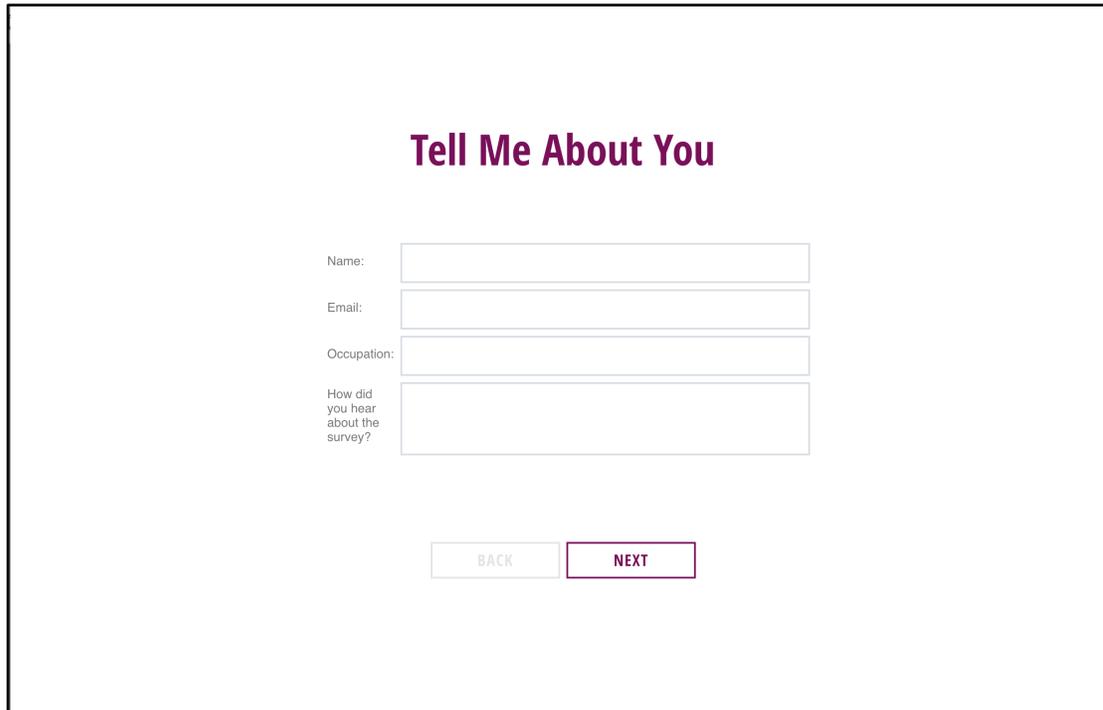
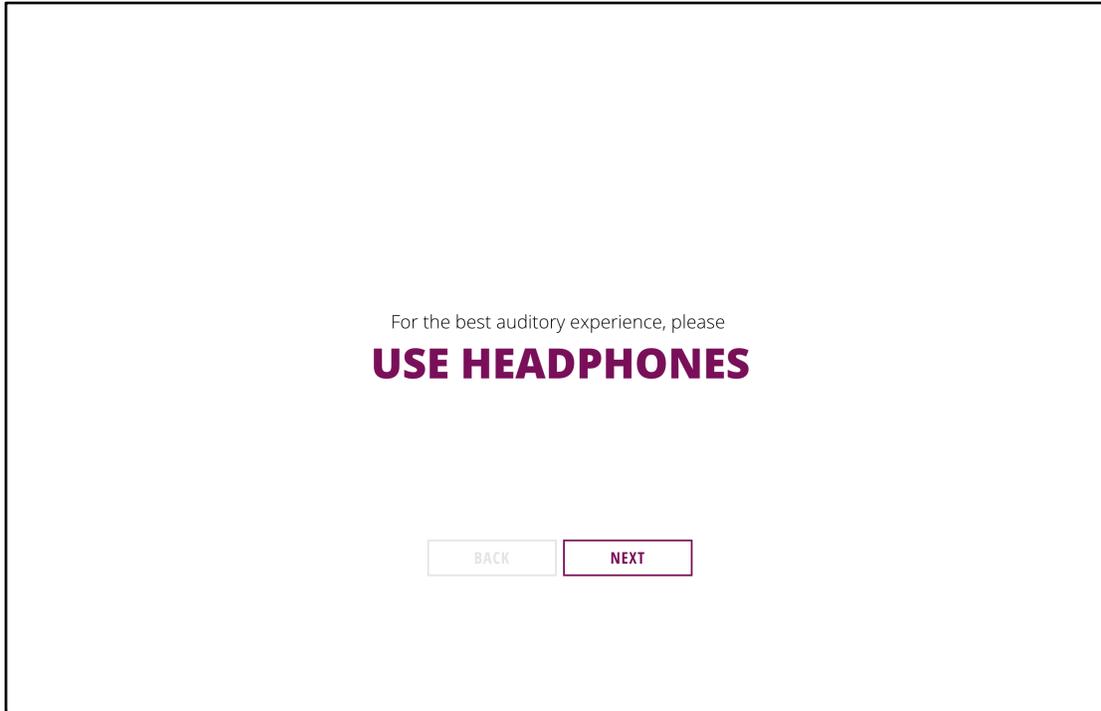
FIGURE 1.***Test Group A: Introduction Screen***

FIGURE 2.***Test Group A: Participant Information Form***

The image shows a web-based form titled "Tell Me About You" in a purple font. The form contains four input fields: "Name:", "Email:", "Occupation:", and "How did you hear about the survey?". Below the input fields are two buttons: "BACK" and "NEXT". The "NEXT" button is highlighted with a purple border.

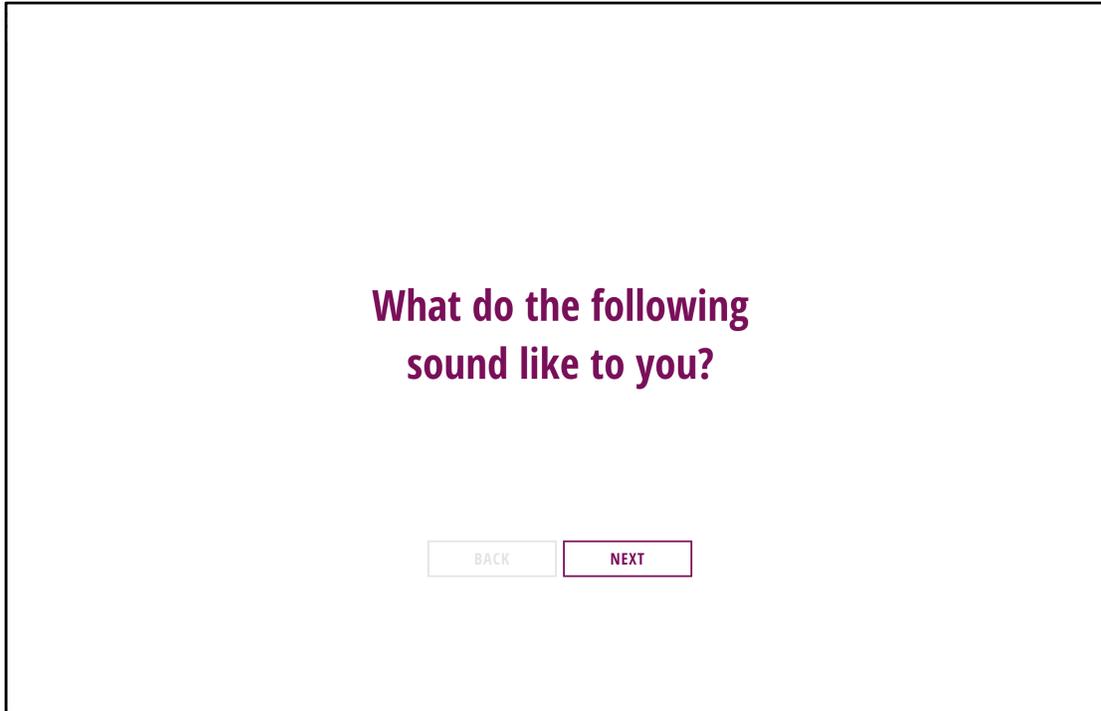
The survey used HTML form elements for input and selection, although responses were recorded manually, in-person by paper form. Participants were asked for the name, email, occupation, and how they heard about the survey. *See Figure 2.*

FIGURE 3.***Test Group A: Prompt for Headphone Use***

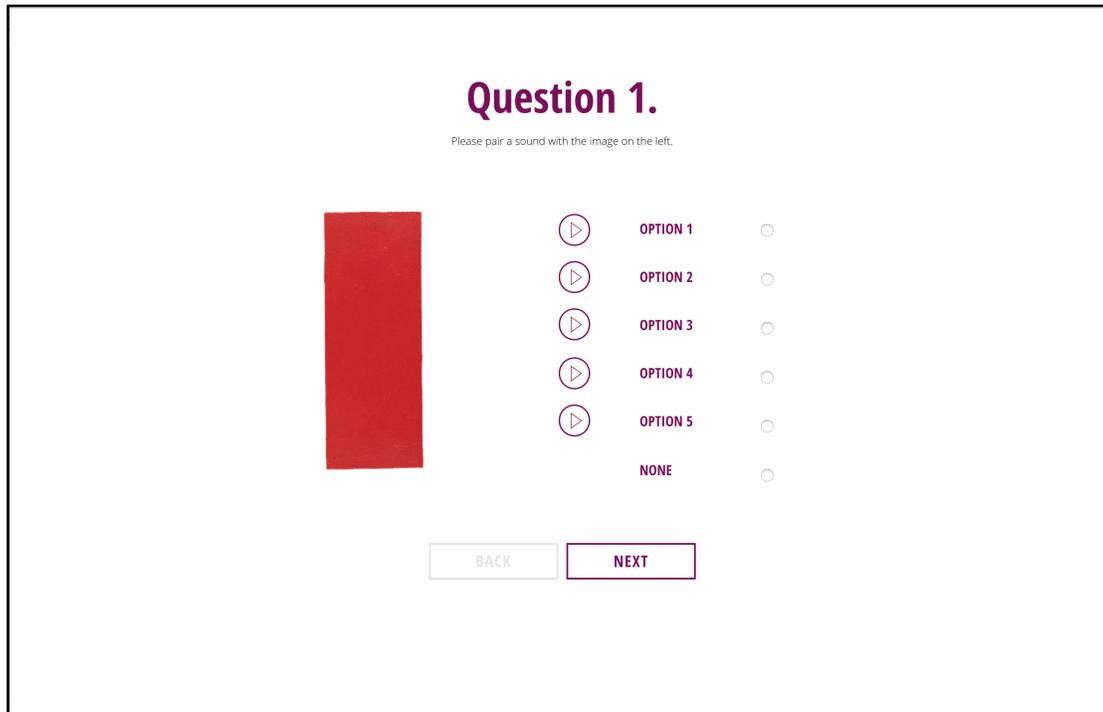
Participants were prompted to put on headphones for the best auditory experience. Wired headphones were supplied by the participants and instructed to be worn in/over both ears so as to avoid any potential additional auditory interference not included in the survey.

FIGURE 4.

Test Group A: Instructional Question Prompt



Participants were asked “What do the following sound like to you?”

FIGURE 5.***Test Group A: Core Question: Red Key***

The screenshot shows a survey question interface. At the top, it says "Question 1." in a purple font. Below that, it says "Please pair a sound with the image on the left." In the center, there is a solid red vertical rectangle. To the right of the rectangle, there are five radio button options, each with a play button icon to its left. The options are labeled "OPTION 1", "OPTION 2", "OPTION 3", "OPTION 4", and "OPTION 5". Below these is a "NONE" option. At the bottom, there are two buttons: "BACK" and "NEXT".

Questions 1-12 will be referred to as the “core questions” for this survey as they remain unchanged between the two test groups. The first question presented a red shape from “Abstract Painting, Red” by Ad Reinhardt (*Appendix F*) for pitch-color pairing. Six options were provided in the following order: F#, C (synesthete variable), B \flat , A, D \flat , and none.

FIGURE 6.***Test Group A: Core Question: Yellow Instrument***

Question 2.

Please pair a sound with the image below.

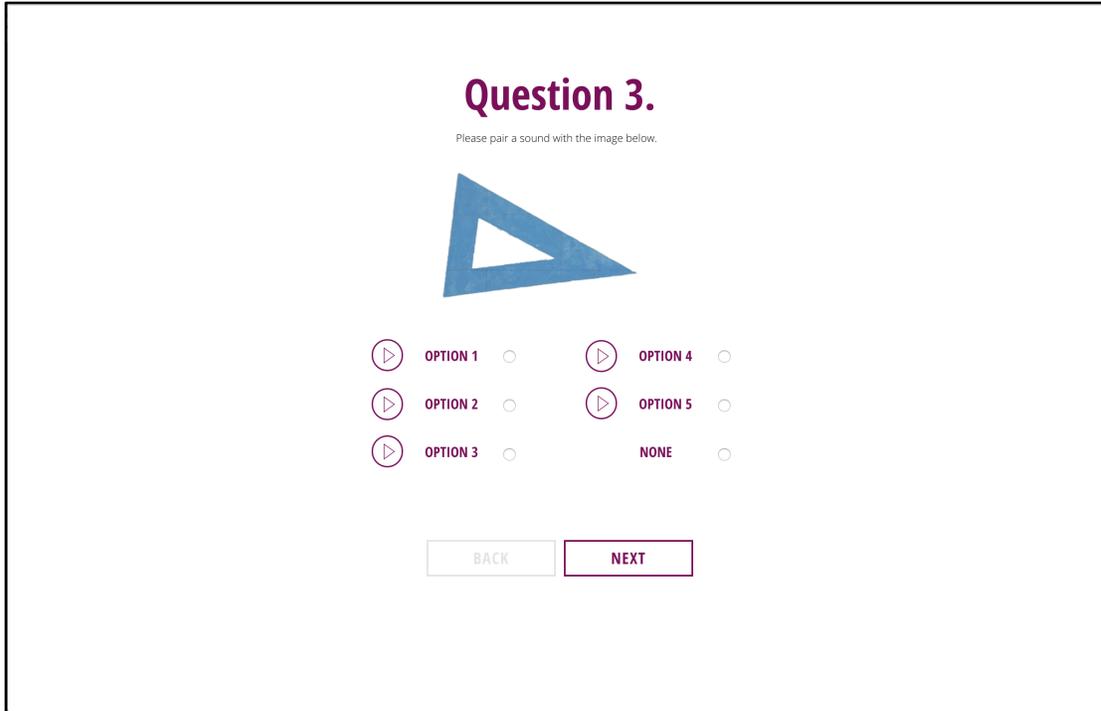


OPTION 1 **OPTION 4**

OPTION 2 **OPTION 5**

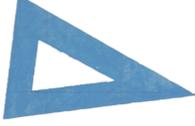
OPTION 3 **NONE**

The second question presented a yellow shape from “Reflector” by Daniel Walsh (*Appendix G*) for instrument-color pairing. Six options were provided in the following order: cello, piano, oboe (synesthete variable), harp, clarinet, and none.

FIGURE 7.***Test Group A: Core Question: Blue Key***

Question 3.

Please pair a sound with the image below.

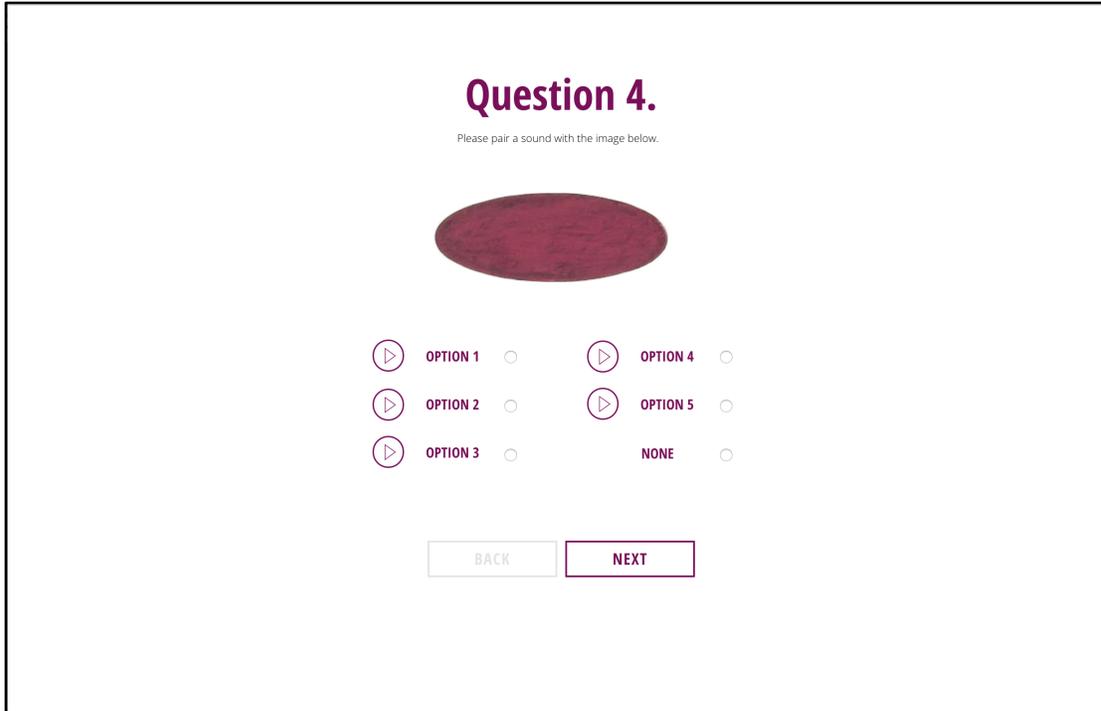


OPTION 1 **OPTION 4**

OPTION 2 **OPTION 5**

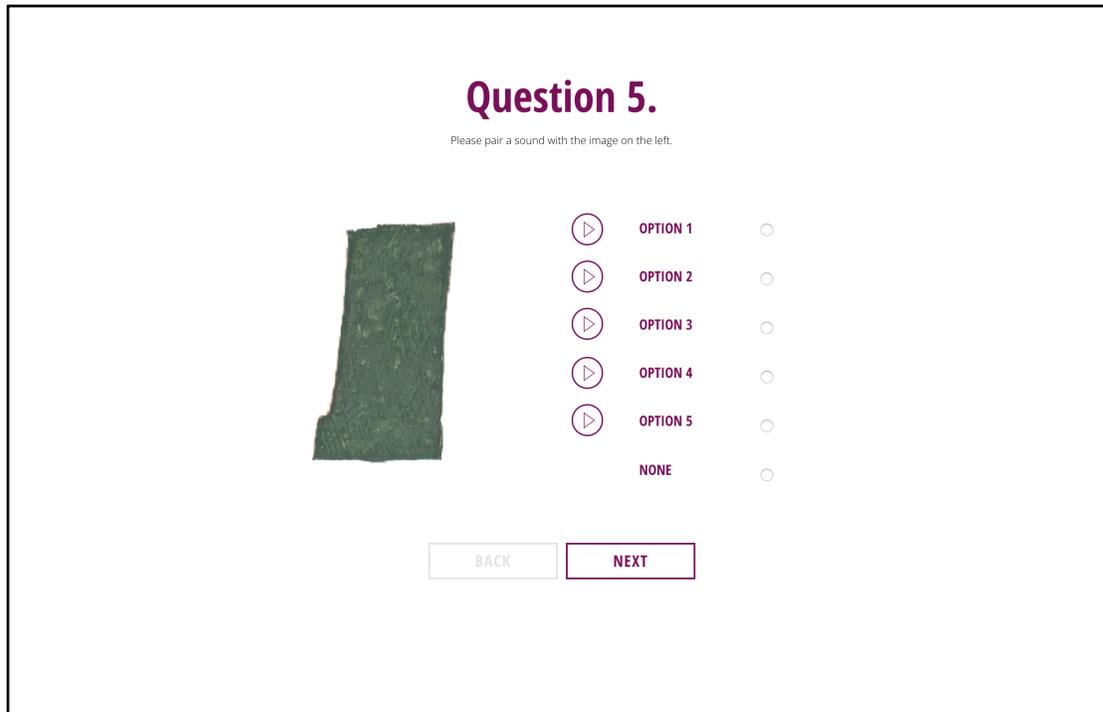
OPTION 3 **NONE**

The third question presented a blue shape from “Abstract” by Josef Albers (*Appendix H*) for pitch-color pairing. Six options were provided in the following order: B (synesthete variable), F, A, D, G#, and none.

FIGURE 8.***Test Group A: Core Question: Violet Instrument***

The screenshot shows a quiz question interface. At the top, it says "Question 4." in a purple font. Below that, it says "Please pair a sound with the image below." in a smaller font. In the center, there is a purple oval shape. Below the shape, there are six options arranged in two columns. Each option consists of a play button icon, the option name, and a radio button. The options are: OPTION 1, OPTION 2, OPTION 3 on the left; and OPTION 4, OPTION 5, NONE on the right. At the bottom, there are two buttons: "BACK" and "NEXT".

The fourth question presented a violet shape from “Mindanao” by Victor Vasarely (*Appendix I*) for instrument-color pairing. Six options were provided in the following order: trumpet, violin, cor anglas (synesthete variable), piano, oboe, and none.

FIGURE 9.**Test Group A: Core Question: Green Key**

Question 5.

Please pair a sound with the image on the left.



 **OPTION 1**

 **OPTION 2**

 **OPTION 3**

 **OPTION 4**

 **OPTION 5**

NONE

BACK **NEXT**

The fifth question presented a green shape from “El Condor, Ecuador Growing” by Josef Albers (*Appendix J*) for pitch-color pairing. Six options were provided in the following order: B \flat , D \sharp , G, F \sharp , A (synesthete variable), and none.

FIGURE 10.***Test Group A: Core Question: Orange Instrument***

Question 6.

Please pair a sound with the image on the left.



OPTION 1

OPTION 2

OPTION 3

OPTION 4

OPTION 5

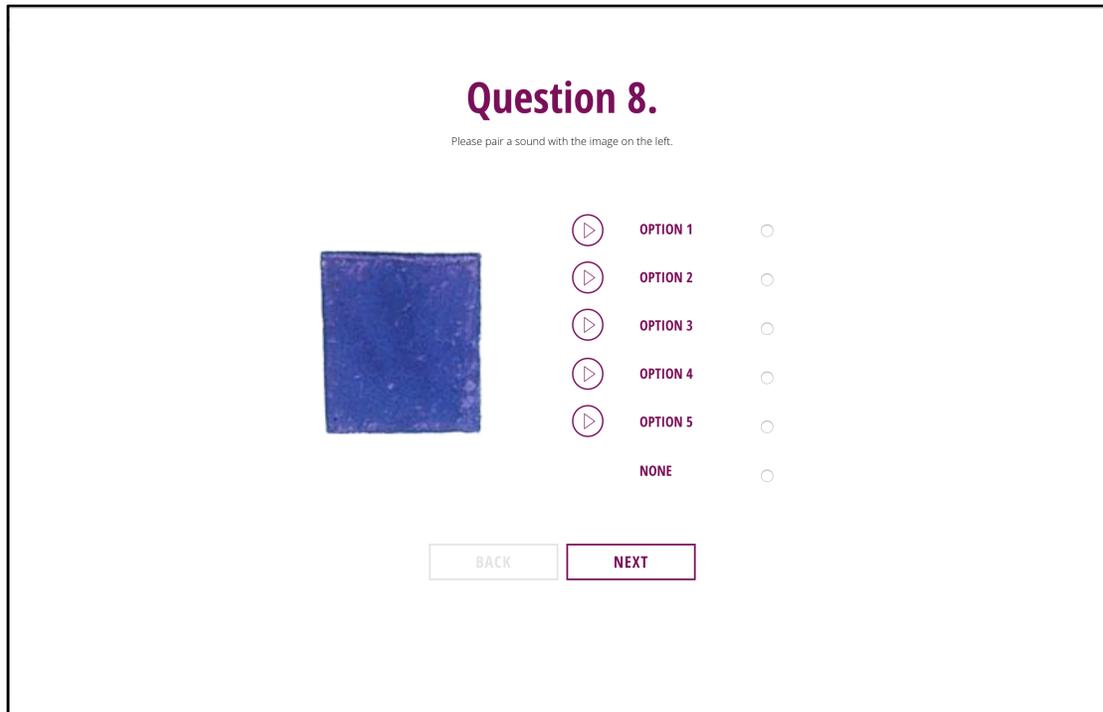
NONE

The sixth question presented an orange shape from “Suprematist Composition” by Kazimir Malevich (*Appendix K*) for instrument-color pairing. Six options were provided in the following order: harp, clarinet, trumpet, French horn (synesthete variable), cello, and none.

FIGURE 11.***Test Group A: Core Question: Yellow Key***

The screenshot shows a quiz question interface. At the top, it says "Question 7." in a purple font. Below that, a smaller instruction reads "Please pair a sound with the image on the left." To the left of the options is a yellow, irregularly shaped object. To the right of the image are five radio button options, each with a play button icon and a label: "OPTION 1", "OPTION 2", "OPTION 3", "OPTION 4", and "OPTION 5". Below these is a "NONE" option. At the bottom of the interface are two buttons: "BACK" and "NEXT".

The seventh question presented a yellow shape from “Variant Botond (Yellow and Gray)” by Batuz (*Appendix L*) for pitch-color pairing. Six options were provided in the following order: B, G#, D (synesthete variable), F, Eb, and none.

FIGURE 12***Test Group A: Core Question: Blue Instrument***

Question 8.

Please pair a sound with the image on the left.



OPTION 1

OPTION 2

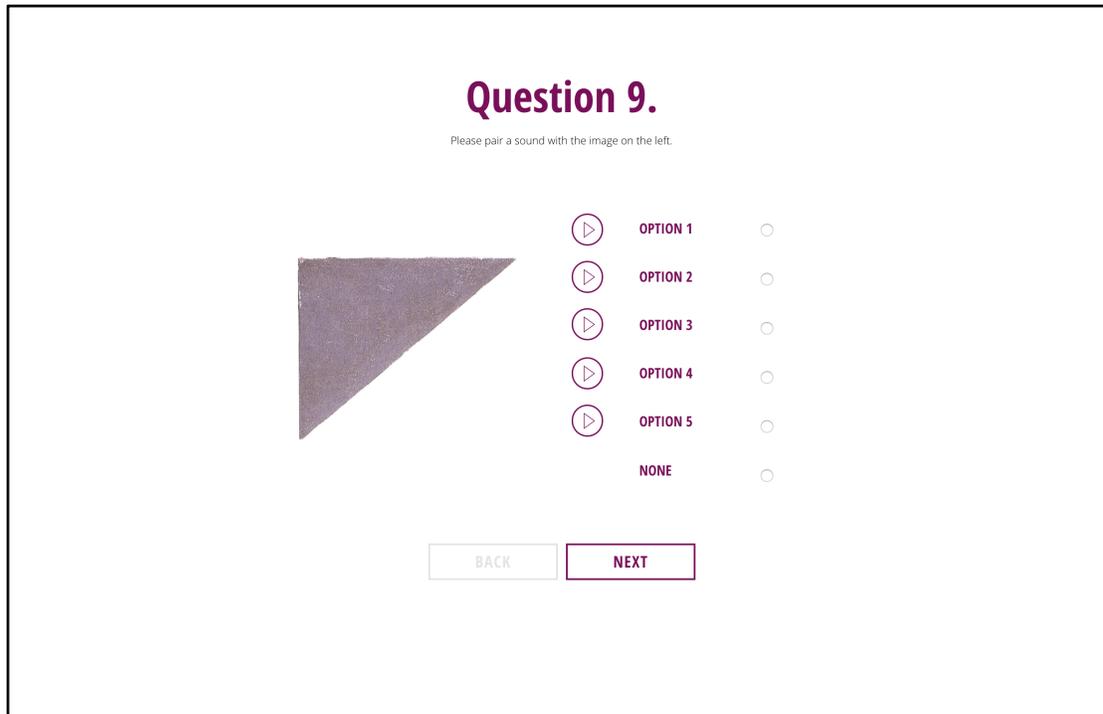
OPTION 3

OPTION 4

OPTION 5

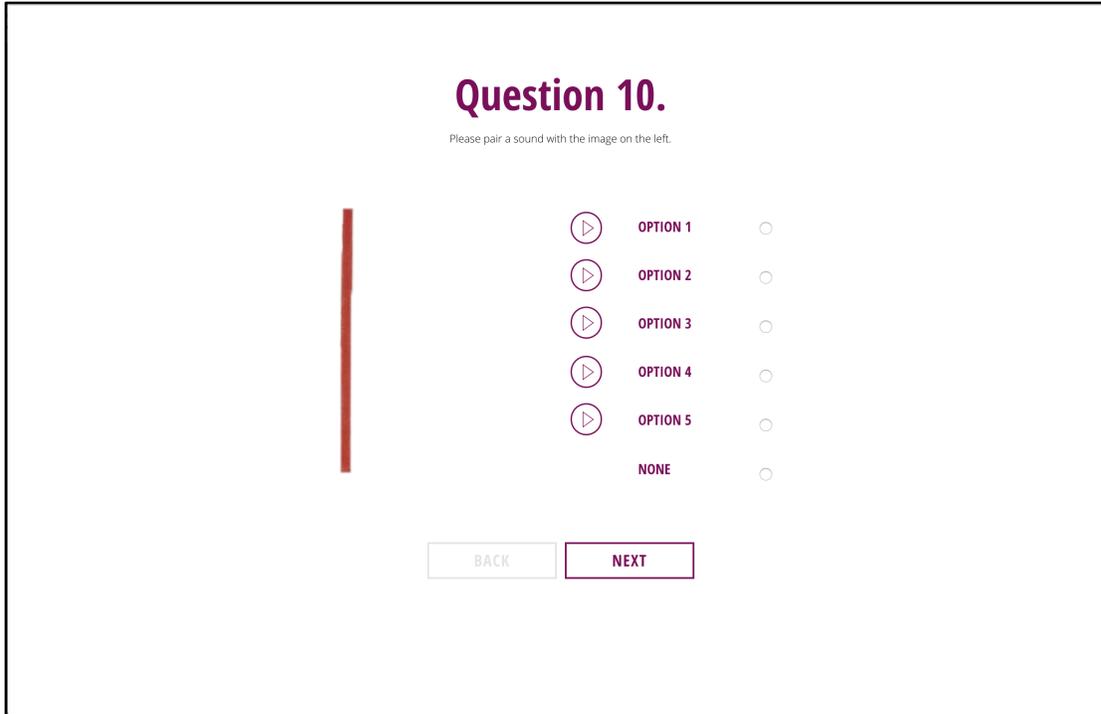
NONE

The eighth question presented a blue shape from “Suprematism No. 50” by Kazimir Malevich (*Appendix M*) for instrument-color pairing. Six options were provided in the following order: cor anglias, cello (synesthete variable), French horn, oboe, violin, and none.

FIGURE 13.**Test Group A: Core Question: Violet Key**

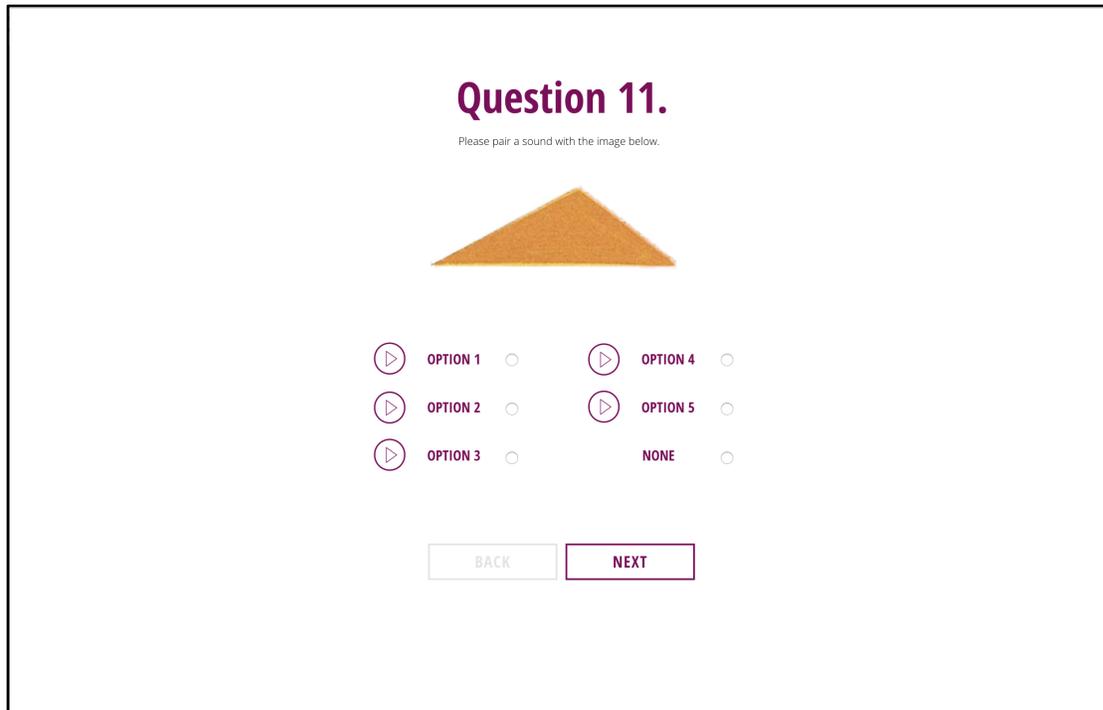
The screenshot shows a quiz question interface. At the top, it says "Question 9." in a purple font. Below that, it says "Please pair a sound with the image on the left." To the left of the options is a purple right-angled triangle. To the right of the triangle are five radio button options, each with a play button icon to its left: "OPTION 1", "OPTION 2", "OPTION 3", "OPTION 4", and "OPTION 5". Below these is a "NONE" option. At the bottom, there are two buttons: "BACK" and "NEXT".

The ninth question presented a violet shape from “Composition no. 2” by Mauro Reggiani (*Appendix N*) for pitch-color pairing. Six options were provided in the following order: A, C# (synesthete variable), G, A#, E, and none.

FIGURE 14.***Test Group A: Core Question: Red Instrument***

The screenshot shows a quiz question interface. At the top, it says "Question 10." in a purple font. Below that, a smaller instruction reads "Please pair a sound with the image on the left." To the left of the options is a vertical red bar. To the right of the bar are five radio button options, each with a play icon in a circle: "OPTION 1", "OPTION 2", "OPTION 3", "OPTION 4", and "OPTION 5". Below these is a "NONE" option. At the bottom of the interface are two buttons: "BACK" and "NEXT".

The tenth question presented a red shape from “Abstract Composition” by Jean Héliion (*Appendix O*) for instrument-color pairing. Six options were provided in the following order: trumpet (synesthete variable), clarinet, cello, piano, violin, and none.

FIGURE 15.***Test Group A: Core Question: Orange Key***

Question 11.

Please pair a sound with the image below.

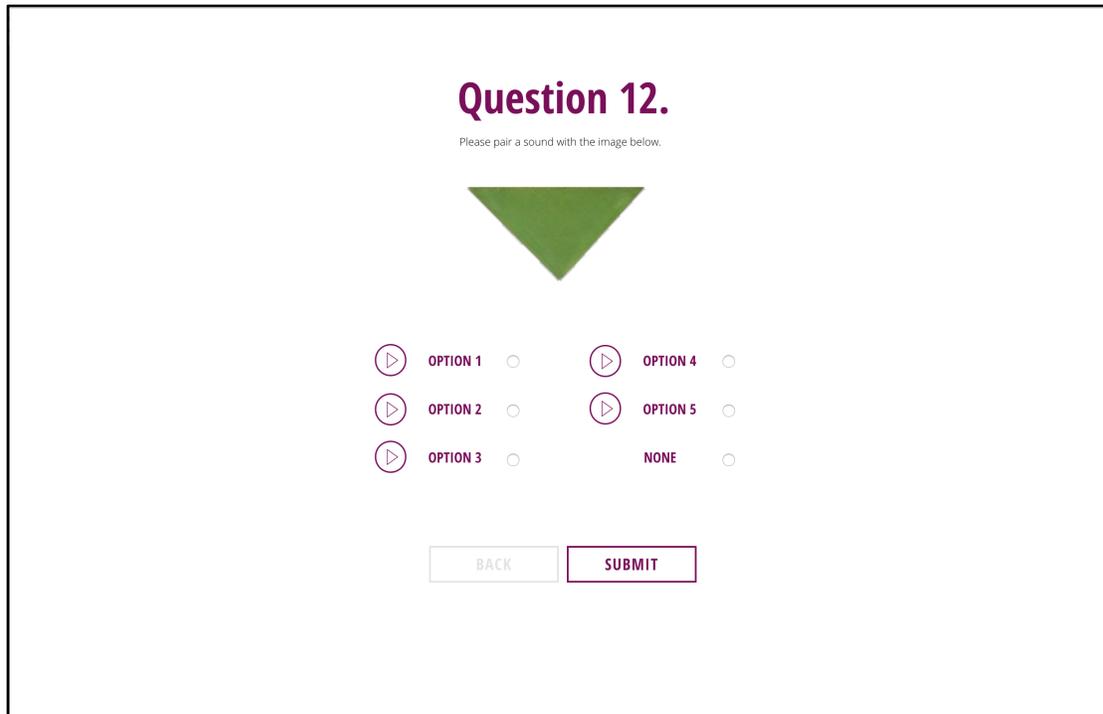


OPTION 1 **OPTION 4**

OPTION 2 **OPTION 5**

OPTION 3 **NONE**

The eleventh question presented an orange shape from “1-geometrica B” by Thomas Scheibitz (*Appendix P*) for pitch-color pairing. Six options were provided in the following order: D_b, E, F, G (synesthete variable), A#, and none.

FIGURE 16.***Test Group A: Core Question: Green Instrument***

Question 12.

Please pair a sound with the image below.

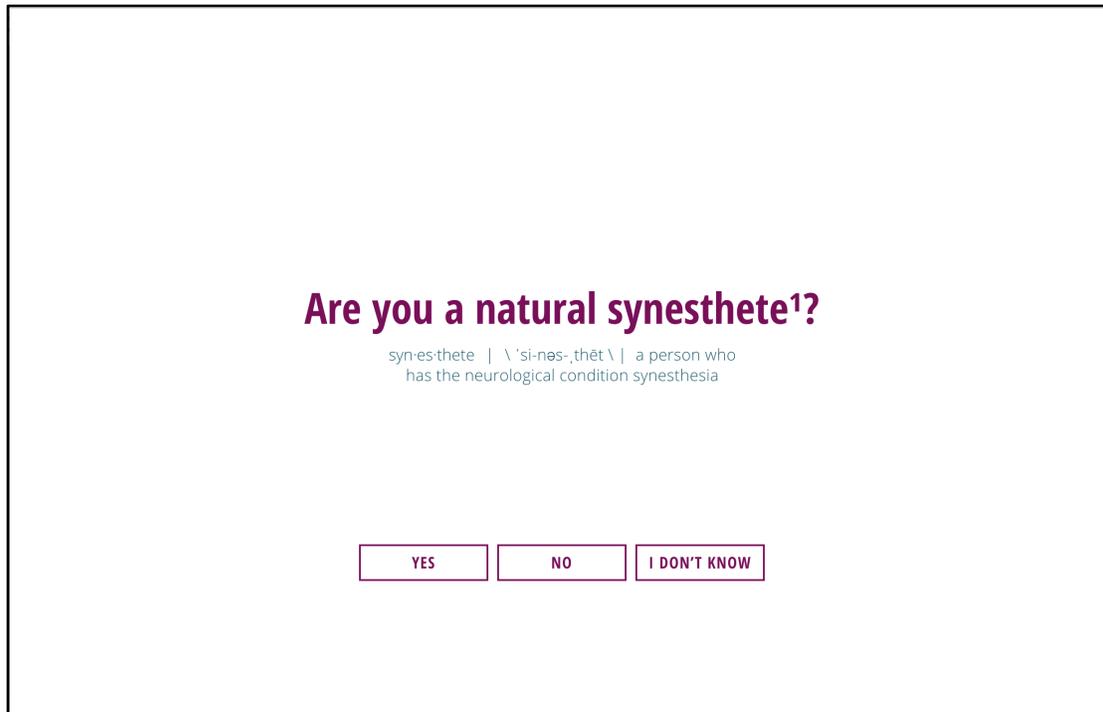


OPTION 1 OPTION 4

OPTION 2 OPTION 5

OPTION 3 NONE

The twelfth and last question for the sound-pairing portion of survey presented a green shape from “Contre composition simultanee (Simultaneous Counter-Composition)” by Theo van Doesburg (*Appendix Q*) for instrument-color pairing. Six options were provided in the following order: clarinet, violin (synesthete variable), piano, trumpet, cello, and none.

FIGURE 17.***Test Group A: Are you a Synesthete Selection Screen***

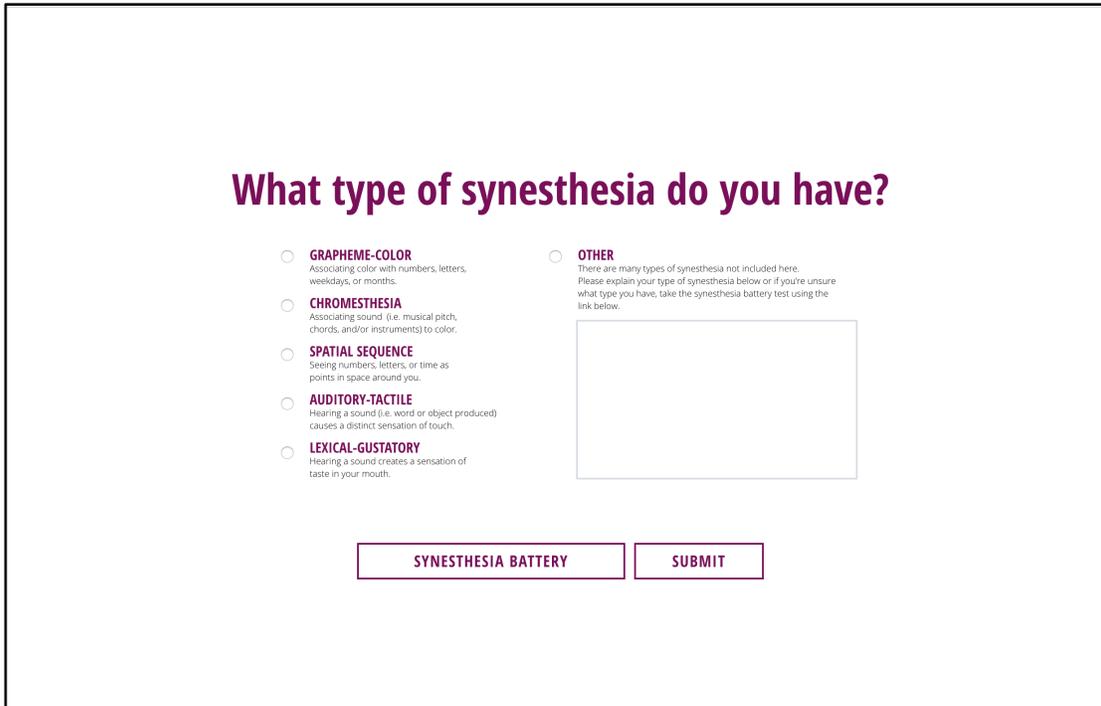
Are you a natural synesthete¹?

syn-es-thete | \ 'si-nēs-,thēt \ | a person who
has the neurological condition synesthesia

YES NO I DON'T KNOW

After the sound-pairing portion of the survey, participants were asked if they are a “natural” synesthete. The question was followed by a brief description of the term: a person who has the neurological condition synesthesia. The term “natural” was used in the event someone was indeed familiar with the condition and could potentially confuse the sound-pairing survey as qualifying them as synesthetic. Participants were asked to choose between three options that did not allow for reverse transaction: “Yes,” “No,” and “I don’t know.” Participants who affirmed their synesthesia were directed to a form to select their type(s) of synesthesia (See Figure 18). Options were given with brief descriptions for the following forms of synesthesia: grapheme-color, chromesthesia,

spatial sequence, auditory-tactile, lexical-gustatory, and other. As mentioned previously, none of the participants selected this option. Participants who declined their synesthetic ability were directed to a conclusion screen thanking them for participating (*See Figure 19*). However, after selecting this option, they were asked to visit synesthete.org to take a short preview questionnaire to verify they're answer (*See Appendix E*). Additional testing was conducted via the synesthesia battery test if they did indeed possess synesthetic abilities. This is discussed further in the Methodology section. Participants who were unsure of their synesthetic ability were directed to the concluding synesthesia test screen that linked to synesthete.org (*See Figure 20*), to take the same short preview questionnaire, and if applicable, subsequent synesthesia battery test.

FIGURE 18.***Test Group A: Synesthesia Selection Form***

What type of synesthesia do you have?

GRAPHEME-COLOR
Associating color with numbers, letters, weekdays, or months.

CHROMESTHESIA
Associating sound (i.e. musical pitch, chords, and/or instruments) to color.

SPATIAL SEQUENCE
Seeing numbers, letters, or time as points in space around you.

AUDITORY-TACTILE
Hearing a sound (i.e. word or object produced) causes a distinct sensation of touch.

LEXICAL-GUSTATORY
Hearing a sound creates a sensation of taste in your mouth.

OTHER
There are many types of synesthesia not included here. Please explain your type of synesthesia below or if you're unsure what type you have, take the synesthesia battery test using the link below.

SYNESTHESIA BATTERY **SUBMIT**

Although this screen was never used, since not one participant confirmed initially that they are a synesthete, this screen was created to provide examples of the common types of synesthesia with descriptions for each. An “Other” option was provided with a text box to enter in any types of synesthesia that were not listed.

FIGURE 19.

Test Group A: Conclusion Screen

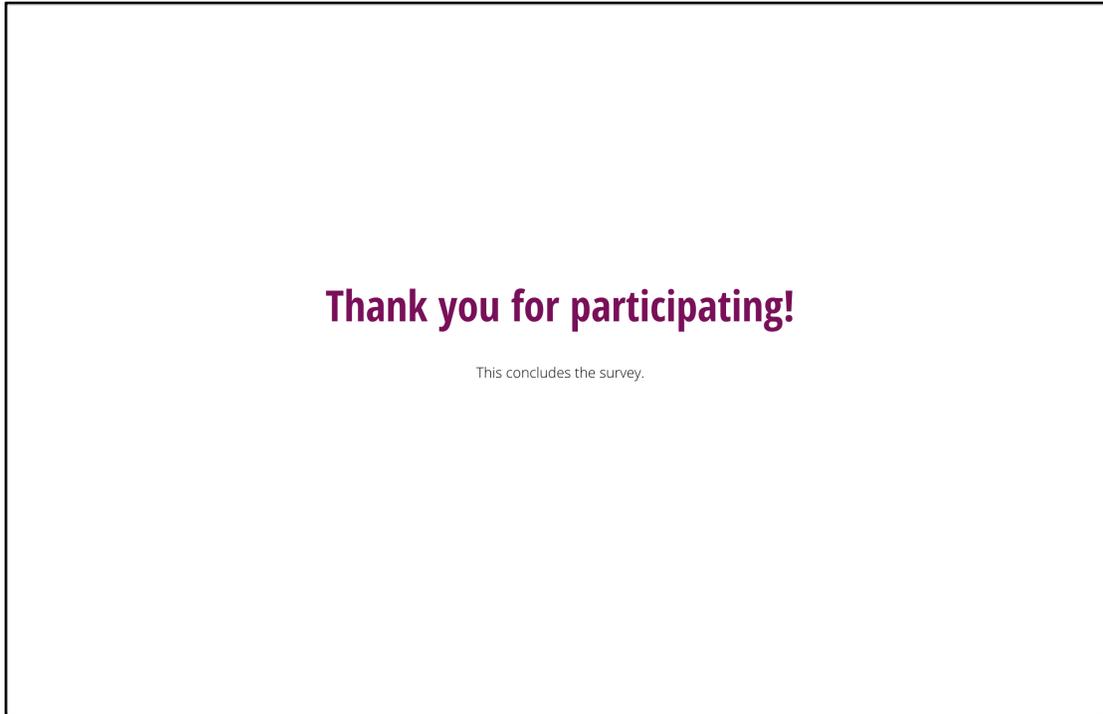
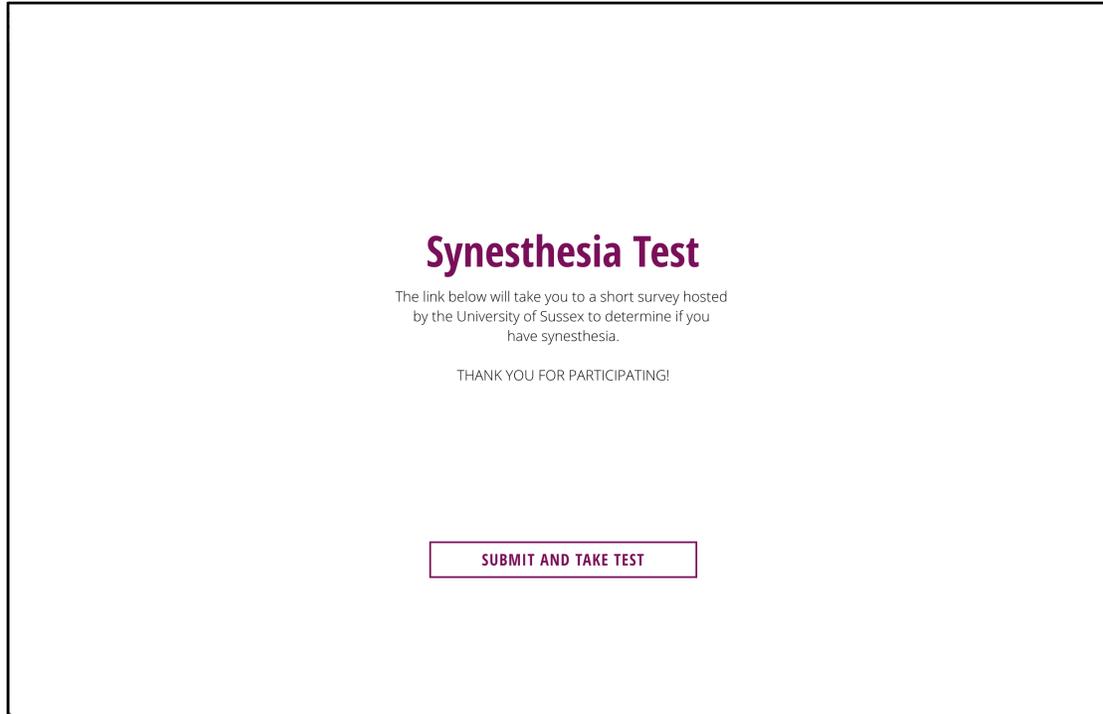


FIGURE 20.***Test Group A: Conclusion and Synesthesia Test Prompt***

After all testing was completed, participants were asked in-person if they possess a musical background particularly in regard to current practice or previous training of an instrument. Of the 19 participants who confirmed that they have a background in music, only 5 currently play an instrument. The remaining had previous instruction either in elementary, middle, or high school. This information has been helpful in determining the potential effect of musical training on the results of the sound-pairing study.

TEST GROUP B: SPRING 2020

The user experience for Test Group B was simplified for the online, multi-page form that was created for the second round of testing, however, the core questions remained unchanged. The form was simplified from its original to reduce the number of clicks needed to begin the core question section. It was built using the responsive framework, Bootstrap, for easy mobile access. The introduction screen (Figure 1) and the personal information screens (Figure 2) from Test Group A were combined for Test Group B to reduce overall page clicks and loading times. Participants were asked for their names, email addresses, survey source, art museum attendance, and musical ability on the first page. Fields were not required in order to submit the form; therefore, questions could be skipped. The headphones (Figure 3) and instructional question (Figure 4) prompts were also combined into one-page view to reduce the number of clicks needed to get to the core question set. Following pages one and two, participants began the core portion of the survey where they paired sound to the visual presented on the screen. These questions remained identical to Test Group A, only varying slightly in layout appearance. This was due to HTML/CSS coding and responsive web design. At the end of the core questions, the synesthesia portion of responses was collected. The synesthesia related questions were the only section that changed slightly from Test Group A. This page combined figures 17 (“Are You a Natural Synesthete”) and 18 from Test Group A. If participants answered “Yes”, they are a natural synesthete, they could check off what types of synesthesia they have.

The response “No” was presented by itself. Participants who responded “Don’t Know” were provided with the synesthesia battery preview questions on my testing website exactly as they are presented on synesthete.org. In Test Group A, participants were monitored in-person, and therefore I could track their responses to the synesthesia battery preview questions. Since Test Group B was not monitored and it is impossible to track form responses that are not on my server, I had to replicate the synesthesia battery preview questions on my own website in order to obtain participant responses. I also asked participants if I could follow up with them regarding their synesthetic ability, if applicable, in order to further my research interest in synesthesia, at a later time.

FIGURE 21.

Test Group B: Form Entry Introduction Screen (Desktop vs. Mobile)

Synesthesia for Universal Design

An exploratory thesis on synesthesia as a method for universal design.

▼

Introduction

This thesis aims to study how sound can be paired with paintings based on research in synesthesia. You will be presented with a series of compositional elements (particularly color and shape) from select paintings to pair with a selection of sounds. The survey will take 5-7 minutes to complete.

All data collected and used herein is strictly for educational research purposes only.

Your Information

Please tell me a little bit about yourself. This information will remain confidential and will not be shared with anyone.

First Name **Last Name**

Email

How did you hear about the survey?

Would you visit or have you ever visited an art museum?

Yes
 No

Do you currently play or have you ever played an instrument?

I currently play an instrument.
 I previously played an instrument.
 No, I do not play nor have I ever played an instrument.

NEXT

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Synesthesia for Universal Design

An exploratory thesis on synesthesia as a method for universal design.

▼

Introduction

This thesis aims to study how sound can be paired with paintings based on research in synesthesia. You will be presented with a series of compositional elements (particularly color and shape) from select paintings to pair with a selection of sounds. The survey will take 5-7 minutes to complete.

All data collected and used herein is strictly for educational research purposes only.

Your Information

Please tell me a little bit about yourself. This information will remain confidential and will not be shared with anyone.

First Name

Last Name

Email

How did you hear about the survey?

Would you visit or have you ever visited an art museum?

Yes
 No

Do you currently play or have you ever played an instrument?

I currently play an instrument.
 I previously played an instrument.
 No, I do not play nor have I ever played an instrument.

NEXT

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FIGURE 22.***Test Group B: Prompt for Headphone Use (Desktop vs. Mobile)***

Participants were prompted to use headphones for the best auditory experience, and to make sure the sound is on. The following question was then posed, “What do the following sound like to you?”

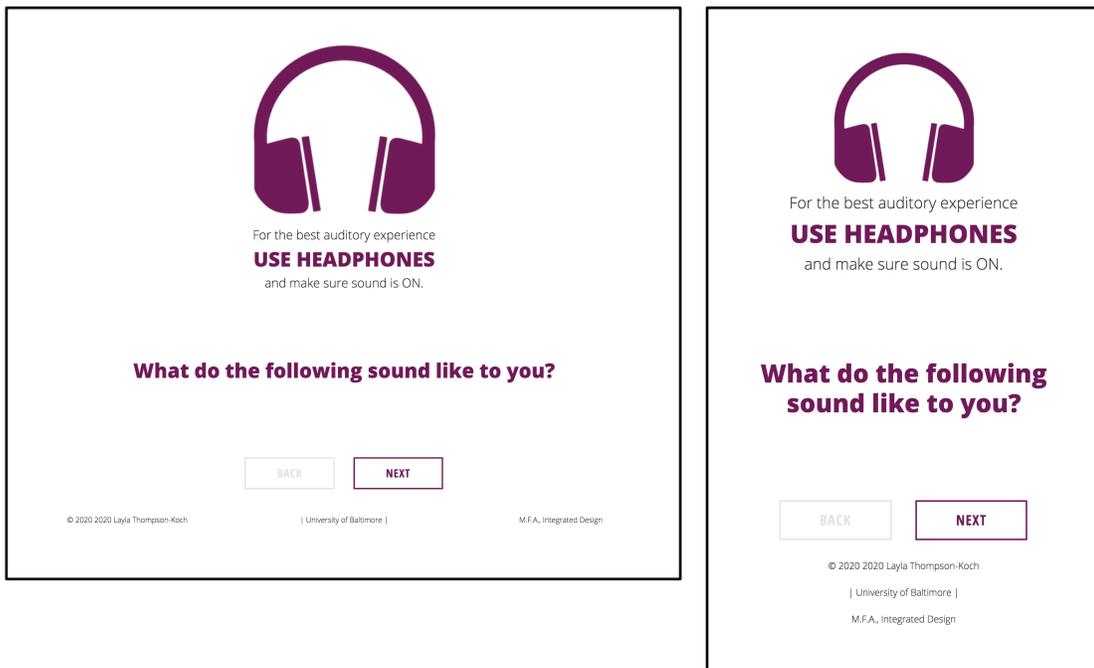


FIGURE 23.

Test Group B: Core Question 1: Red Key (Desktop vs. Mobile)

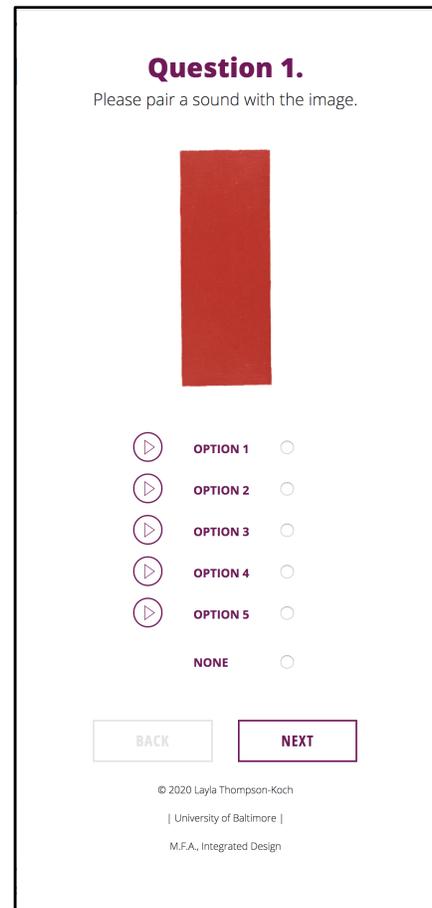
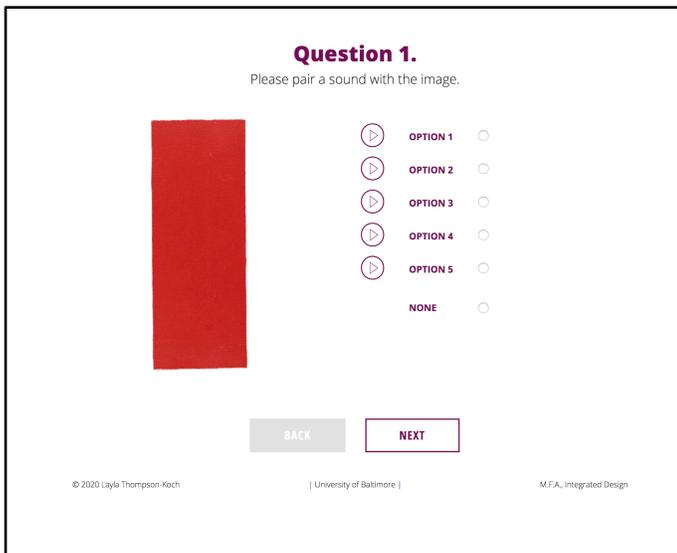


FIGURE 24.

**Test Group B: Core Question 2: Yellow Instrument
(Desktop vs. Mobile)**

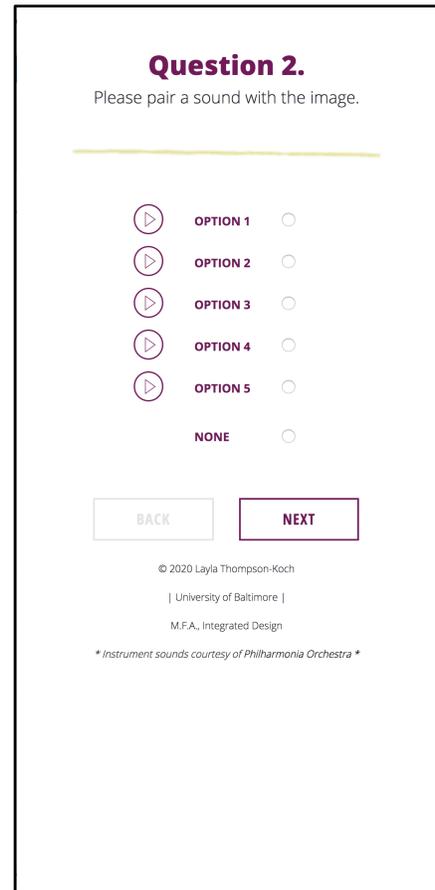
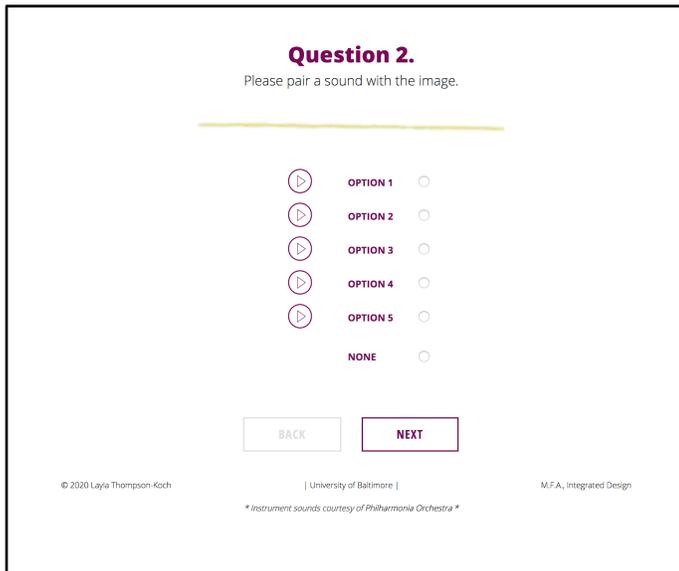


FIGURE 25.

Test Group B: Core Question 3: Blue Key (Desktop vs. Mobile)

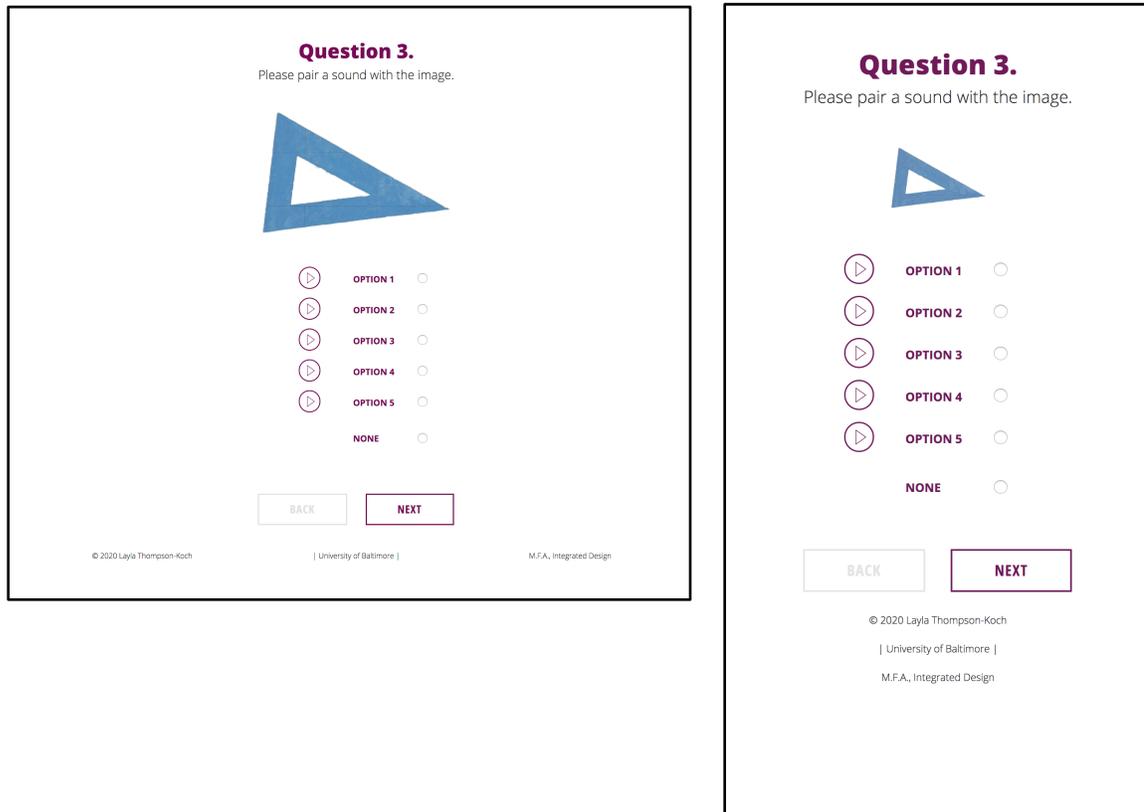


FIGURE 26.

**Test Group B: Core Question 4: Violet Instrument
(Desktop vs. Mobile)**

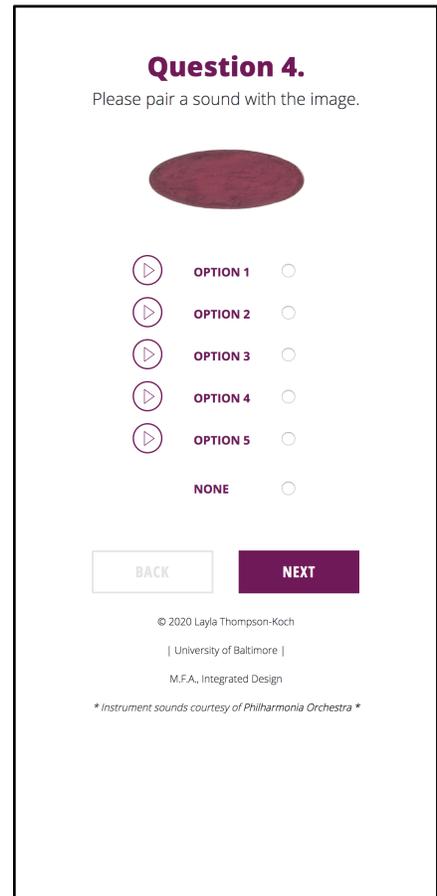
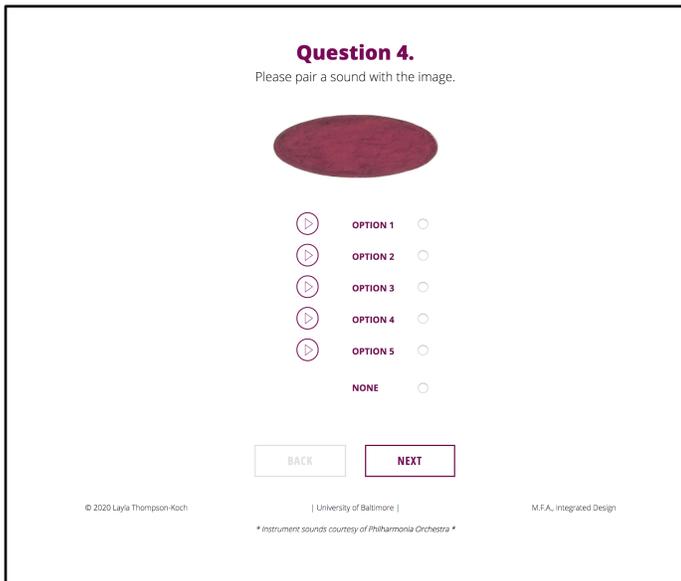


FIGURE 27.

Test Group B: Core Question 5: Green Key (Desktop vs. Mobile)

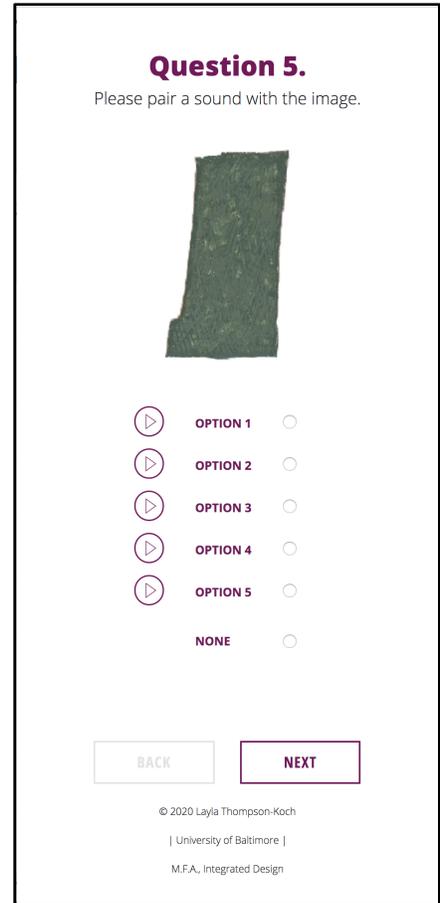
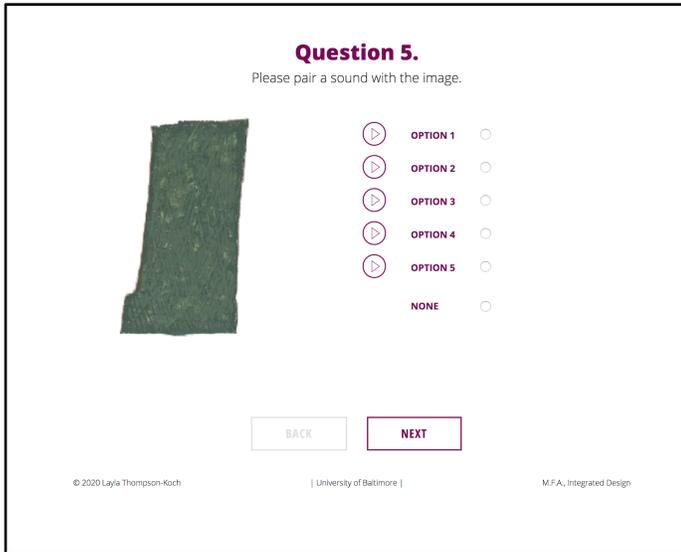


FIGURE 28.

**Test Group B: Core Question 6: Orange Instrument
(Desktop vs. Mobile)**

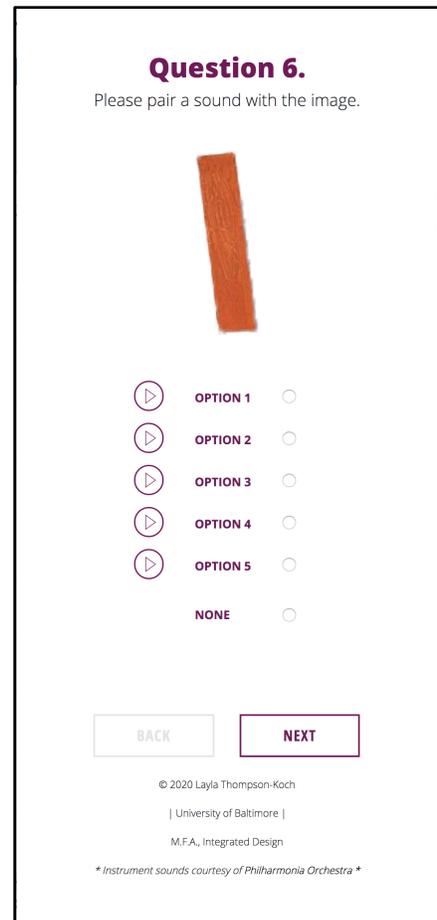
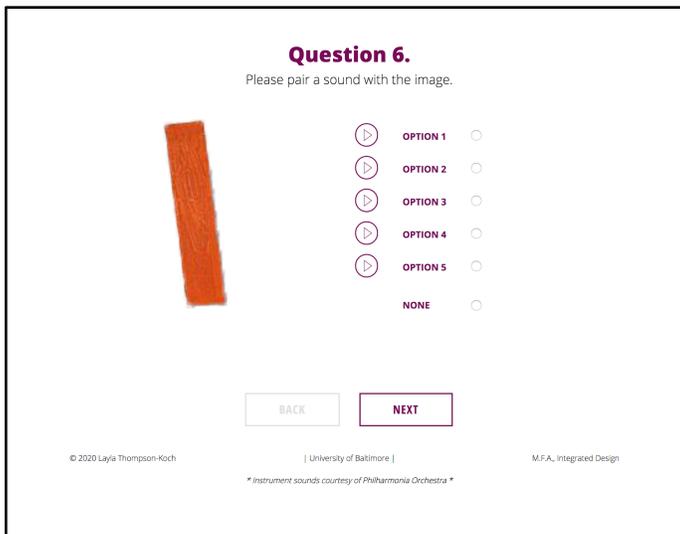


FIGURE 29.

Test Group B: Core Question 7: Yellow Key (Desktop vs. Mobile)

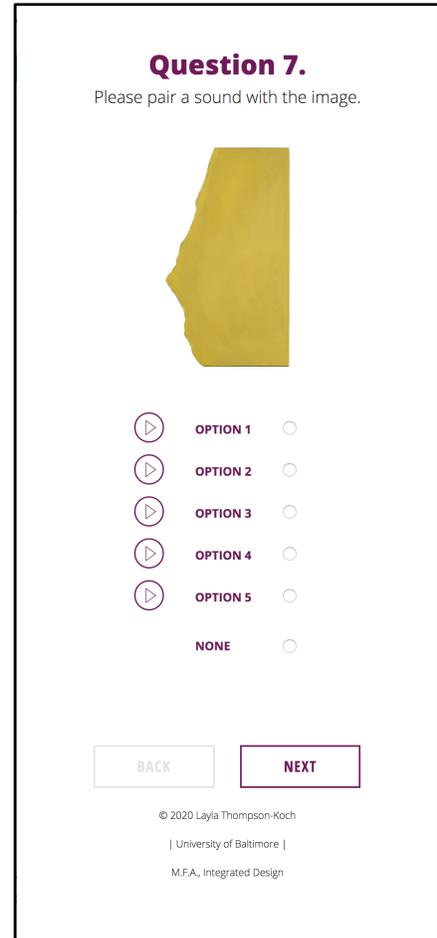
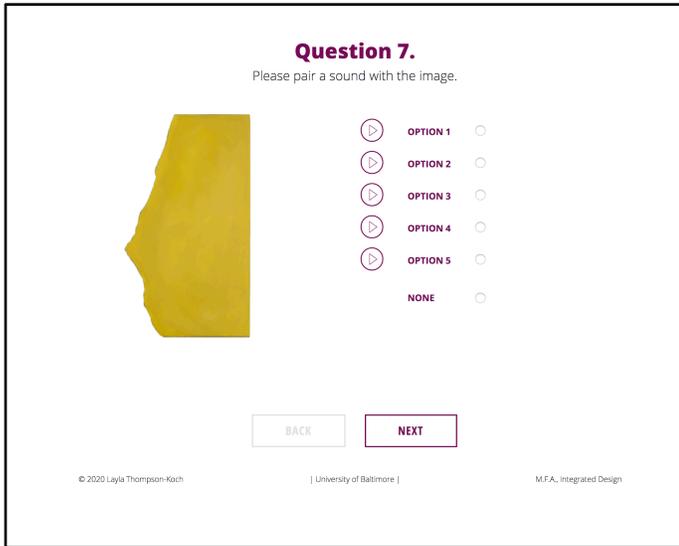


FIGURE 30.

Test Group B: Core Question 8: Blue Instrument (Desktop vs. Mobile)

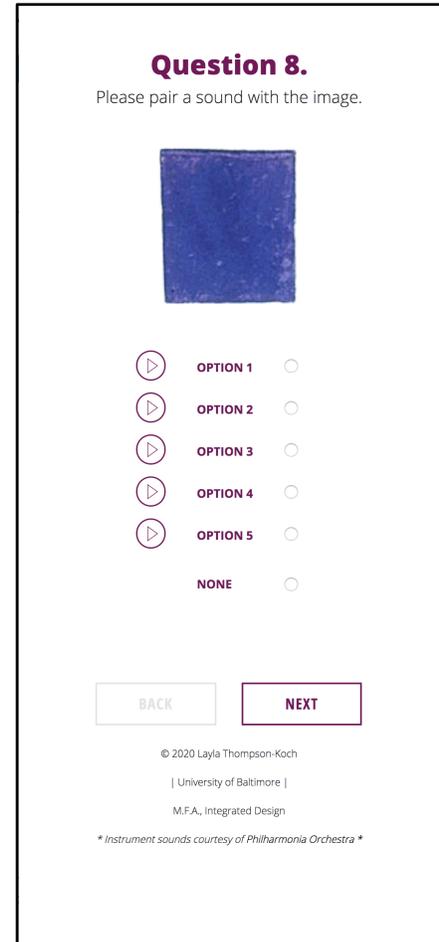
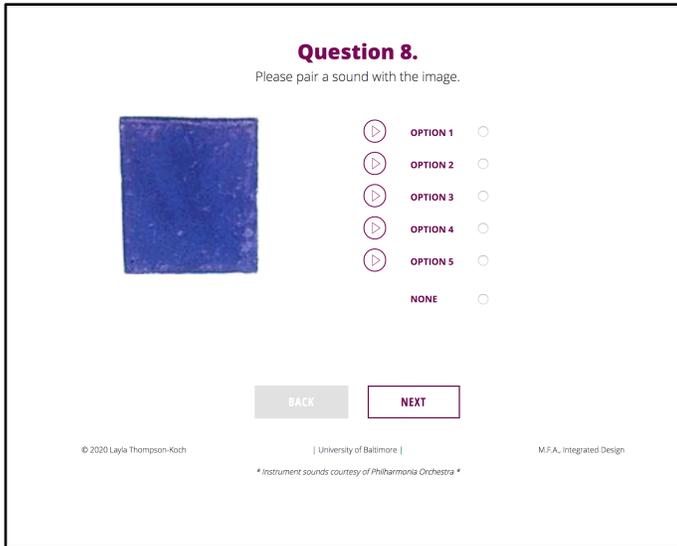


FIGURE 31.

Test Group B: Core Question 9: Violet Key (Desktop vs. Mobile)

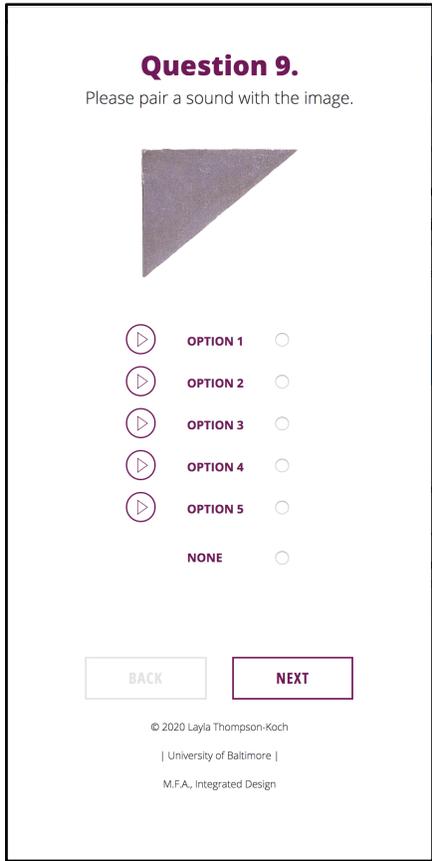
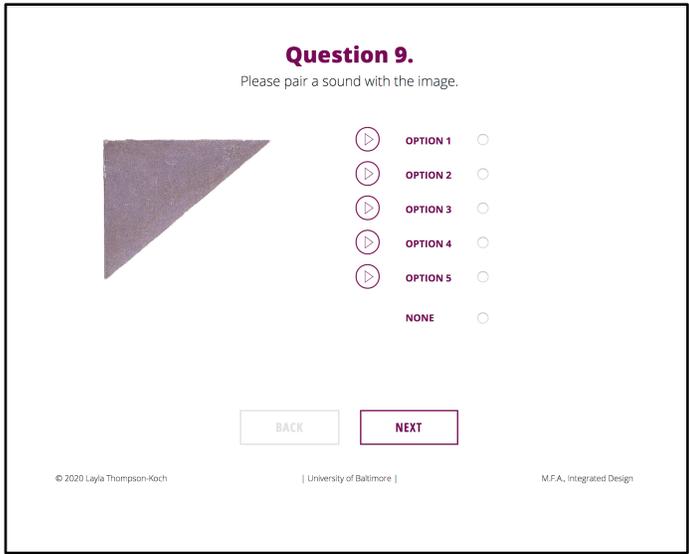


FIGURE 32.

Test Group B: Core Question 10: Red Instrument (Desktop vs. Mobile)

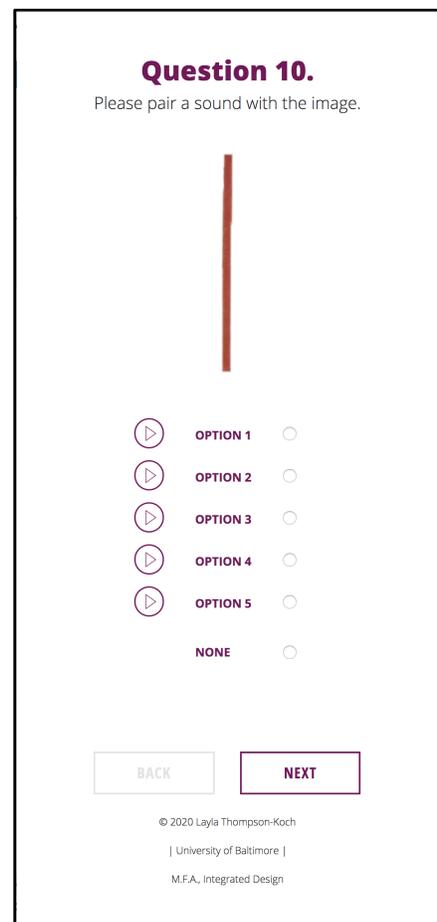
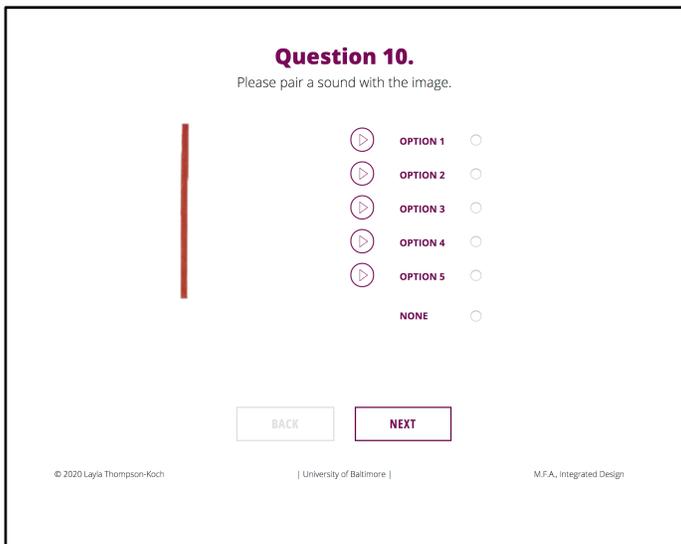


FIGURE 33.

Test Group B: Core Question 11: Orange Key (Desktop vs. Mobile)

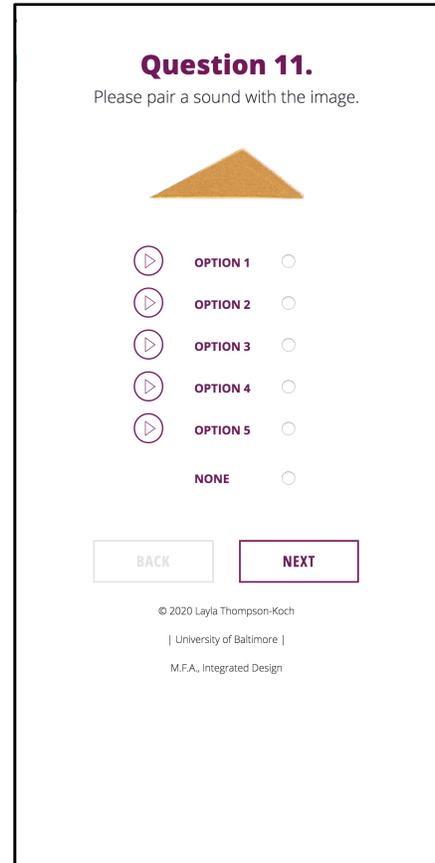
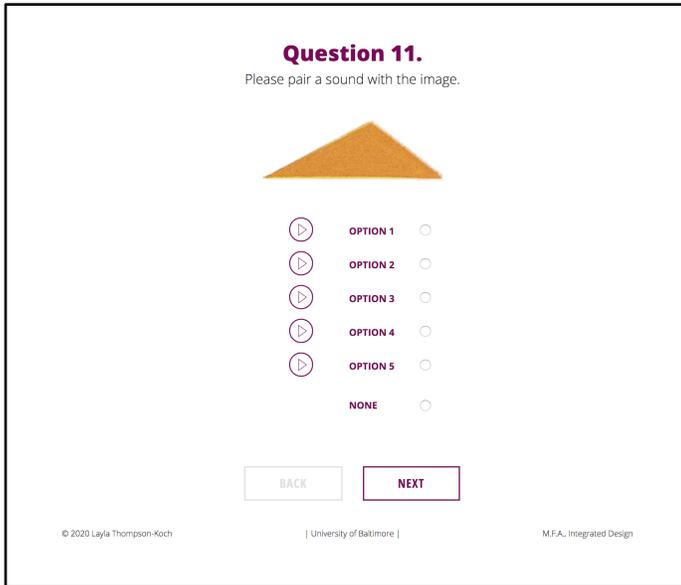


FIGURE 34.

**Test Group B: Core Question 12: Green Instrument
(Desktop vs. Mobile)**

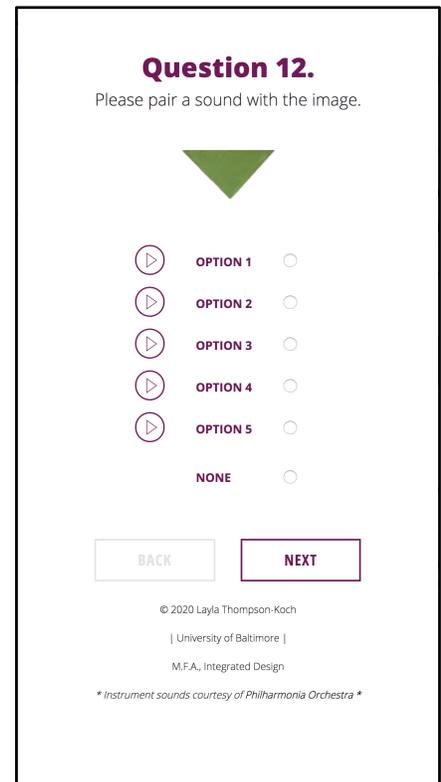
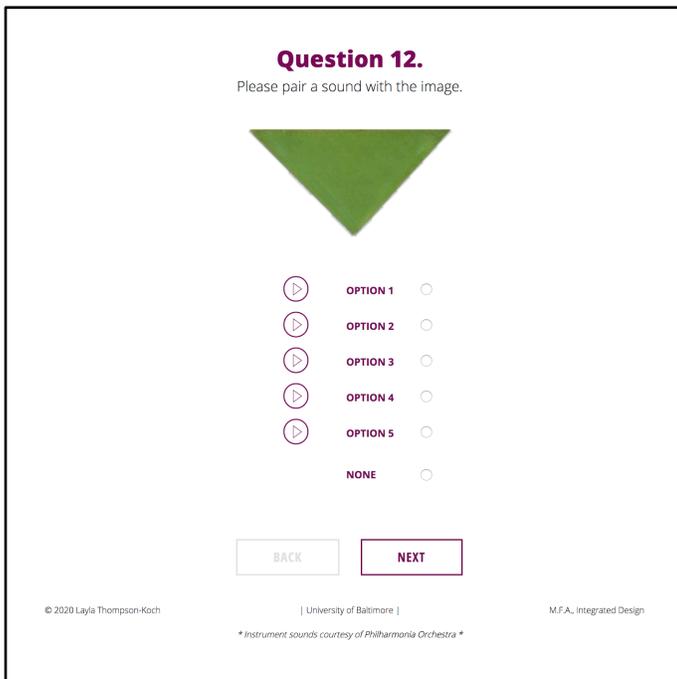


FIGURE 35.

Test Group B: Synesthetic Ability and Follow-Up Screen

Are you a natural synesthete¹?

¹ synesthete | \ 'si-nēs-thēt \ | a person who has the neurological condition synesthesia

YES

If yes, please select your type(s) of synesthesia:

- Grapheme-Color
- Chromesthesia
- Spatial Sequence
- Auditory Tactile
- Lexical Gustatory
- Other

NO

DON'T KNOW

If you don't know, please answer the following questions:

Do numbers or letters cause you to have a color experience? Example: Does the letter J "mean" yellow to you? Or does "5" make you perceive purple?

- Yes, I have had similar experiences
- No, I have not had such experiences

Do weekdays and months have specific colors? Example: Does July always mean Navy Blue to you? Is Wednesday always orange?

- Yes, I have similar associations
- No, I do not have such associations

Do you imagine or visualize weekdays, months and/or years as having a particular location in space around you? Example: Is September always located two feet in front of you to the left?

- Yes, I have always felt these specific spatial locations
- No, I have never had this kind of association

Does hearing a sound make you perceive a color? Example: Does a shrill car horn cause you to see the color green? Does C sharp make you see pink?

- Yes, I do have such experiences
- No, I have not had such experiences

Do certain words trigger a taste in your mouth? Example: Does the name 'Derek' taste like earwax?

- Yes, this is familiar to me
- No, I have never felt like this

Do you feel a sense of touch when you smell things? Example: Does the smell of coffee make you feel as though you are touching a cold glass surface?

- Yes, I have had such experiences
- No, this doesn't happen with me

We have described a few types of synesthesia. Many other unusual blendings of the senses have been reported. Do you suspect that you experience an unusual blending that other people do not have (other than the ones listed above)? These could include automatically hearing a sound when you see movement, or the sense of a shape being triggered by a taste, or experiencing a color when feeling pain.

- Yes, I believe I may have other forms of unusual sensory experiences
- Not that I know of

May I contact you regarding your synesthetic ability, if applicable?

YES **NO** **N/A**

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 * Synesthesia related questions are courtesy of The Synesthesia Battery created by David Eagleman *

FIGURE 36.***Test Group B: Results and Thank You Screen***

First Name: No answer.
Last Name: No answer.
Email: Not given.
Where they heard about this: Facebook
Have they visited a museum:
Can they play an instrument: No answer.
Answer 1: No answer.
Answer 2: No answer.
Answer 3: No answer.
Answer 4: No answer.
Answer 5: No answer.
Answer 6: No answer.
Answer 7: No answer.
Answer 8: No answer.
Answer 9: No answer.
Answer 10: No answer.
Answer 11: No answer.
Answer 12: No answer.
Synesthesia Question: No answer.
Synesthesia Type(s): Not set.
Synesthesia Battery Q1: No answer.
Synesthesia Battery Q2: No answer.
Synesthesia Battery Q3: No answer.
Synesthesia Battery Q4: No answer.
Synesthesia Battery Q5: No answer.
Synesthesia Battery Q6: No answer.
Synesthesia Battery Q7: No answer.
Okay to follow up? No answer.

Thank you for your participation!

SPECIAL THANKS

I would like to thank my thesis committee members Ian Power, Meghan Rhee, Lori Rubeling, and previous committee member, Amy Pointer, for their commitment, advice, and guidance during this research process. I would also like to thank my colleagues for their support, especially Jim Doran for his web expertise in javascript and PHP which made this survey functional. And my family and friends for helping and supporting me through the many, many...MANY years of blood, sweat, and tears to achieve my academic and career dreams.

Methodology

TEST GROUP A: SPRING 2019

Participants

There were twenty-five participants included in Test Group A. Participants were recruited by email or in-person conversations. Participants confirmed participation via email (e.g. Google) calendar invitations over the course of a two-week period. The only information provided to participants before the scheduled testing was that the survey's purpose was for a thesis inspired by research in synesthesia. Participants were chosen based on their identification as a creative (visual artist, creative writer, etc.) and were categorized into two audiences, visual artist or creative strategist (see Table 2). Seventeen visual artists included designers, photographers, a videographer, a carpentry artist, an administrative assistant, and web developer. Creative strategists included those in marketing and communications, both with and without a creative writing background. This included a magazine editor, assistant magazine editor, project managers, a communications manager, a director in marketing and communications, and an associate vice president in marketing and creative. This audience was chosen as a selective representation of creatives usually involved in developing a multisensory (museum) experience.⁴

TABLE 2.***Test Group A: Sound-Pairing Survey Participants***

Participant	Occupation	Synesthete/Type	Musical
Participant 1A	Visual Artist	No	Yes
Participant 2A	Visual Artist	No	Yes
Participant 3A	Visual Artist	Yes/Grapheme-Color	Yes
Participant 4A	Visual Artist	No	Yes
Participant 5A	Visual Artist	No	Yes
Participant 6A	Visual Artist	Yes/Grapheme-Color	Yes
Participant 7A	Visual Artist	No	No
Participant 8A	Creative Strategist	Yes/ Sequences-Spatial Locations	Yes
Participant 9A	Visual Artist	No	Yes
Participant 10A	Visual Artist	Yes/Grapheme-Color	Yes
Participant 11A	Visual Artist	Yes/Chromesthesia	Yes
Participant 12A	Visual Artist	Yes/ Sequences-Spatial Locations	Yes
Participant 13A	Visual Artist	Yes/Sound-Smell	No
Participant 14A	Visual Artist	No	Yes
Participant 15A	Visual Artist	No	No
Participant 16A	Creative Strategist	No	No
Participant 17A	Creative Strategist	Yes/Chromesthesia	Yes
Participant 18A	Visual Artist	Yes/Chromesthesia/ Grapheme-Color	Yes
Participant 19A	Creative Strategist	No	Yes
Participant 20A	Visual Artist	No	Yes
Participant 21A	Creative Strategist	No	No
Participant 22A	Visual Artist	Yes/Chromesthesia/	Yes
Participant 23A	Visual Artist	No	Yes
Participant 24A	Creative Strategist	Yes/ Sequences-Spatial Locations	No
Participant 25A	Creative Strategist	Yes/Chromesthesia	Yes

Materials

Technology required for each participant was a computer with internet access and a pair of headphones. The majority of testers used either an iMac or MacBook computer, while only a handful used Windows based computers. The choices of headphones were majority earbuds, however, a few used circumaural, over the ear, headphones. Responses were tracked via a paper form that were later input into an online survey program (Zoho Survey) in order to analyze statistical information.

Procedure

SOUND-PAIRING SURVEY

Testing was conducted in person for each individual in a location where they were comfortable and affluent with the technology needed to complete the testing (home, office, school lab). There was little to no interference by the participants' surroundings. Participants were instructed to progress through the survey as if they were not being observed. They clicked each play button, usually in the numerical order of which they were presented and selected one option for each question. They were not rewarded or swayed in any manner to choose options. The sound-pairing survey took participants between 5-10 minutes to complete.

SYNESTHESIA TESTING

All participants were directed to the Synesthesia Battery Preview Questions after completing the sound-pairing survey found a synesthete.org (*Appendix E*). Using HTML form radio buttons, participants selected whether they did or did not have similar experiences expressed in questions relating to grapheme-color synesthesia,

chromesthesia, spatial sequence synesthesia, smell-touch synesthesia, and others. If a participant selected “yes” in response to any of the questions, they were prompted to register an account and complete the synesthesia battery test.

In the grapheme-color trials, participants were presented with a single grapheme (either a letter, number) or word (weekday or month) and asked to select the color they associate it with using an HTML color picker with a palette of over 16.7 million different colors (“color consistency test”). Each alphabetical character, number, weekday, and/or month was presented for association three times each, in randomized order. The results were then analyzed for consistent color patterns. Participants had the option of not associating color with a particular letter or word with the “no color” choice provided. It has been observed in previous studies that a synesthete doesn’t necessarily have to associate a color with every letter of the alphabet in order to be synesthetic.⁶ Several of my participants did not have a color association for every grapheme presented to them. The ending result calculates a number where below 1 is considered synesthetic, and around 2 is non-synesthetic. A score between 1 and 2 may constitute a retest taken a later date.

A similar testing environment was given to those who selected pitch-color, chord-color, and/or instrument-color synesthesia. Participants played a sound and were asked to associate the sound with a color using the same HTML color picker used in the grapheme-color trials. If the participant did not associate a color to the sound, the option “no color” was selected. The same scoring range for the grapheme-color trials was used to rate participants chromesthesia.

A speed test was administered to those who selected letter-color or number-color (3 of the participants). The purpose of the “speeded congruency test” is to eliminate the potential for cheating the color consistency test since there isn’t a time limit for the color consistency test and color patterns could potentially be memorized. A letter or number is flashed on the screen for one second, and participants are asked to answer as quickly as possible if the color matched their synesthetic association. This test was not administered for chromesthesia responses.

Following these trials, participants were presented with personal questions about themselves. They were told if they did not feel comfortable answering these questions, that they were not required to as some were medically personal. Following these questions, participants were presented with Vividness of Visual Imagery and Projector Associator test in which they were asked to rate their visual imagery on a scale of 1 to 5. Concluding the battery test, participants were asked to share results with me, the researcher which enables continued access to their individual results.

TEST GROUP B: SPRING 2020

Participants

Test Group B consisted of 105 new participants (*see Appendix S*) that were recruited through various online channels including social media and email mailing lists. This portion of testing (Test Group B) was open to everyone to complete. Their field of study or professional field was not recorded, and participants were not recruited for any particular identifier. It was made open to a wider participant pool since a gallery experience is

open to everyone and also because you do not need to be considered “creative” to have synesthesia or a synesthetic experience.

Initially, the survey link and some descriptive text was shared to LinkedIn and Facebook but was later replaced by a typographic image that was created using Snapchat and shared on Instagram, LinkedIn, and Facebook (*see Appendix R*). Additionally, the posts received 10 shares, and several comments stating how “interesting” and “fun” it was to complete, and a reach of 838 views.

In addition to social media posts, I sent emails to my institutional advancement colleagues at UMBC and fellow students at University of Baltimore. All forms of communication included a link to the online survey where responses were collected and sent to my email address using PHP.

In the introduction portion of the survey, participants were provided with a brief description of the survey:

“This thesis aims to study how sound can be paired with paintings based on research in synesthesia. You will be presented with a series of compositional elements (particularly color and shape) from select paintings to pair with a selection of sounds. The survey will take 5-7 minutes to complete.

All data collected and used herein is strictly for educational research purposes only.”

Participants were asked to provide their first and last name as well as their email address. Form fields were not required; however, all participants provided their names and the majority provided their email addresses. This personal information has been removed from this paper

for confidentiality purposes. Participants will be referred to by the name “Participant” followed by their number and the letter B to represent Test Group B. They were also asked how they heard about the survey; whether they would or have ever visited an art museum (to gauge interest in the gallery experience); as well as whether they currently play, have previously played, or have never played an instrument.

Materials

Materials needed by participants in order to complete the survey were a computer or smartphone with sound enabled and a pair of headphones. The online test was not monitored, and therefore it is unknown to what extent materials were or were not used by participants, including headphones. Participants were prompted with a screen during testing to use headphones and to make sure the volume was on. Since the survey was built using responsive web design, participants could have been mobile or using a desktop computer to complete the survey. This information was not tracked since it was not relevant to the primary goal of this thesis.

Procedure

Participants clicked through a total of 16 screens, twelve of them were the core questions involving the sound to visual pairing. Since this test group was not monitored, the speed rate is unknown, however the average completion rate for Test Group A was five minutes. On the submission screen, participants were asked if they are a natural synesthete and prompted with the same synesthesia battery preview questions that are located on synesthete.org. After submission,

participants were given their responses in addition to a “Thank you for participating” message. On submission, an email was sent to me with their responses that I then entered into Zoho Survey for analysis.

Results

TEST GROUP A: SPRING 2019

25 participants completed the sound-pairing survey during the month of March 2019. The average time participants took to complete the sound-pairing survey was around 10 minutes. The majority of participants after listening to all five sounds per question played back two or three of the sounds before choosing a selection. This could have been for many reasons, although one particularly is speculated. After the testing was completed, many participants mentioned how “interesting” the study was, with some participants noting they’re unfamiliarity of pairing sound to something visual. Sound was recorded as “generous” by one participant and many participants adjusted overall volume after playing the first options in question one. Volume was less likely to be adjusted again after this.

Results were calculated based on an ordinal scale to break down how many participants matched their sound choices to synesthete controls in order to answer the question, “Do people pair sound with color as chromesthetes do?” Four of the twelve questions (33%) administered during the Test Group A survey were successfully paired by the majority of participants with synesthete variables (*Table 3*). Participants paired the key of C with red, violet with the cor anglais, orange with the French horn, and green with the violin (*see Figure 21*). Questions 4, 6, and 12 paired instruments to color, while only Question 1 paired color to pitch (or key). It could be speculated based on these

particular findings that people are more likely to associate color with instruments as opposed to key, however, more research is needed.

TABLE 3.

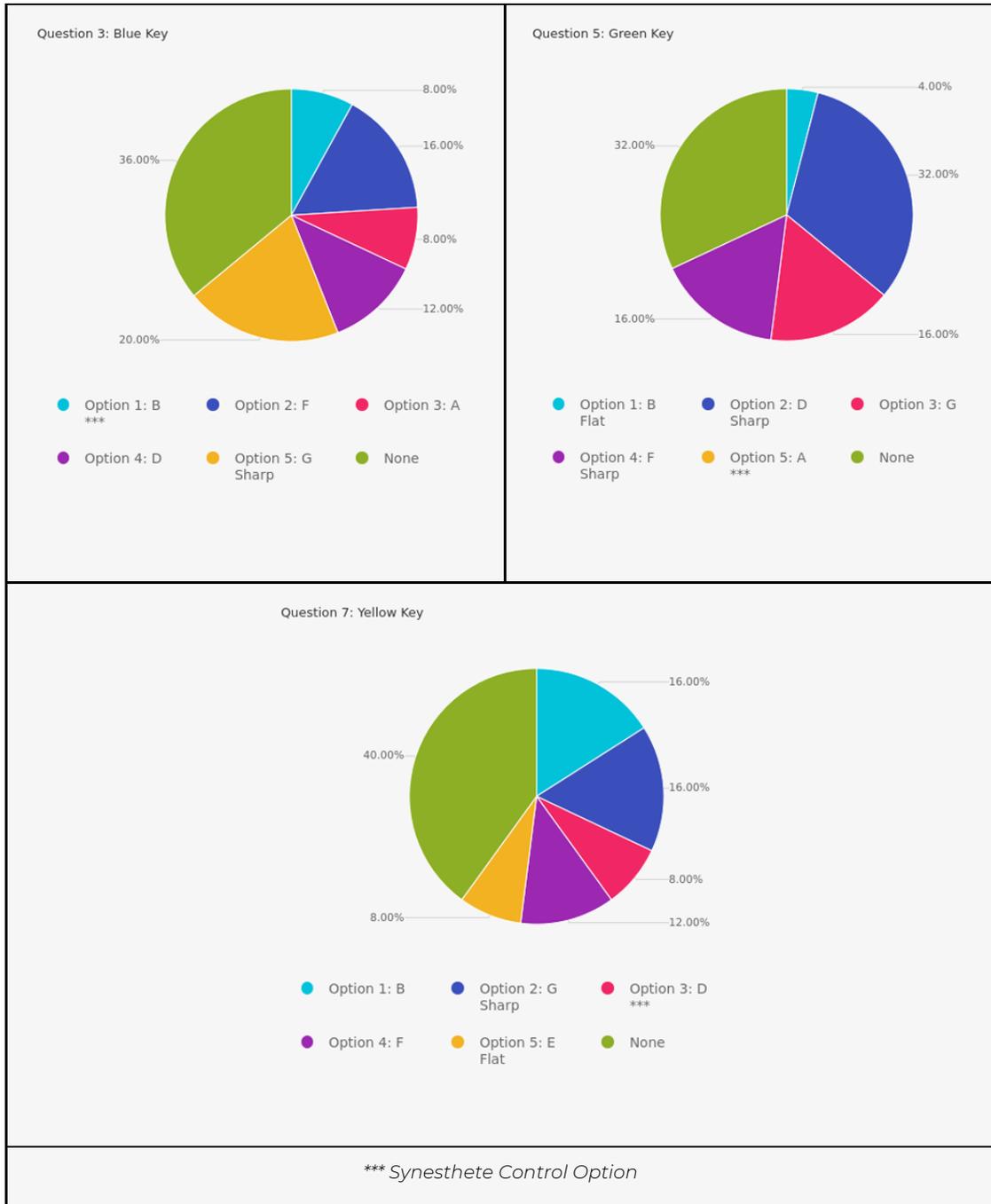
Test Group A: Synesthete Control Pairing



Three of the 12 questions administered were observed as not having a pairable sound by the majority of participants (*Table 4*). This could be due to the perception of shape over color. The majority of questions presented color in generally symmetrical, geometric shapes, such as triangles, rectangles, or lines. Questions 3, 5, and 7 presented color asymmetrically in uneven rectangles (*see Figure 9 and Figure 11*) or in incomplete shapes such as a hollowed triangle (*see Figure 7*). In Test Group A, this meant that 30-40% of participants had trouble pairing any sound at all to these shapes. It could be assumed that shape may affect perception of color when it doesn't take a symmetrical and/or complete geometric form. Since questions remained unchanged between groups, these questions are further analyzed for Test Group B and Combined Test Groups.

TABLE 4.

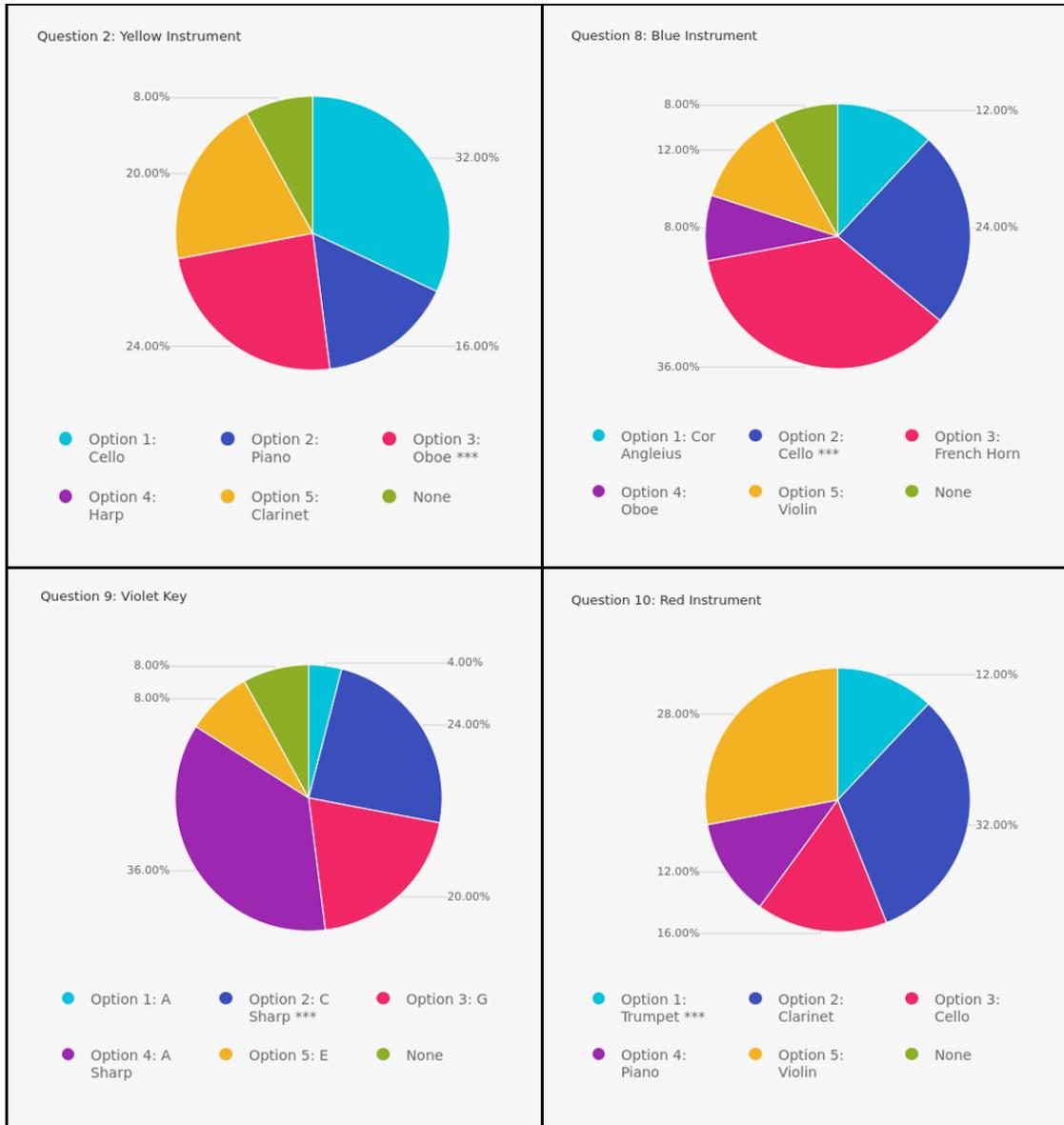
Test Group A: No Pairable Sound Results

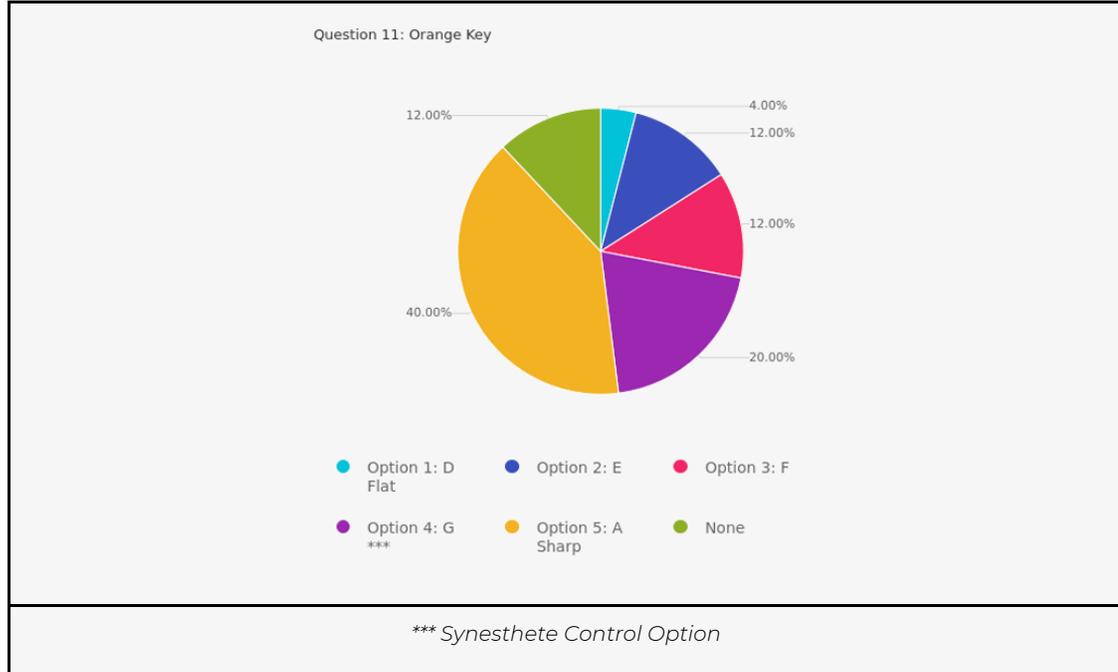


The remaining five questions did not match synesthete variables. Participants paired yellow with a cello and red with a clarinet for Questions 2 and 10. The similarity between the two questions is the form in which they were presented, a line (*see Figure 6 and Figure 14*). Questions 9 and 11 were paired with A sharp for violet and orange. The similarity between the two questions is both in form and shade. Both are triangular and could be considered light in color saturation (*see Figure 13 and Figure 15*). It could be speculated that a higher pitched note was chosen for both because of the perception of light colors, however, further research would need to be conducted to conclude this. Participants paired blue with a French horn for Question 8, which in comparison to the previously selected French horn for orange is only 4% lower in majority.

TABLE 5.

Test Group A: Unsuccessful Synesthete Control Pairing





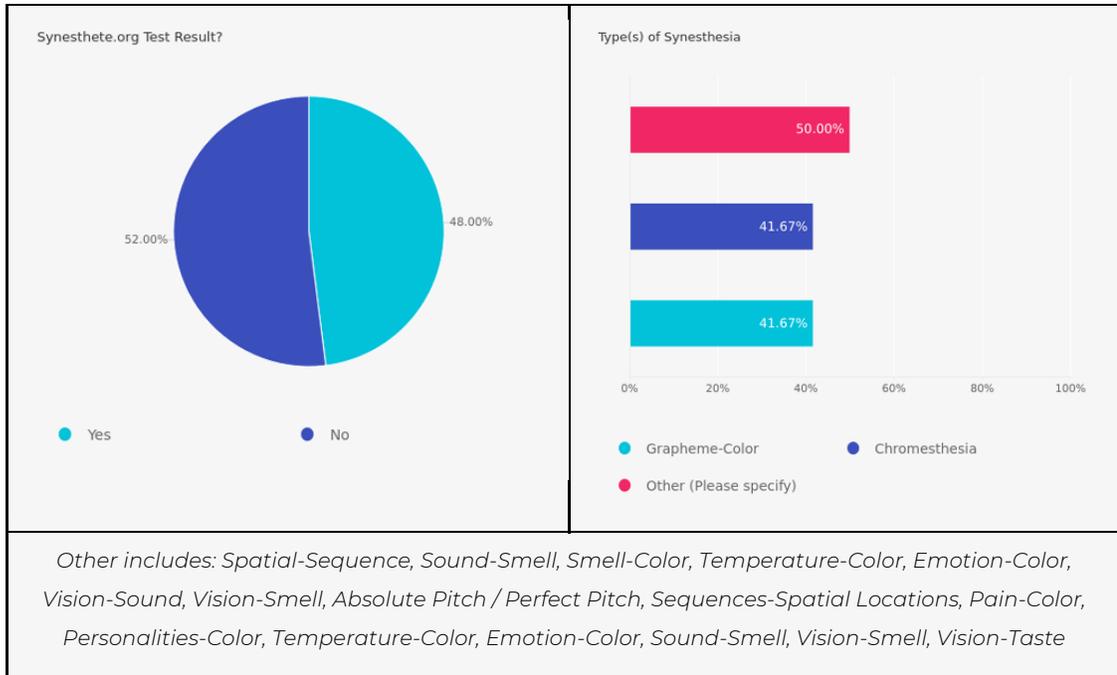
It can also be observed that although these questions are ranked ordinally, the majority percentages for all questions are below 50%. Future testing using a Likert scale could provide a better understanding of how people pair a particular sound with a particular color.

Synesthete Results

All participants completed the synesthesia battery preview questionnaire (*Appendix E*). Sixteen participants went on to register for the proceeding synesthesia battery test, and of them 12 were rated as synesthetic.

TABLE 6.

Test Group A: Synesthete and Synesthesia Types Results



Synesthete results were determined based on a number of factors, one being the rating calculated by the synesthesia battery test. The synesthesia battery test rates grapheme-color and chromesthesia test results between 0-1 as synesthetic and around 2 or more as non-synesthetic. Between one and two could constitute a retest in order to better determine synesthetic ability. Seven of the 12 participants completed grapheme-color or chromesthesia trials that fell between 1 and 2. However, six of these participants also selected types of synesthesia that technology limits us to test for using the synesthesia battery. These six participants are considered synesthetes since additional testing is not available at this time. Five of the 7 participants were tested using various chromesthesia trials (pitch-color, chord-color,

and/or instrument-color). Participant 17 did not select any types of incalculable synesthesia, however, when tested for chromesthesia, scored 1.04 during the instrument-color trials. A speed congruency test was not administered proceeding these trials for chromesthetes, as was conducted for those with grapheme-color synesthesia. This data may have provided additional information to determine true synesthetic potential. Therefore, Participant 17 remains classified as a chromesthete. Two of these 6 synesthetes scored within the range of 0 and 1 for other grapheme-color and/or chromesthesia trials, classifying them as synesthetes. Four of the 12 participants selected types of incalculable synesthesia (spatial-sequence and sound-smell synesthesia) using the synesthesia battery test and are also considered synesthetes for the purpose of this paper.

TABLE 7.
Test Group A: Synesthete Classifications

Participant	Type(s) of Calculable Synesthesia	First Trial	Score	Second Trial	Score	Third Trial	Score	Fourth Trial	Score	Fifth Trial	Score	Speed Congruency Test Score	Types of Synesthesia Unable to Conduct Testing For
Participant 3	Grapheme->Color	months-color	1.78	vision-sound	unknown	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Smell->Color Temperature->Color Emotion->Color Vision->Smell
Participant 6	Grapheme->Color	number-color	0.64	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	speed 90%	n/a
Participant 8	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Sequences->Spatial locations (Sequences such as numbers, weekdays or months) Absolute Pitch
Participant 10	Grapheme->Color	weekday-color	1.29	month-color	1.28	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Pain->Color Temperature->Color
Participant 11	Chromesthesia	pitch-color	1.232	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Pain->Color Personalities->Color Temperature->Color Emotion->Color Sound->Smell Vision->Smell Vision->Taste
Participant 12	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Sequences->Spatial locations (Sequences such as numbers, weekdays or months)
Participant 13	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Sound->Smell
Participant 17	Chromesthesia	pitch-color	1.36	chord-color	2.14	instrument-color	1.04	n/a	n/a	n/a	n/a	n/a	n/a
Participant 18	Chromesthesia Grapheme->Color	month-color	0.51	pitch-color	2.128	chord-color	2.2	instrument-color	1.23	n/a	n/a	n/a	Smell->Color Pain->Color Temperature->Color Emotion->Color Vision->Smell Sound->Touch
Participant 22	Chromesthesia Grapheme->Color	weekday-color	0.66	month-color	0.88	pitch-color	2.3	chord-color	1.65	instrument-color	0.42	n/a	Sequences->Spatial locations (Sequences such as numbers, weekdays or months) Taste->Color Smell->Color Pain->Color Temperature->Color Emotion->Color Sound->Smell Vision->Smell
Participant 24	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Sequences->Spatial locations (Sequences such as numbers, weekdays or months)
Participant 25	Chromesthesia	letter-color	2.38	chord-color	2.04	instrument-color	1.2	n/a	n/a	n/a	n/a	speed 71%	Taste->Color Smell->Color Pain->Color Personalities->Color Temperature->Color Emotion->Color Vision->Smell
	Battery Retest (Possibly) Needed												
	Synesthete												

Two synesthetes matched half the synesthete controls (for a total of 6 matches) during the sound-pairing survey, while three synesthetes matched five, and one synesthete matched 4.

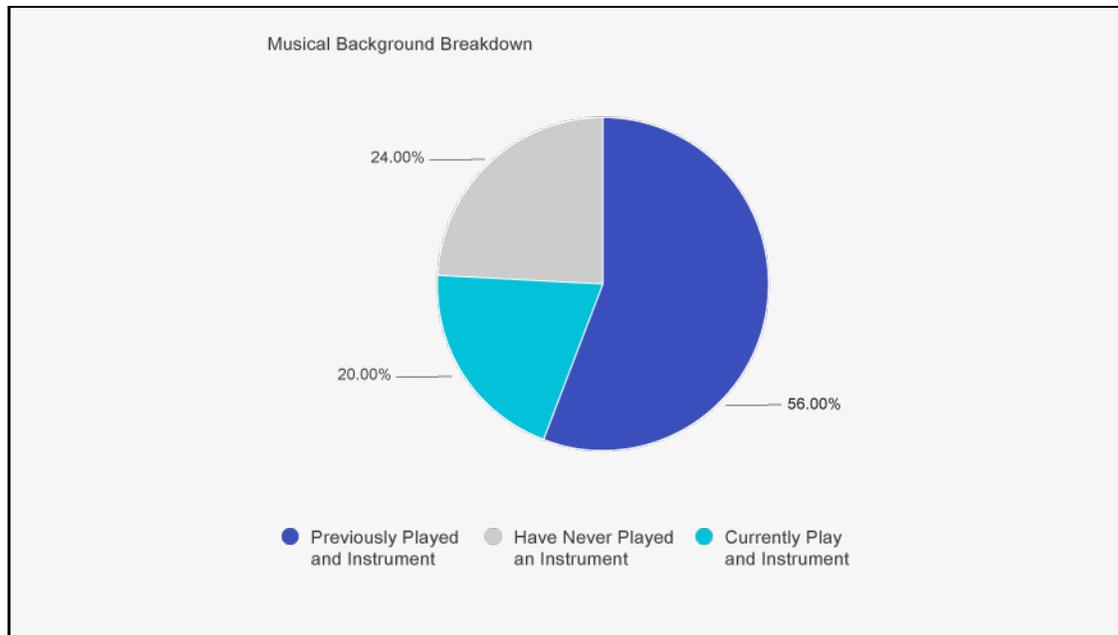
TABLE 8.

Test Group A: Synesthete Sound Choice vs. Synesthete Control

Participant #	Question 1 (P)	Question 2 (I)	Question 3 (P)	Question 4 (I)	Question 5 (P)	Question 6 (I)	Question 7 (P)	Question 8 (I)	Question 9 (P)	Question 10 (I)	Question 11 (P)	Question 12 (I)	Number of Successful Synesthete Pairings	Type(s) of Synesthesia
Participant 3	2	3	1	3	4	2	5	2	2	2	5	5	5	Grapheme->Color (month-color) Vision/Movement->Sound Smell->Color Temperature->Color Emotion->Color 6 Vision->Smell
Participant 6	4	NONE	3	3	4	4	3	3	2	3	5	2	5	5 Grapheme->Color (number-color)
Participant 18	2	1	4	3	2	5	1	3	2	1	4	1	5	Grapheme->Color (month-color) Chromesthesia (instrument-color) Smell->Color Pain->Color Temperature->Color Emotion->Color Vision->Smell 5 Sound->Touch
Participant 22	2	2	5	3	2	4	1	1	3	4	3	2	4	Grapheme->Color (weekday-color, month-color) Chromesthesia (instrument-color) Sequences->Spatial locations (Sequences such as numbers, weekdays or months) Taste->Color Smell->Color Pain->Color Temperature->Color Emotion->Color Sound->Smell 4 Vision->Smell
Participant 24	2	2	5	3	4	4	NONE	2	4	5	4	NONE	5	Sequences->Spatial locations (Sequences such as numbers, weekdays or months)
Participant 25	5	3	2	3	NONE	3	NONE	2	4	1	4	2	6	Chromesthesia (instrument-color) Taste->Color Smell->Color Pain->Color Personalities->Color Temperature->Color Emotion->Color 6 Vision->Smell
Synesthete Variable														

Musical Training Results

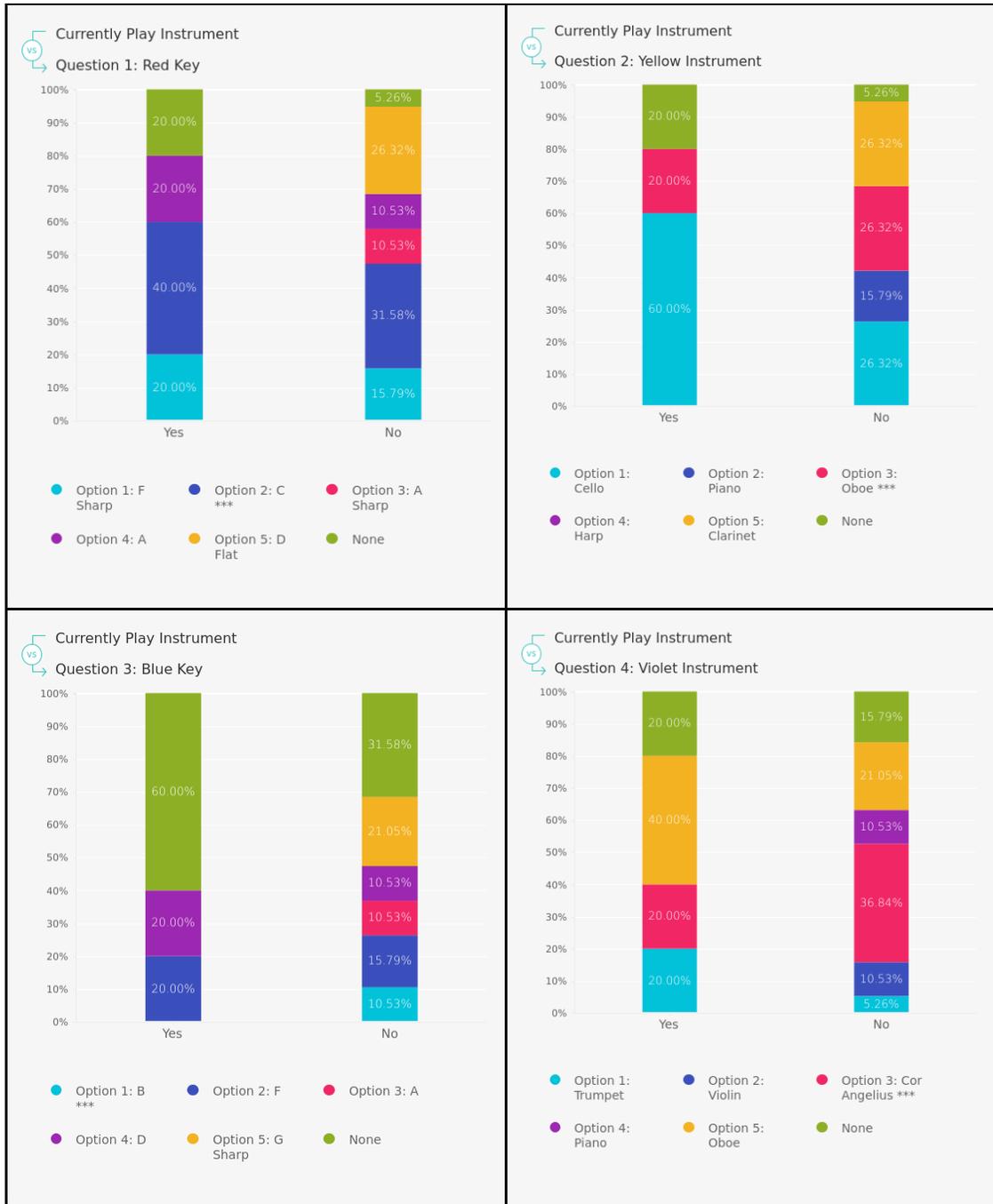
Participants at the end of the survey were asked if they currently play an instrument, previously played an instrument, or have never played an instrument. All participants answered the question, with 56% having previously played an instrument, 24% having never played an instrument, and 20% currently playing an instrument.

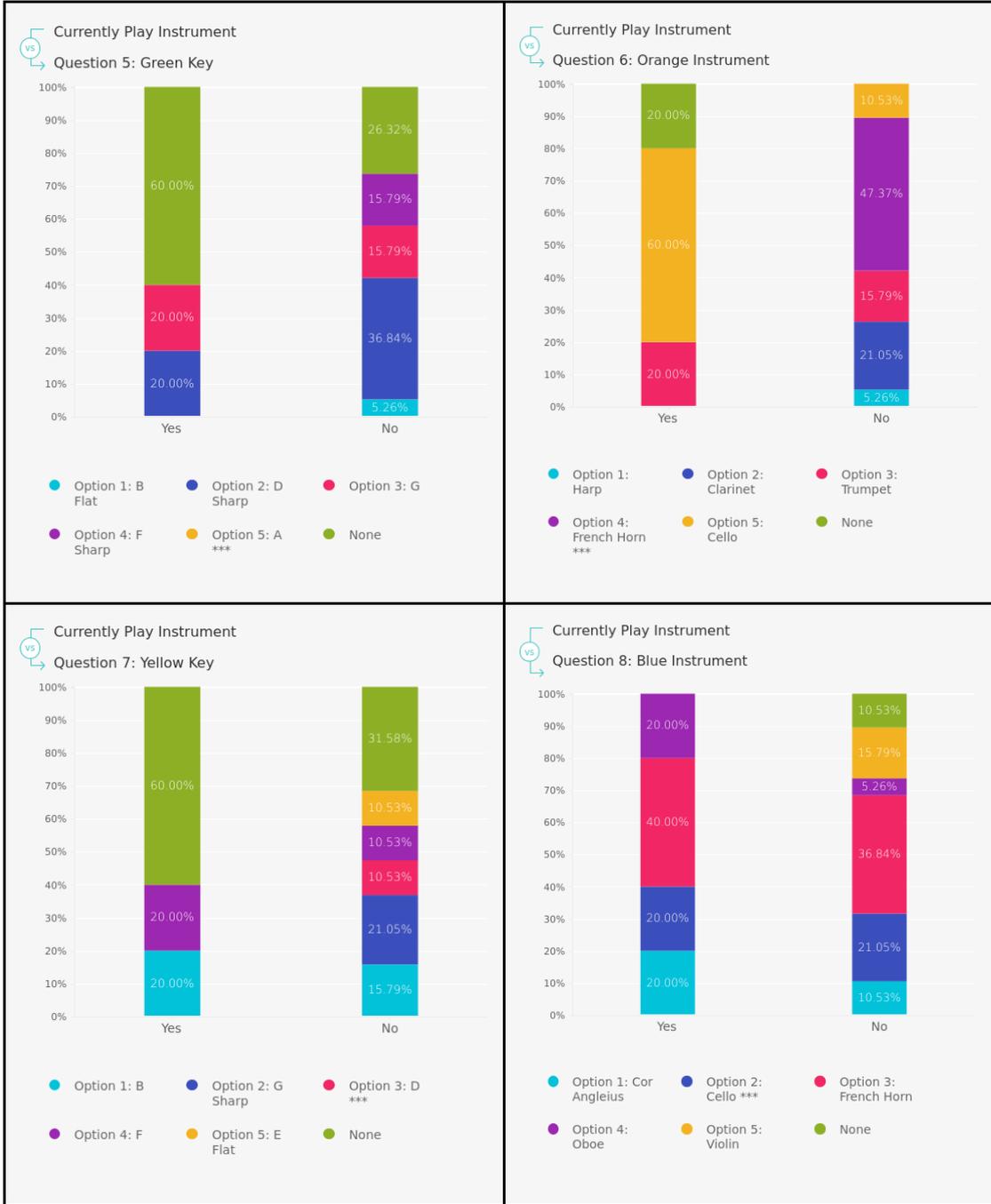
TABLE 9.***Test Group A: Musical Background Breakdown***

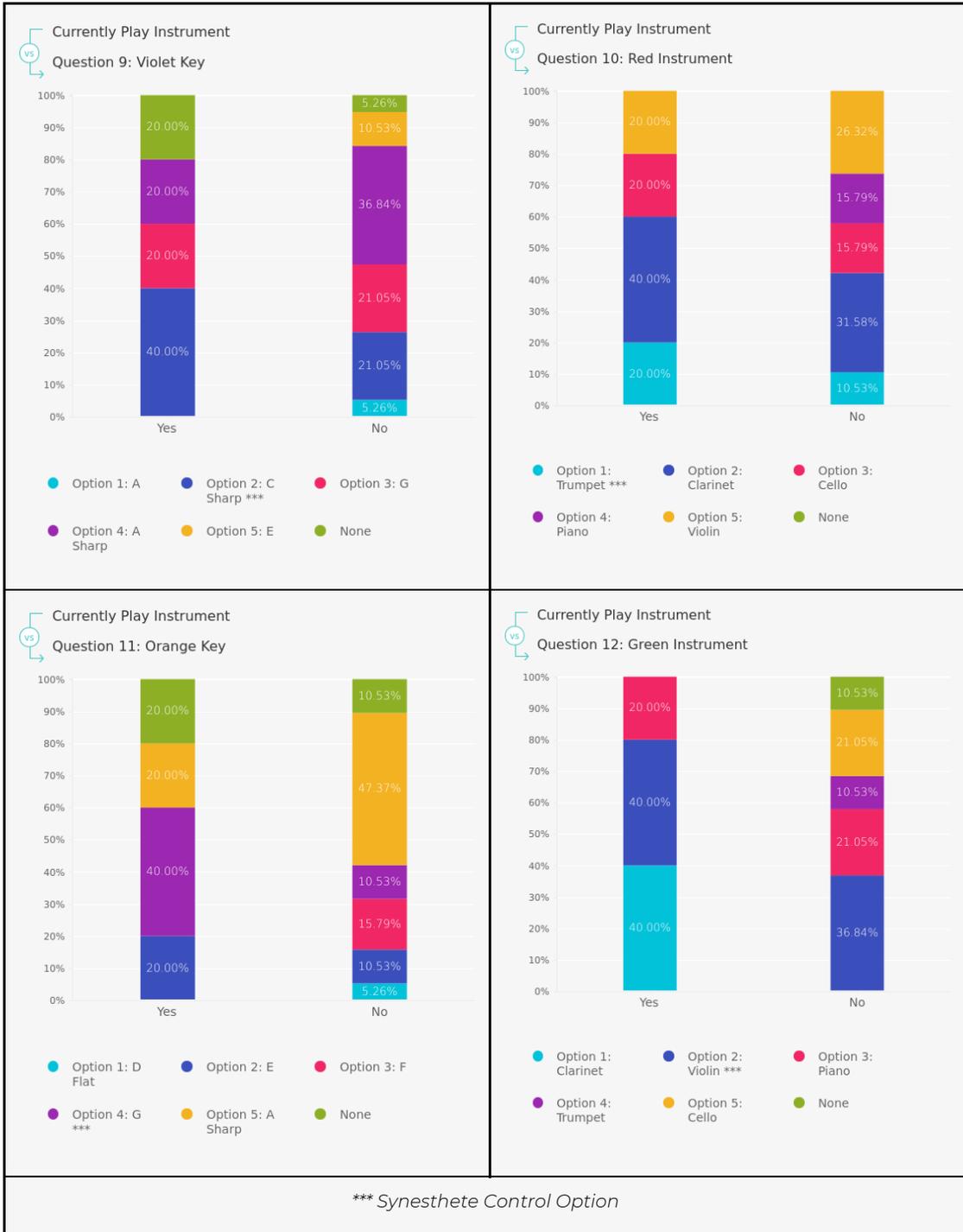
Participants who currently play an instrument were more unified in their sound choices with most percentages over 40% and a few at 60%. Current musicians were less likely to have picked a variety of choices, and were more consolidated to 3-4 choice options rather than 6.

TABLE 10.

Test Group A: Currently Play an Instrument Question Responses





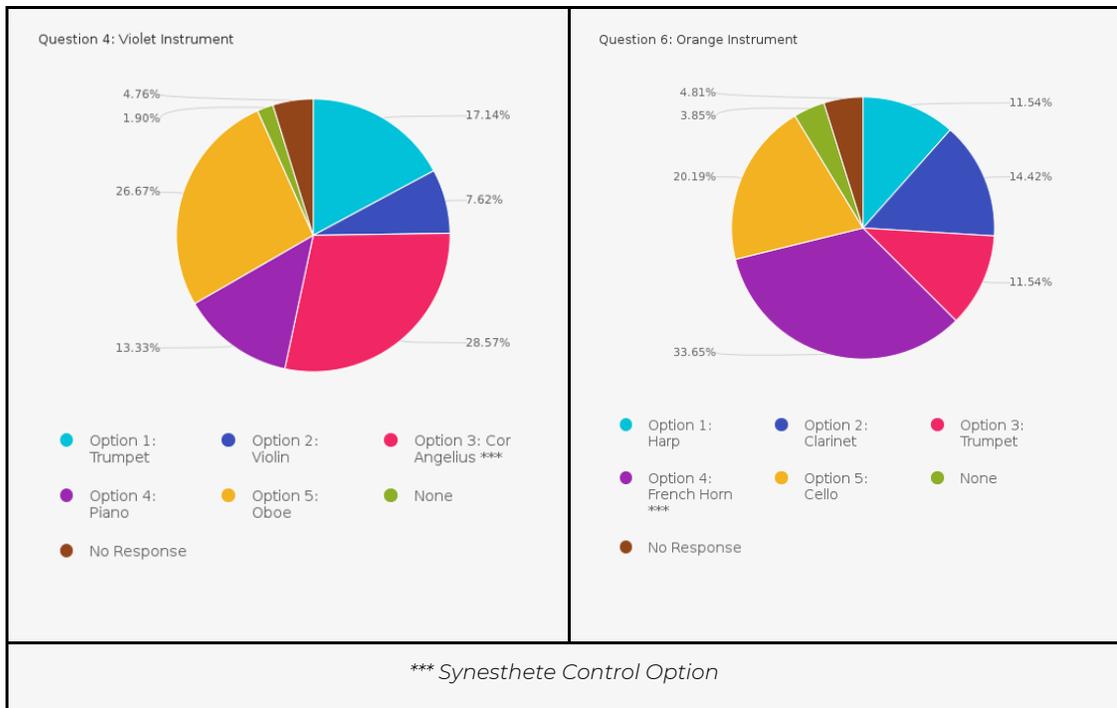


TEST GROUP B: SPRING 2020

One hundred and five participants completed the live, online survey during the month of January 2020. Results were calculated based on an ordinal scale to break down how many participants matched their sound choices to synesthete controls in order to answer the question, “Do people pair sound with color as chromesthetes do?” Only 2 of the 12 questions had a majority response, meaning that the synesthete control was the highest chosen percentage for these questions of all the options (marked by 3 asterisks). It is important to note that all percentage values are lower than 50%.

TABLE 11.

Test Group B: Synesthete Control Pairing

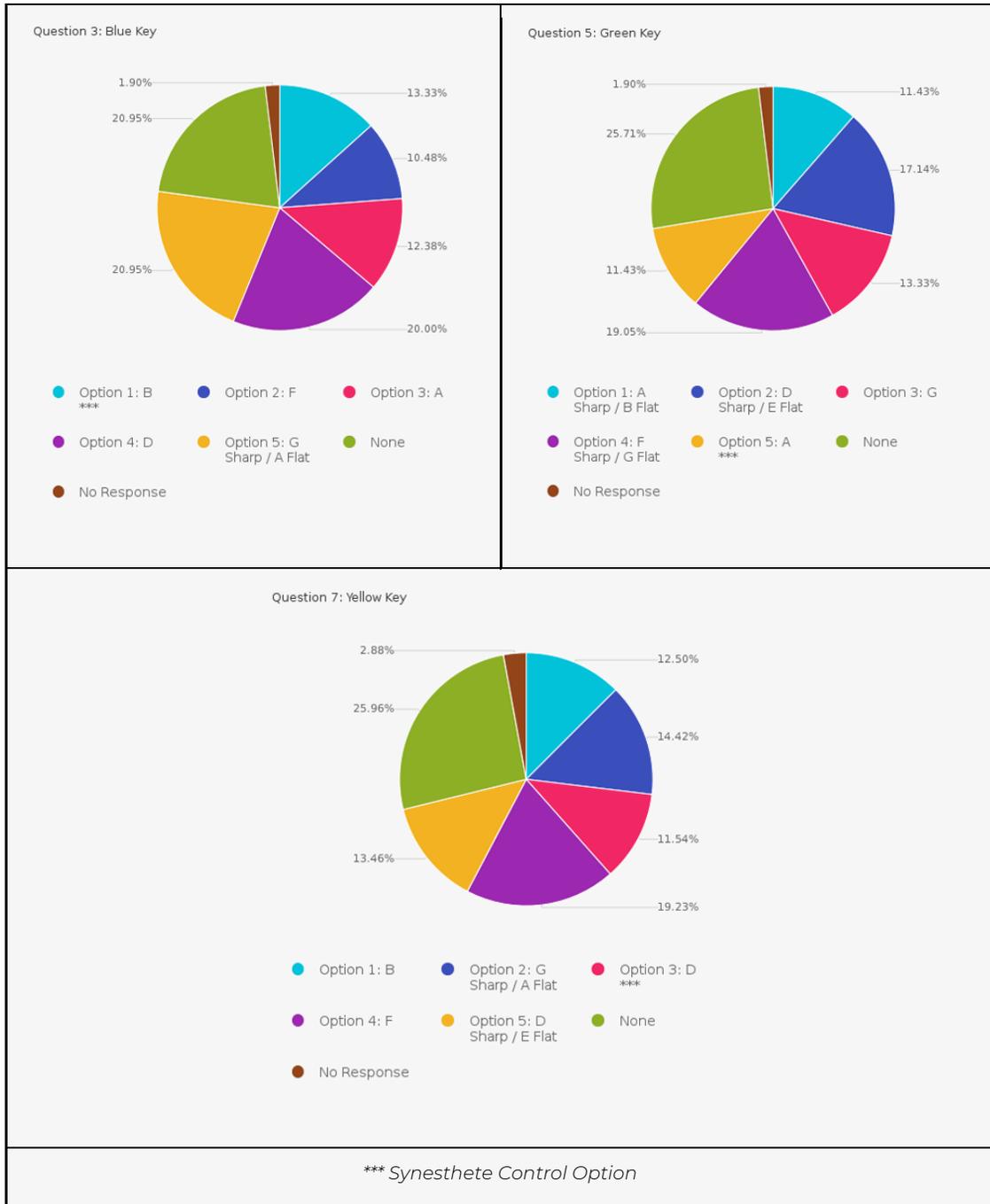


Question 4 had around 29% of participants hearing violet as the cor anglais. Question 6 had around 34% of participants hearing orange as the French horn. It's important to note however that in addition to these numbers being a low majority, question 4 also had people pairing violet in close second to the oboe, at around 27%.

In Test Group A, I had discovered that potentially asymmetrical or incomplete shapes could be affecting participants' perception of color (see Table 4), based on responses to Questions 3 (see Figure 7), 5 (see Figure 9), and 7 (see Figure 11). Test Group B was presented with the exact same questions as Test Group A, and had a lower percentage rate of "None" responses than Test Group A participants. Test Group A responded with majorities in the 30-40% range, meaning that a third to almost half of participants were having trouble pairing a sound to asymmetrical, incomplete shapes. Test Group B's responses were slightly lower, in the low-to-mid 20% range but still accounted for the majority response in comparison to the other options. 75-80% of participants remained unaffected by asymmetrical or incomplete shapes and chose a sound option.

TABLE 12.

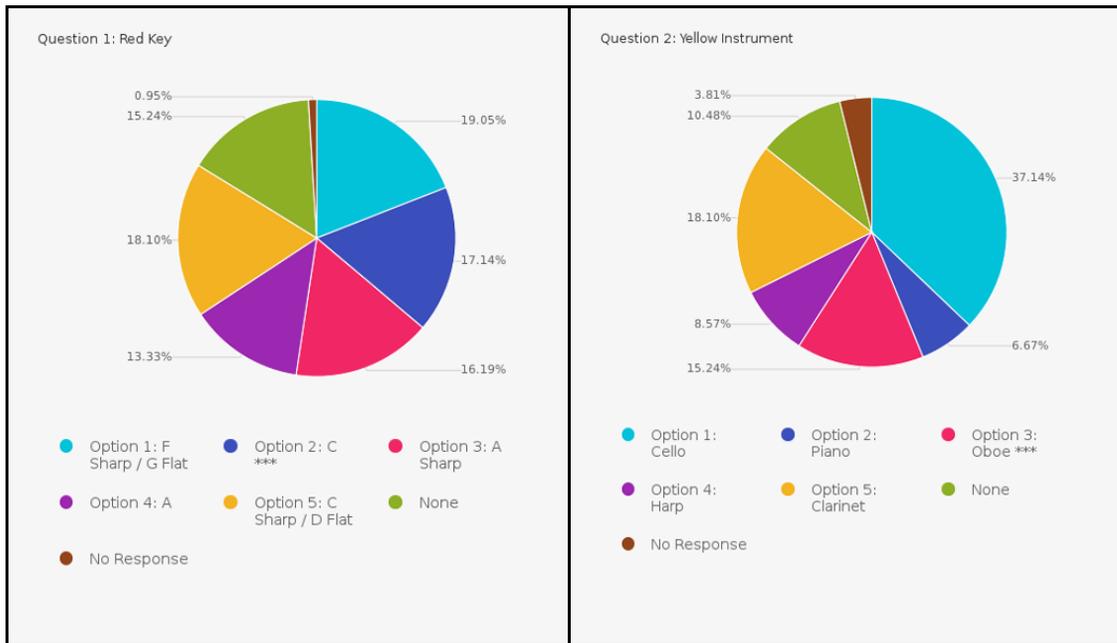
Test Group B: No Pairable Sound Results

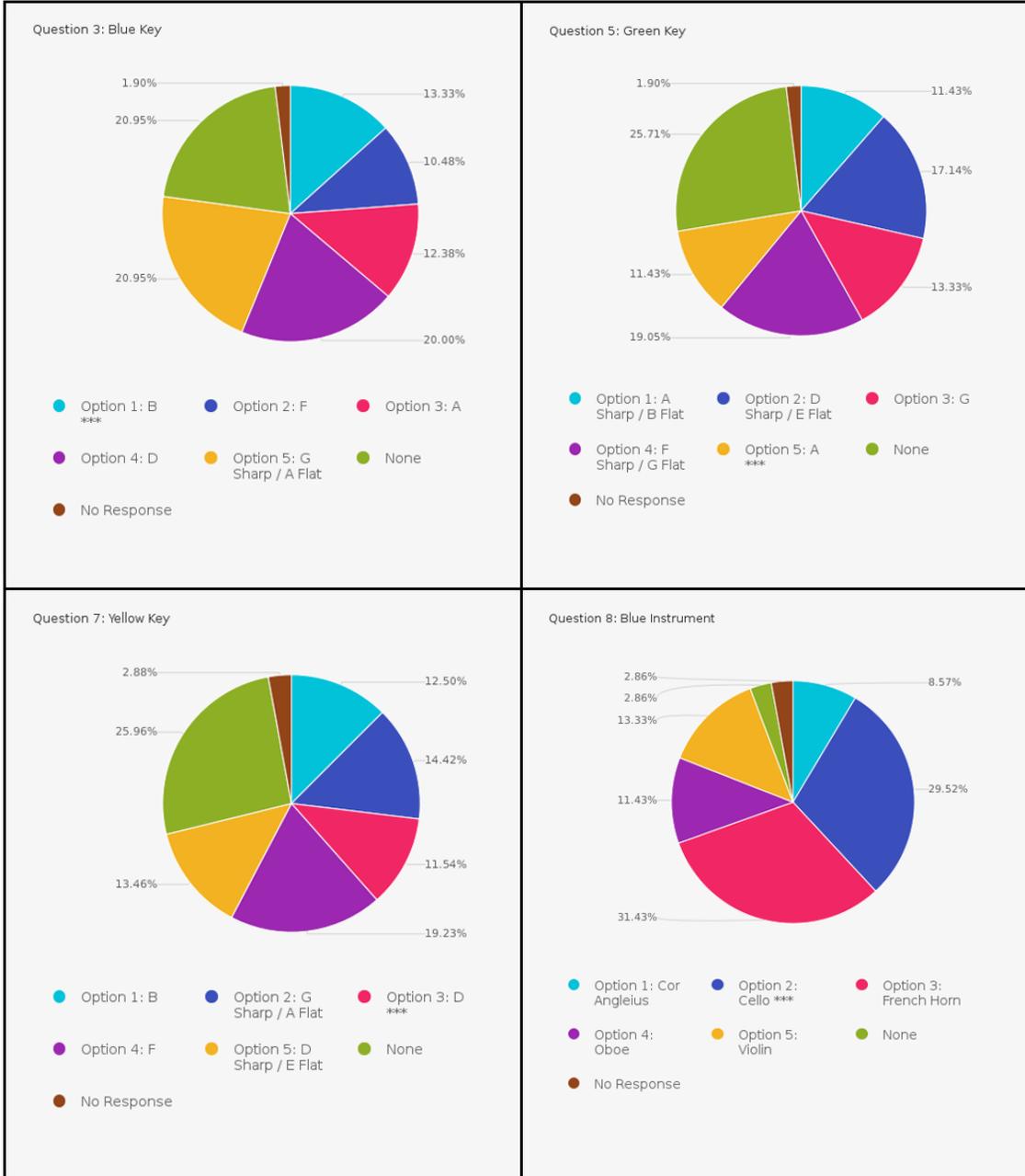


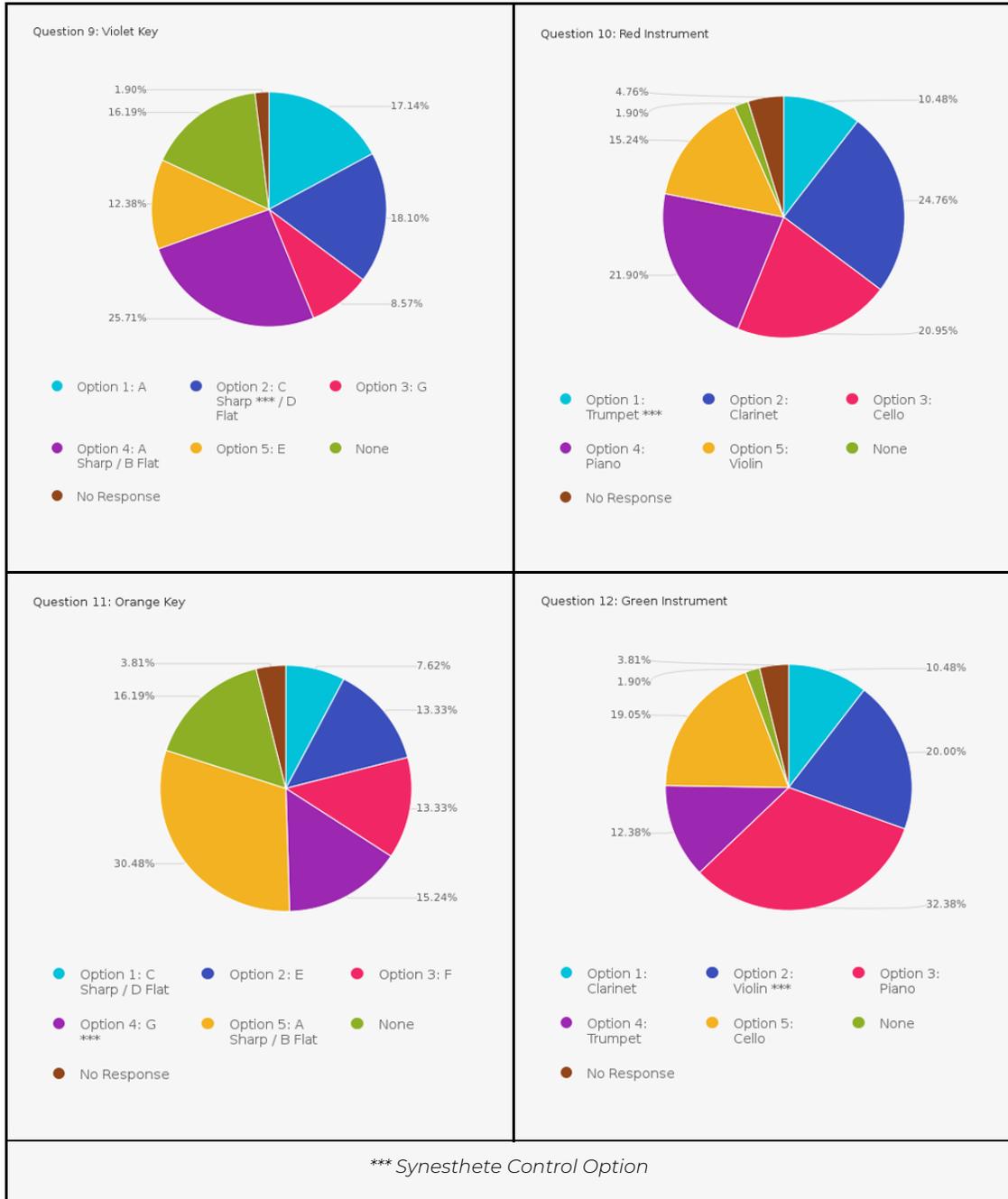
The sound-pairing survey consisted of 12 questions that each contained a synesthete control option. 10 of those 12 questions resulted in participants not choosing the synesthete control option. These questions were 1, 2, 3, 5, 7, 8, 9, 10, 11, and 12.

TABLE 13.

Test Group B: Unsuccessful Synesthete Control Pairing





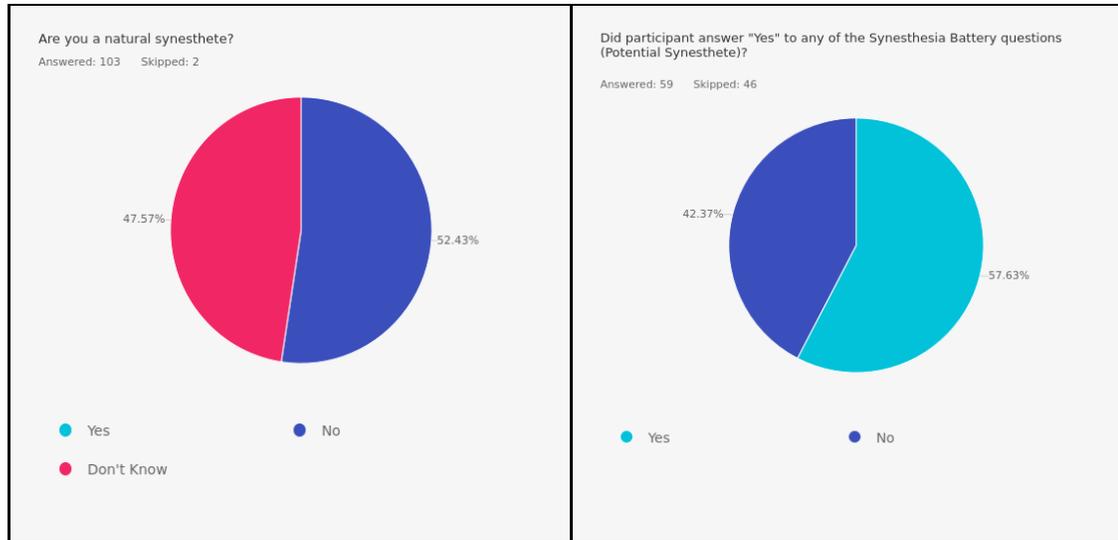


Although Test Group B participants, overall, did not hear what chromesthetes hear, there are some larger majority responses to one sound for a few of the questions. Questions 2, 8, 11, and 12 had some

participants agreeing as to what sound best represented the color on screen, however, it is important to note that these numbers are still below 50%. For Question 2, 37% of participants felt that the yellow sounded like a cello. Participant responses to Question 8 paired blue with the French horn at 31%. The synesthete control for this question came in second, with 30% choosing the cello. Orange in Question 11 was paired with A sharp (which is also B flat) at 30% and green in Question 12 with the piano at 32%.

Synesthete Results

105 participants participated in the 2020 survey, of which not one participant immediately identified themselves as a synesthete. Of the participants who answered the question, “Are You a Natural Synesthete,” 52% of participants (54 participants) responded that they are not while 48% (49 participants) were unsure.

TABLE 14.***Test Group B: Synesthete Identification and Potential Synesthete***

Fifty-nine participants answered the Synesthesia Battery Preview questions and of those 59 participants, 34 participants (58%) answered “yes” to one or more of the synesthesia related questions. The Synesthesia Battery Preview questions are a precursor to the registered version of the Synesthesia Battery. Any participant who answers “yes” to one of these questions is considered potentially synesthetic and are rated on a scale of how synesthetic they are during the registered Synesthesia Battery.

Participants in the 2020 survey did not complete the full Synesthesia Battery test (for time reasons), therefore, the extent or full diagnosis of their synesthesia is unknown. However, using the Synesthesia Battery Preview questions, potential forms of synesthesia were recorded and analyzed to see if potential synesthetes or non-

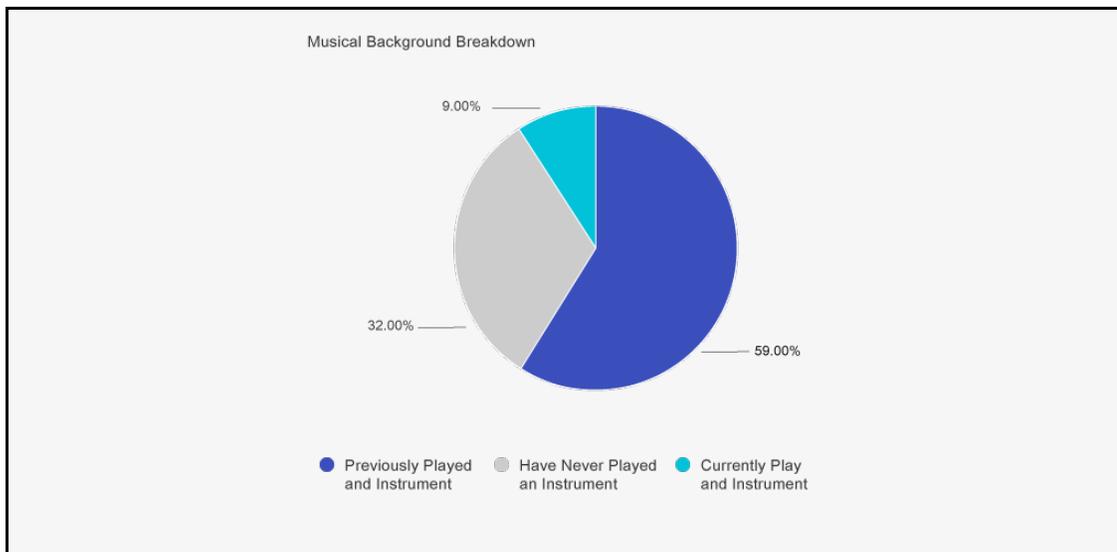
synesthetes picked the synesthete control options. These responses were also all below 50% and there was nothing of particular interest to note.

Musical Training Results

Participants at the beginning of the survey were asked if they currently play an instrument, previously played an instrument, or have never played an instrument. All participants answered the question, with 59% having previously played an instrument, 32% having never played an instrument, and 9% currently playing an instrument.

TABLE 15.

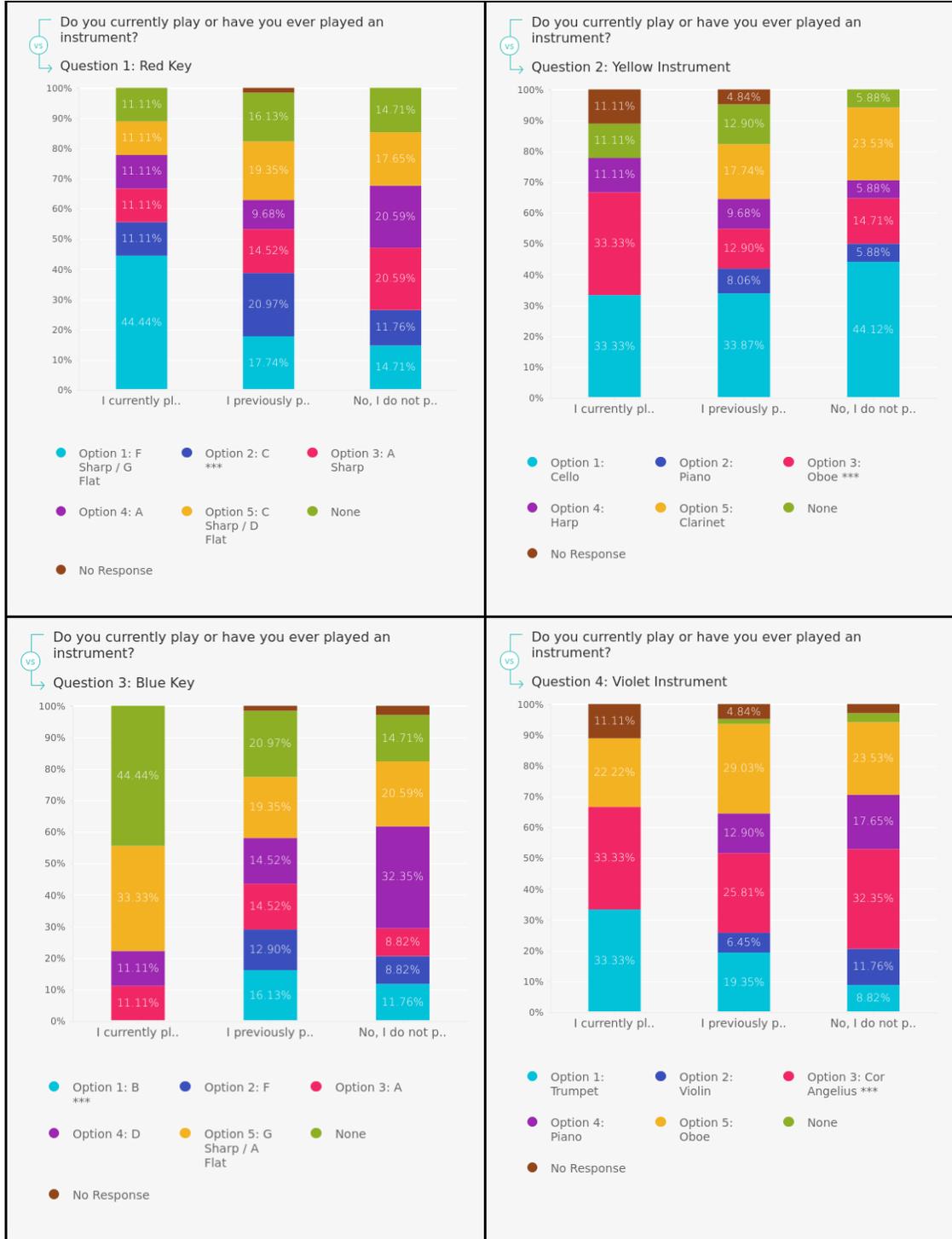
Test Group B: Musical Background Breakdown

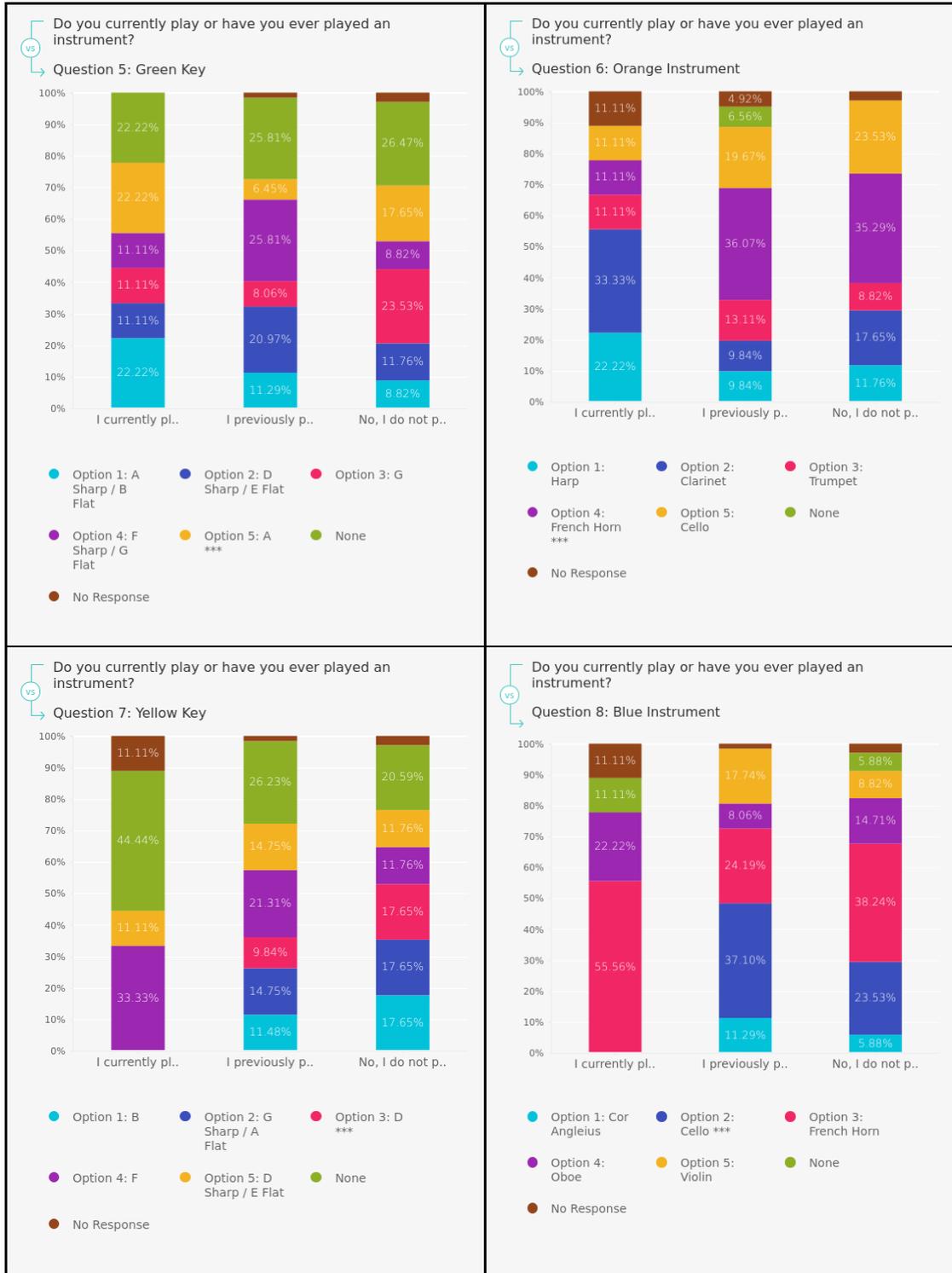


Participants who currently play an instrument were more unified in their sound choices with some percentages over 40% and a couple over 50%. Current musicians were less likely to have picked a variety of choices, and were more consolidated to 3-4 choice options rather than 7.

TABLE 16.

Test Group B: Currently Play an Instrument Question Responses





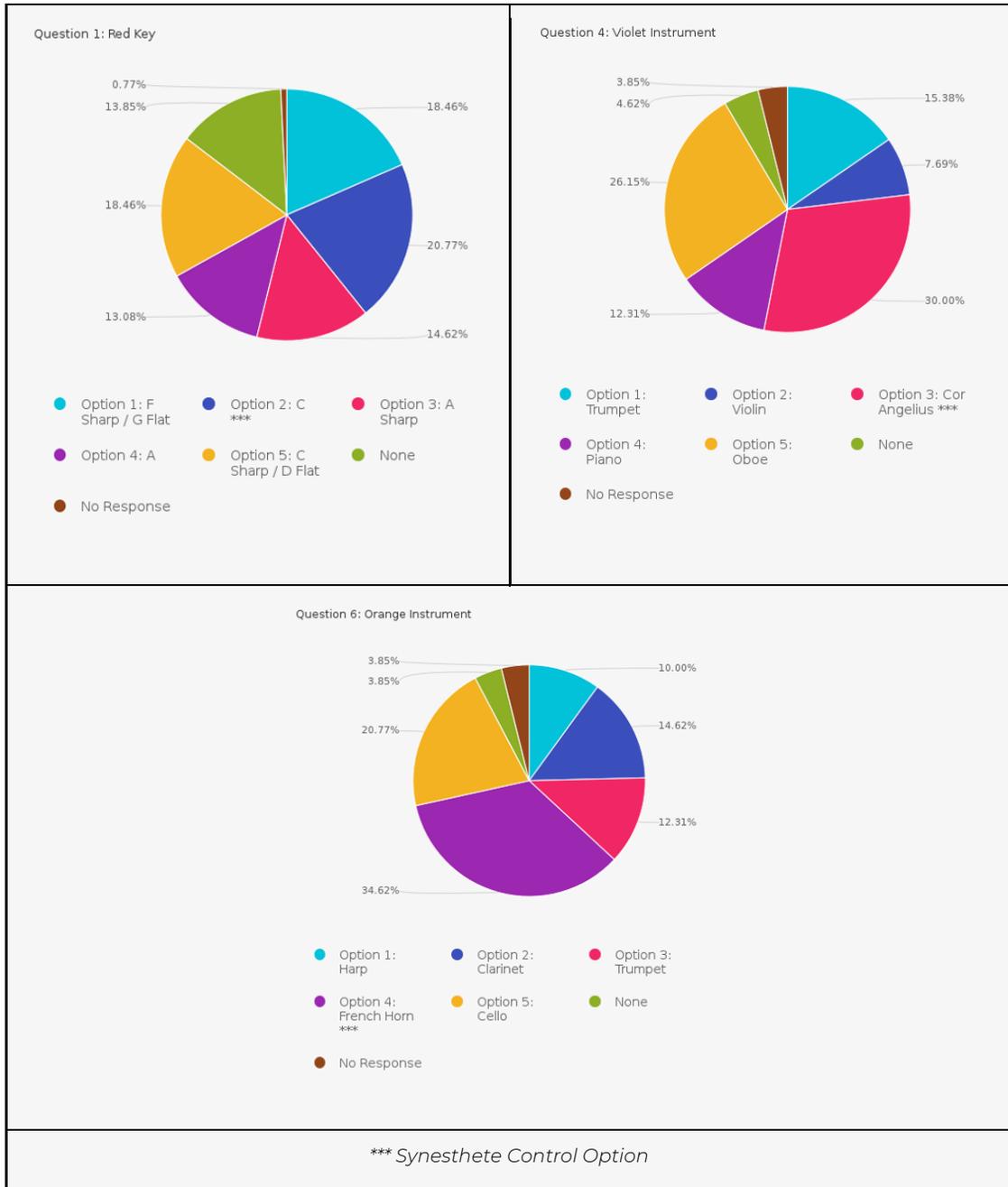


TOTAL RESULTS

A total of 130 participants participated in my study (both Test Group A and Test Group B combined) over the course of a year. Results were calculated based on an ordinal scale to break down how many participants matched their sound choices to synesthete controls in order to answer the question, “Do people pair sound with color as chromesthetes do?” Only 3 of the 12 questions had a majority response, meaning that the synesthete control was the highest chosen percentage for these questions of all the options (marked by 3 asterisks). It is important to note that all percentage values are lower than 50%.

TABLE 17.

Total Results: Test Groups A & B: Synesthete Control Pairing

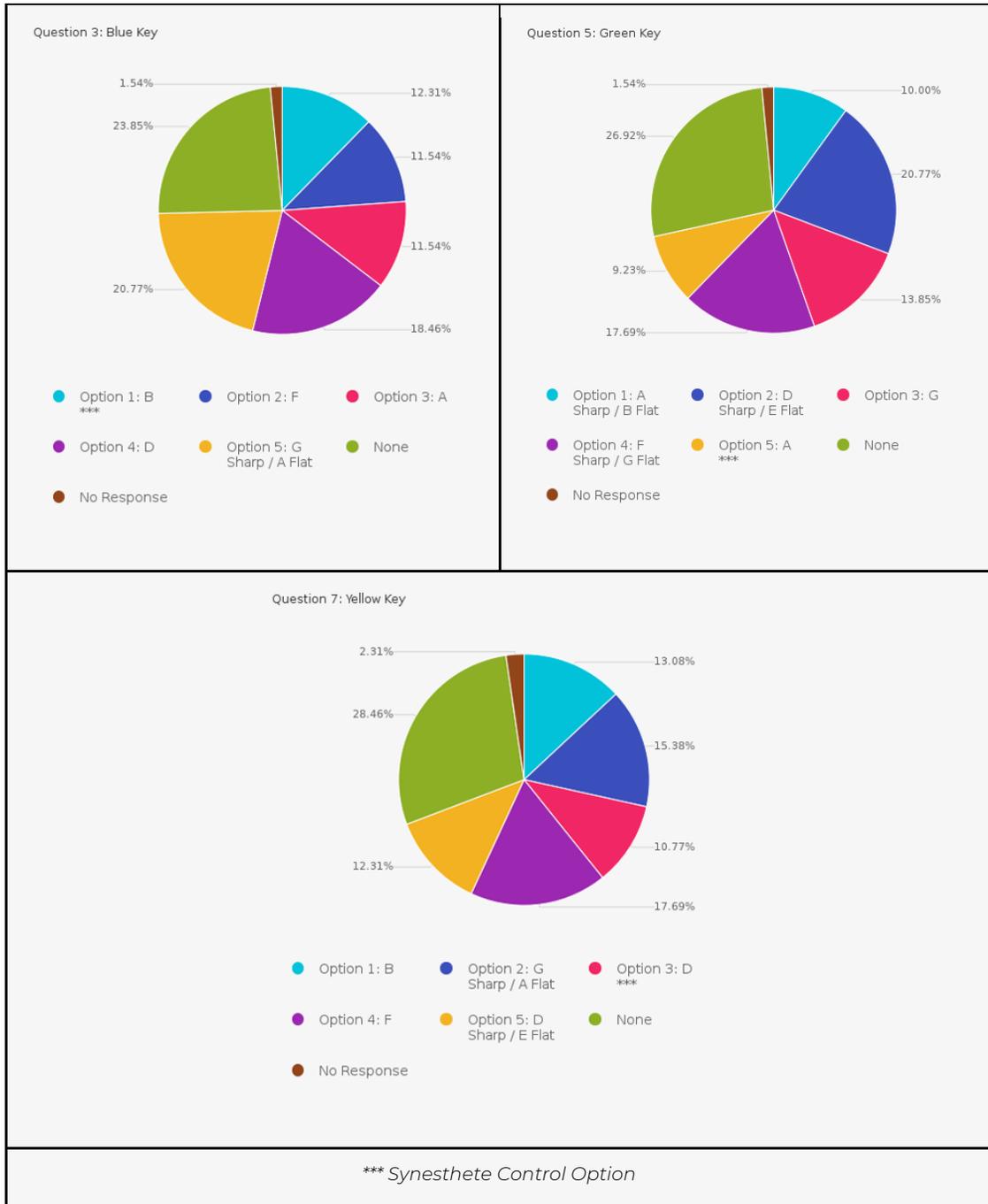


Question 1 resulted in around 21% of participants pairing red with the key of C. Question 4 had 30% of participants pairing violet with the cor anglais. Question 6 had around 35% of participants pairing orange with the French horn.

In Test Group A, I had discovered that potentially asymmetrical or incomplete shapes could be affecting participants' perception of color (see Table 4), based on responses to Questions 3 (see Figure 7), 5 (see Figure 9), and 7 (see Figure 11). In combining results, these questions still had a lower percentage rate of “None” responses. Test Group A responded with majorities in the 30–40% range, meaning that a third to almost half of Test Group A participants were having trouble pairing a sound to asymmetrical, incomplete shapes. Total participants responded in the mid-high 20% range but “None” accounted for the majority response in comparison to the other options. 70–75% of total participants remained unaffected by asymmetrical or incomplete shapes and chose a sound option.

TABLE 18.

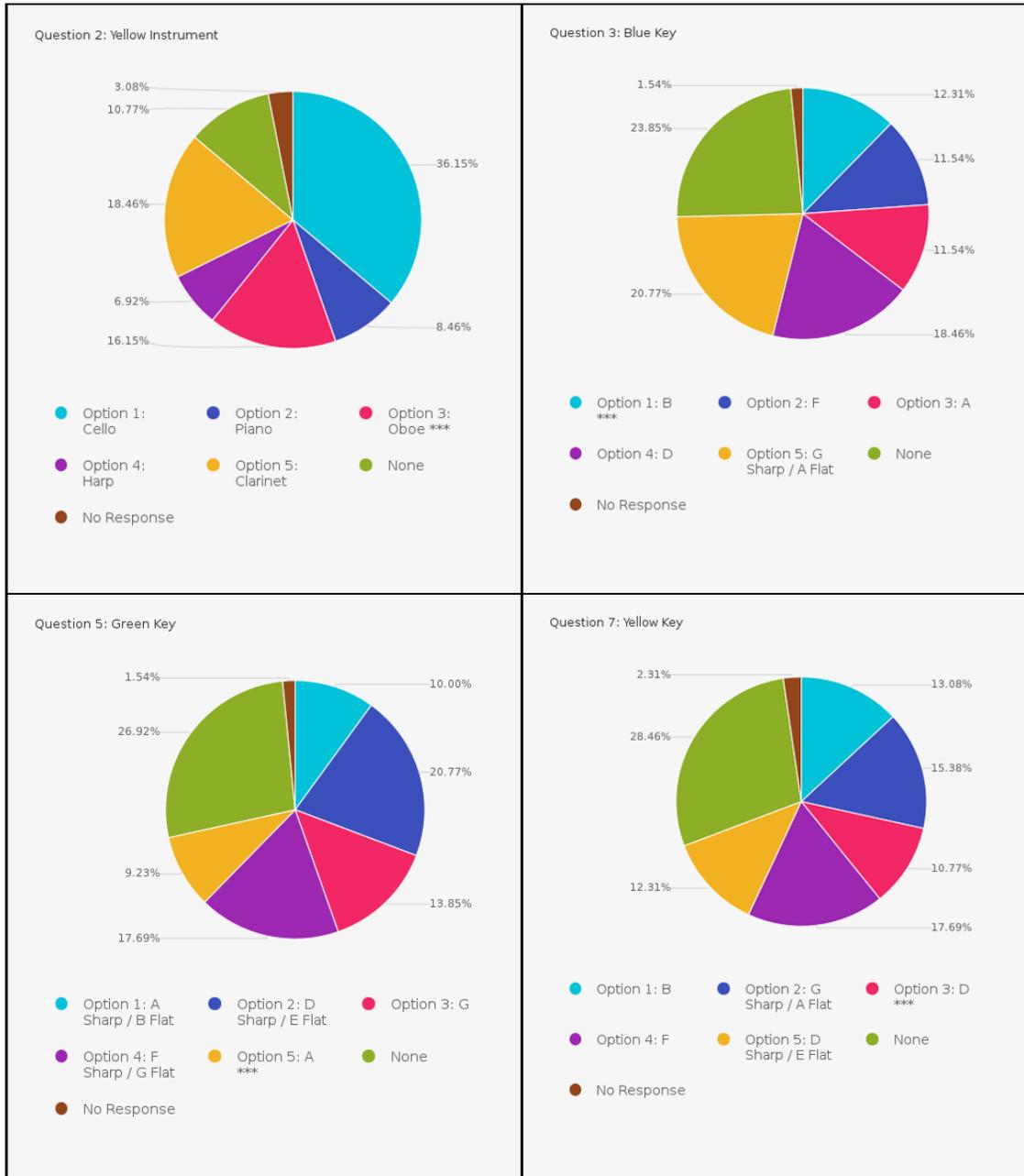
Total Results: Test Groups A & B: No Pairable Sound Results

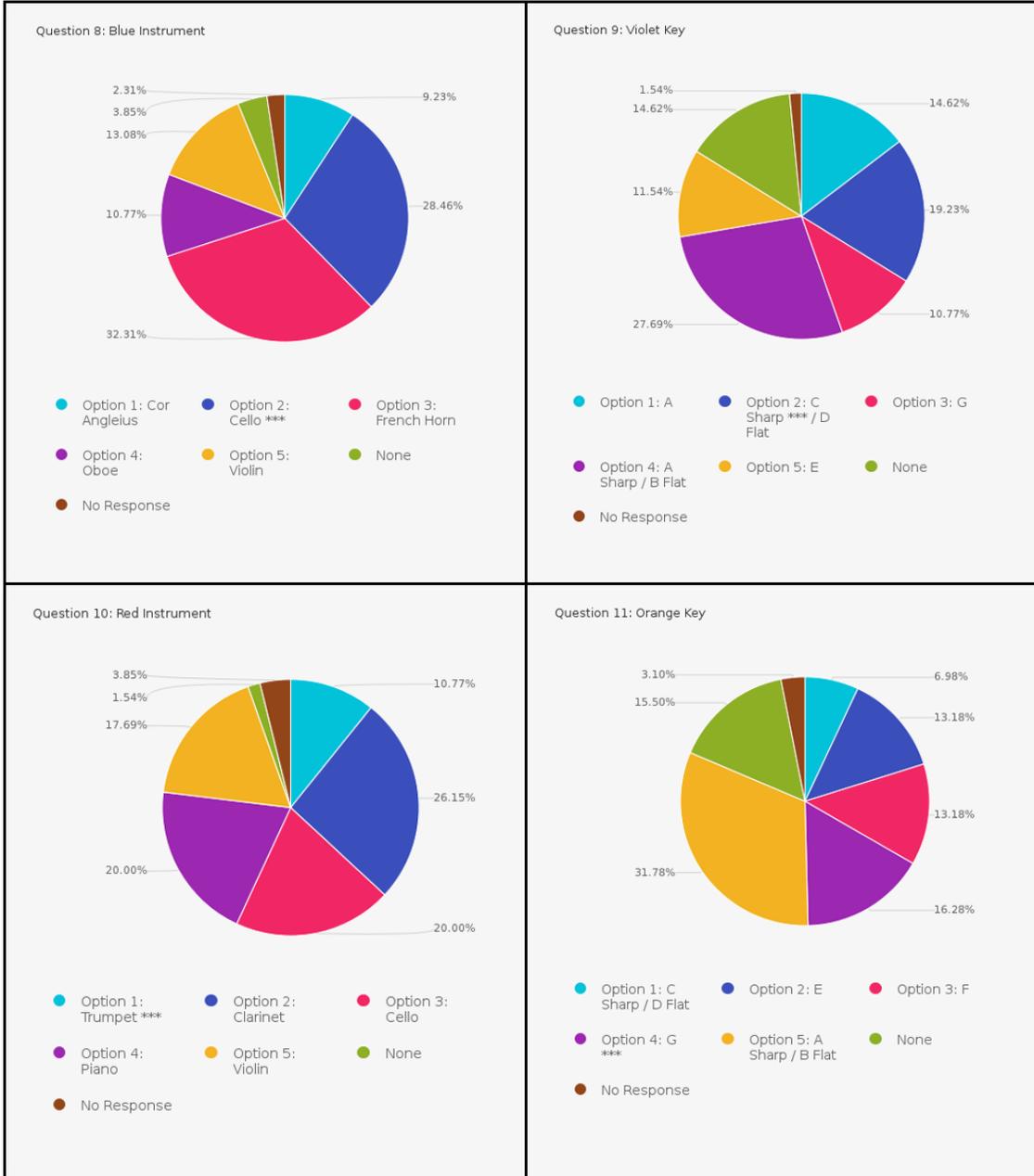


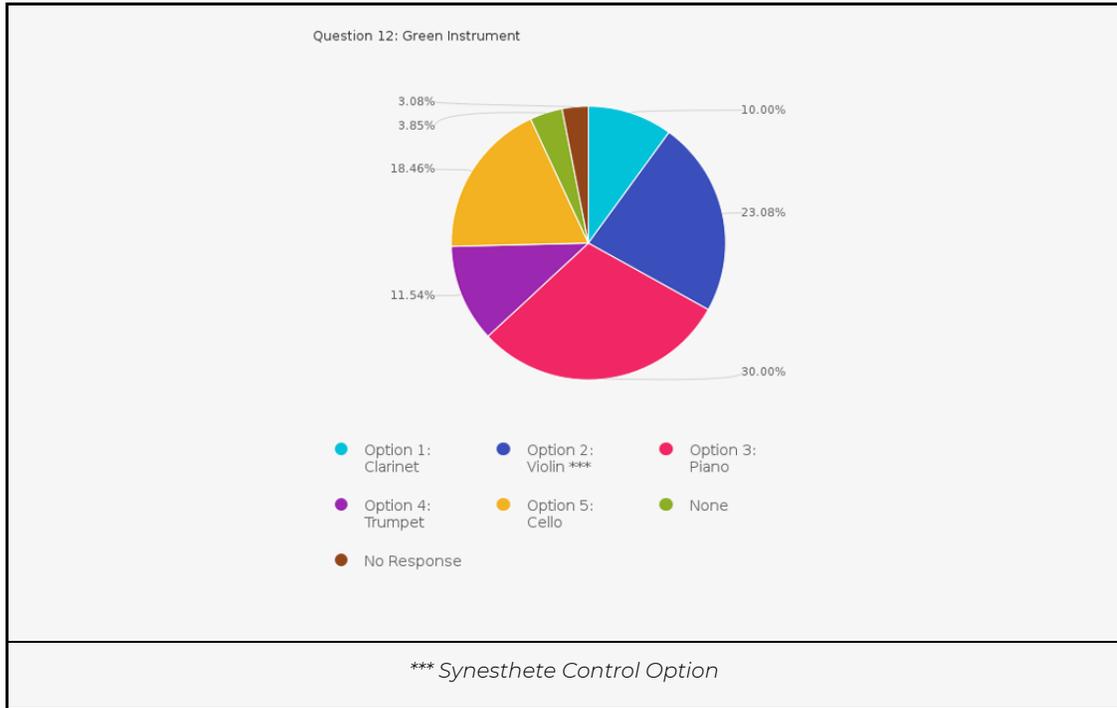
The sound-pairing survey consisted of 12 questions that each contained a synesthete control option. Nine of those 12 questions resulted in participants not choosing the synesthete control option. These questions were 2, 3, 5, 7, 8, 9, 10, 11, and 12.

TABLE 19.

**Total Results: Test Group A & B: Unsuccessful Synesthete
Control Pairing**







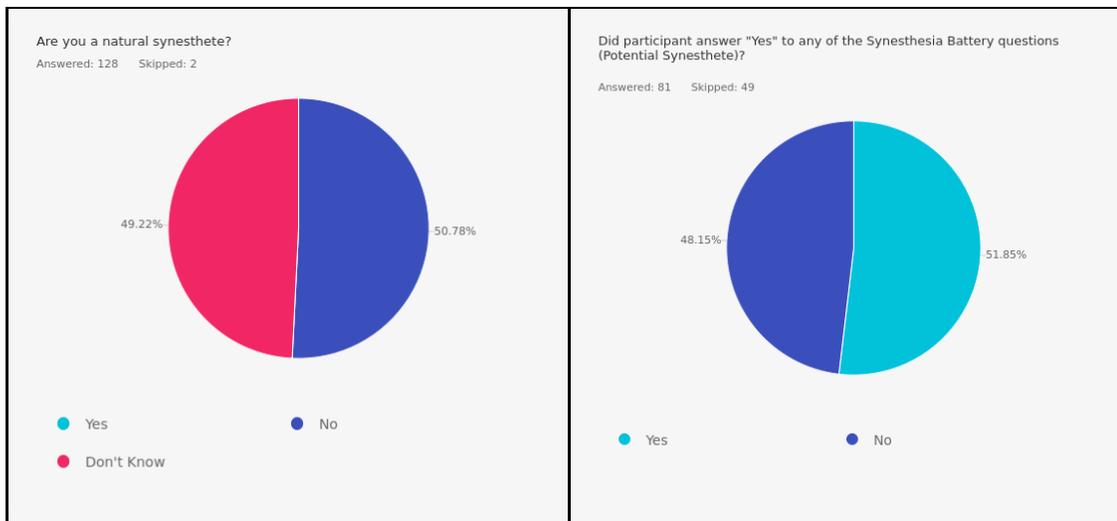
Although, overall, the total number of participants did not hear what chromesthetes hear, there are some larger majority responses to one sound for a few of the questions. Questions 2, 8, 9, 10, 11, and 12 had some participants agreeing as to what sound best represented the color on screen, however, it is important to note that these numbers are still below 50%. For Question 2, 36% of participants felt that yellow sounded like a cello. Participant responses to Question 8 paired the blue with the French horn at 32%. The synesthete control for this question came in second, with 28% choosing the cello. Question 9 paired violet to A Sharp (which is also B flat) at 28%. The clarinet represented red in Question 10 with a 26% majority. Orange in Question 11 was paired with A sharp at 30% and green in Question 12 with the piano at 30%.

Synesthete Results

A total of 130 participants participated in my study over the course of a year during which not one participant self-identified as a synesthete. Of the 128 participants who answered the question, “Are You a Natural Synesthete,” 51% of participants (65 participants) responded that they are not while 49% (63 participants) were unsure. Since nearly half of all participants were unaware of their synesthetic ability, it is concluded that many people are still unaware of the condition and whether they possess it. While the results do not necessarily prove absence of general knowledge on the topic of synesthesia, there is a definite uncertainty amongst the population as to whether they have synesthesia.

TABLE 20.

Total Results: Test Group A & B: Synesthete Identification, Potential Synesthete, and Potential Synesthesia Type



Eighty-one participants answered the Synesthesia Battery Preview questions and of them, 42 participants (52%) answered “yes” to one or more of the synesthesia related questions could be synesthetic.

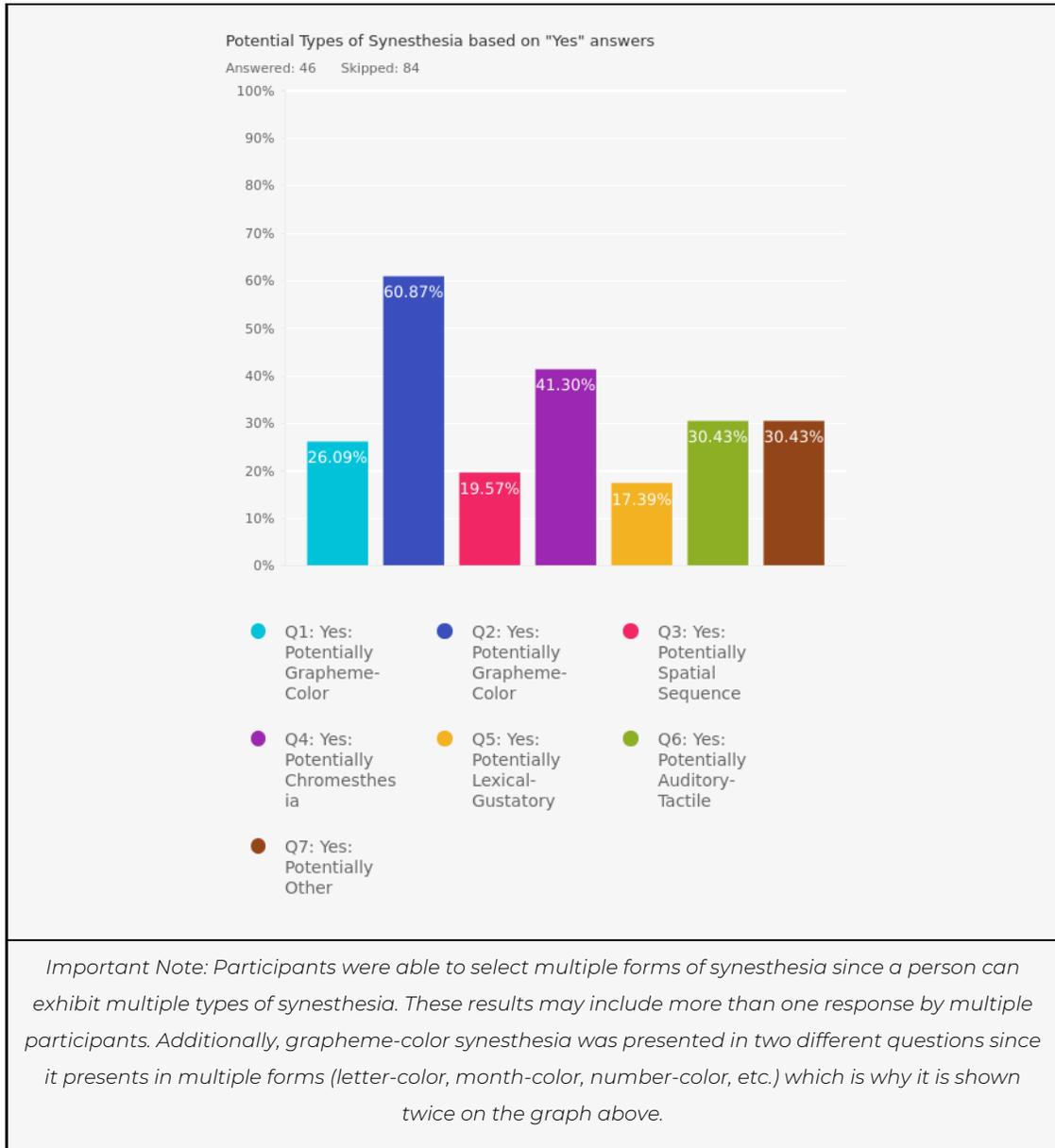
All participants were given the opportunity to answer the Synesthesia Battery Preview Questions in both test groups. In Test Group A, 16 participants (52%) did not know if they are a synesthete and subsequently answered yes to one or more questions. If a participant answered “yes” to any of these questions, they were directed to register an account and complete additional testing to rate their synesthesia. Of the 16 participants in Test Group A who were unsure of their synesthetic ability, 62% tested “positive” for, were rated as having synesthesia. For the 48% that responded “No (they are not a natural synesthete)” in Test Group A, 33% were “confirmed” as synesthetic using the same synesthesia battery test. In Test Group B, 48% (49 participants) of participants were unsure if they are a synesthete, while 52% (54 participants) responded that they are not a synesthete. However of those 52%, 8 participants still answered the Synesthesia Battery Preview Questions even though they said they are not a synesthete. Of those 8 participants, 2 responded “yes” to one of the preview questions and could potentially be a synesthete. If these 8 participants answered these preview questions even though their initial response was that they are not a synesthete, it could be assumed they were actually unsure of their synesthetic ability, or they answered to further prove their inability.

Based on the results completed during the full Synesthesia Battery Testing completed in Test Group A, it could be speculated that more than 4% of the population does have this ability, disagreeing with previous

research conducted by synesthetic researchers that synesthesia only occurs in an estimated 4% of the population. In total, 130 participants completed my study. 42 of them answered “yes” to a synesthesia related question. Although further testing using the registered synesthesia battery test would need to be completed for Test Group B, with these numbers alone, it could be projected that 20-30% of the population actually possesses some form of synesthesia. Additionally, the synesthesia portion of my research supports the previously conceived notion that chromesthesia and grapheme-color synesthesia remain the most commonly reported types of synesthesia.

TABLE 21.

Total Results: Test Group A & B: Potential Synesthesia Types



Using the Synesthesia Battery Preview questions as a guide to participants being potentially synesthetic, forms of synesthesia were

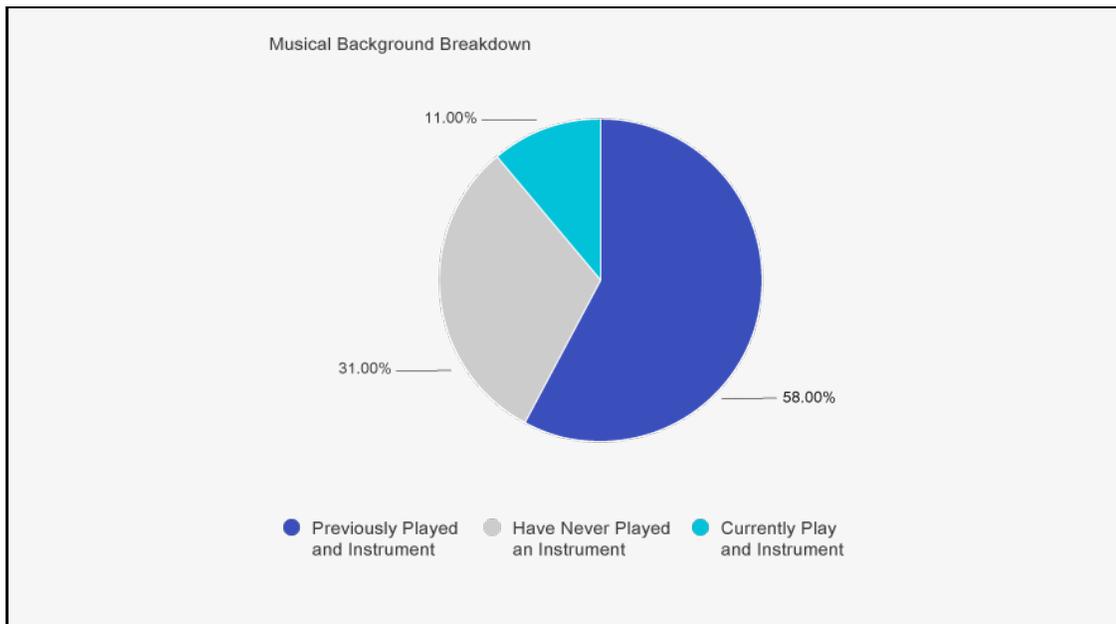
recorded and analyzed to see if potential synesthetes or non-synesthetes picked the synesthete control options. These responses were also all below 50% and there was nothing of particular interest to note.

Musical Training Results

All participants were asked if they currently play an instrument, previously played an instrument, or have never played an instrument. All participants answered the question, with 58% having previously played an instrument, 31% having never played an instrument, and 11% currently playing an instrument.

TABLE 22.

Total Results: Test Group A & B: Musical Background Breakdown



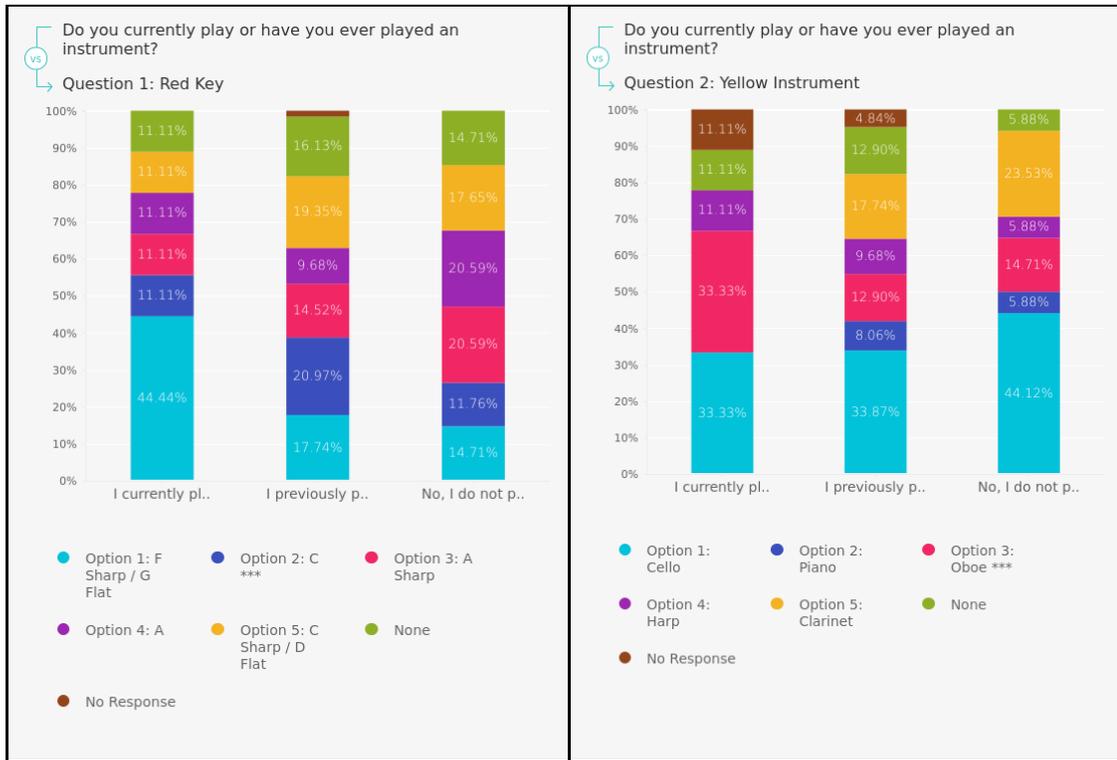
Participants who currently play an instrument were more likely to be unified in their sound choices with most percentages over 30%, some around 40%, and a couple at 50%. Current musicians were less likely to

have picked a variety of choices and were more consolidated to 4-5 choice options rather than 7.

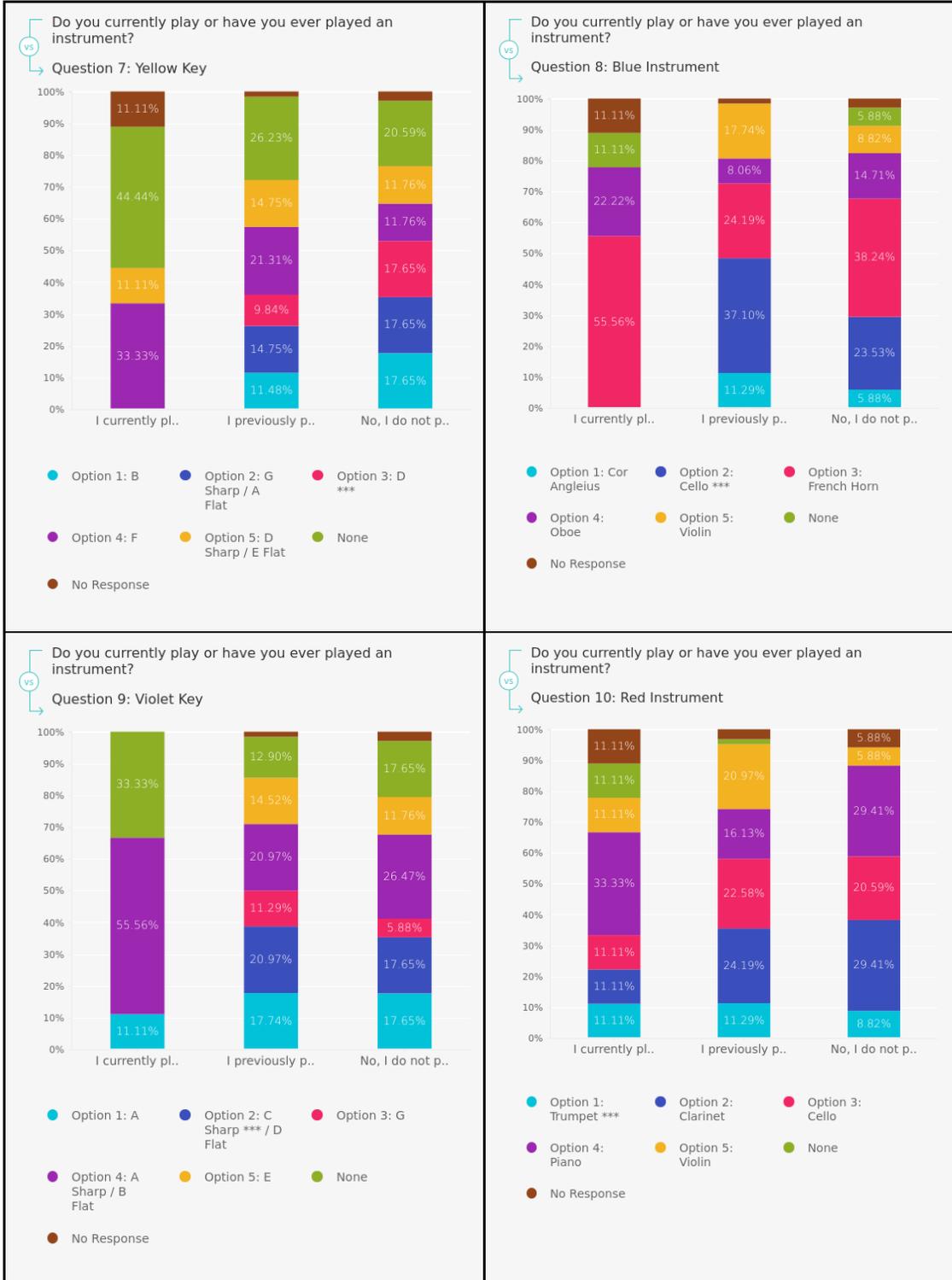
TABLE 23.

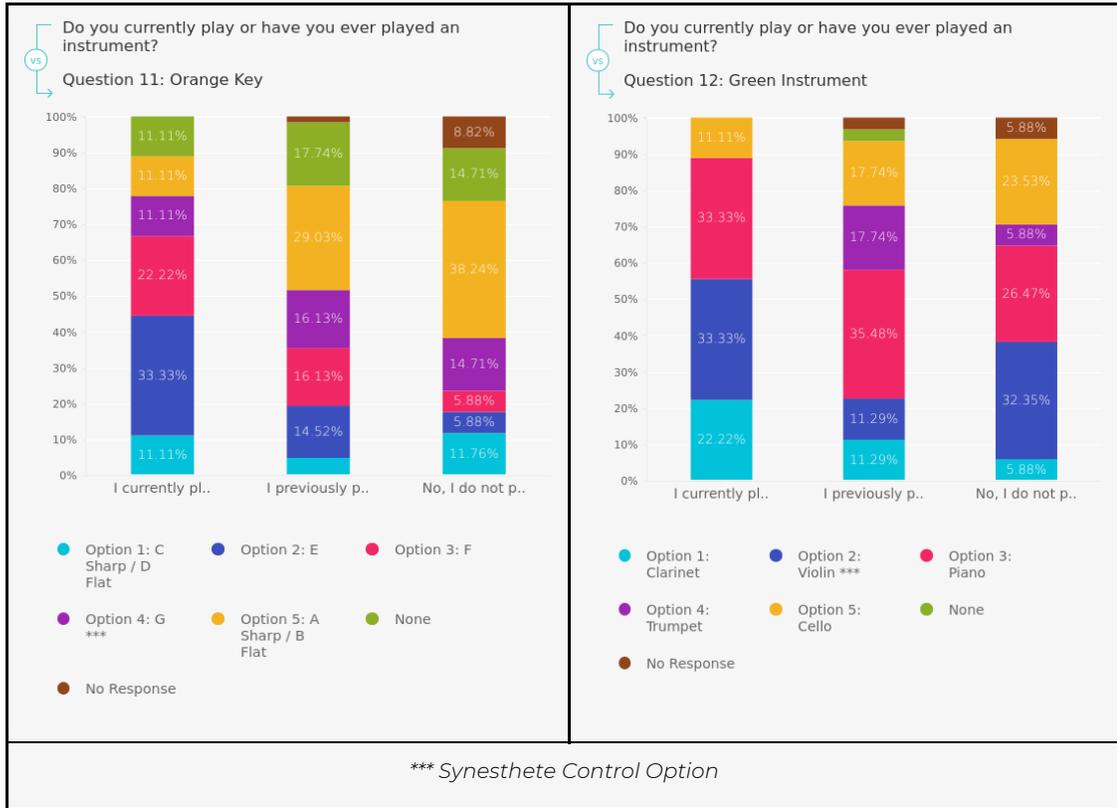
Total Results: Test Group A & B: Currently Play an Instrument

Question Responses









Limitations

It should be understood that while I attempted to provide as thorough results as possible, there were limitations to this survey. Physical disabilities such as color-blindness and hearing problems were not recorded. Although one participant during Test Group A did mention their hearing problem, they did not have trouble hearing the sounds played in the survey. Since Test Group B was not monitored and disabilities unrecorded, it's important to note that sound may have been heard differently by each participant. It is also unknown as to whether any of the participants had any visual impairments that may have altered the appearance of the visuals displayed. This is an area that would require further, refined, accessibility testing.

Gender specifications were not recorded by participants for this survey. During a 2004 survey conducted by the Smithsonian Institution, the study found that 59% of art museum visitors were female.²⁵ A 2008 survey also conducted by the Smithsonian Institution specifically for the Cooper-Hewitt National Design Museum, where *Design for the Senses* was held, also had a majority female visitor percentage at 63%.²⁶ Since the results of my testing would be used as a way to pair sound with paintings for a multisensory gallery experience, it could be speculated that the rise in female visitors over the past and future years would require a larger female participant base. In addition, scientific studies have suggested that the synesthetic gene is carried by the X-chromosome and that women, in having two X-chromosomes, are more likely to possess and pass on this ability to their children. Having a majority female participant

selection for testing in synesthesia specifically could prove useful to research on synesthesia.

Test Group B was unmonitored and therefore environmental factors were out of my control. Participants could have been distracted by their outside environment during the survey. Any technical problems in regard to the participants internet connection, browser, computer, phone, and headphones remain unknown.

A select group of synesthete experiences were used as controls for this study. It is recognized that there are many people who have synesthesia; however, recordings are sparse since the topic remains fairly unknown and people are unaware of their synesthetic ability. Therefore, it was my choice to use synesthetic experiences from well-known artists Wassily Kandinsky, musician Alexander Scriabin, and composer Joachim Raff as a starting point. This study could have been more inclusive of other synesthetes' experiences had there been enough recordings of them. There are also little to no recorded instances of shape-sound synesthesia that I could've used for comparison in regard to the color visuals I used presented in shapes.

Discussion

I attempted to understand if there was a way we could pair sound with elements from abstract paintings using experiences from a select number of chromesthetes as a control. I wasn't really sure how to begin preparing sound choices for participants to choose from and research in chromesthesia provided a starting point. Since these sounds were to be paired with paintings, and paintings are (generally) complex, full of many compositional elements, I took compositional components from these paintings to better dissect what sound these individual elements might bring to mind in the museum visitor population. Did participants choose the chromesthetic sound options for the majority of the questions? No. In total, only 3 of the 12 questions had a majority vote for the chromesthetic control, and those results were below 50%. However, I learned a few things along the way:

1. People are interested in participating in research like this. Within two weeks of posting the survey for Test Group B participation, I had 109 responses (4 were returning participants from Test Group A). People were remarking across social media and through email how interesting and exciting the survey was. Some mentioned they really had to think about their responses, but that it was engaging. If the research is engaging, I would project the exhibition created from this visitor-centered research would also be engaging and well attended.

2. Shapes may affect how people perceive color and in turn, sound. There needs to be more understanding of how people perceive sound in shapes. Little is known about sound-shape synesthesia to use as a guide.
3. Synesthesia is still not a widely known topic among the general public. While I am not a neurologist specifically studying this phenomenon, I can agree with previous research that people are generally unaware of their synesthesia and add that they still are today based on the synesthesia results obtained from my own research.
4. The questions in my survey that paired timbre, particularly regarding musical instruments, with a visual had a higher majority rating than those pairing pitch to a visual. People may feel that musical instruments better represent visuals, auditorily, than pitch.
5. Perception (whether auditory, visual, etc.) may be uniquely personal and there may not be a formal method of interpreting it. Results for most questions were split amongst the five sound choices. Rudolf Arnheim suggests that what a person sees in a work of art “depends entirely on who he is, what he is interested in, what he has experienced in the past, and how he chooses to direct his attention.”
6. While my results did not favor synesthetic sound choices, a multisensory gallery experience could still be created using the results I’ve obtained. Some attendees may not particularly agree with the sounds played with the artworks;

however, I think most gallery experiences take a certain amount of risk in how people perceive art since it may be uniquely personal. People may have more of an experience, an emotional connection, with one particular work of art in an entire exhibition hosting multiple artworks. I don't feel that the exhibit I would create based on this research would be unsuccessful, but I would like to add additional engaging measures to ensure its success. For instance, I've thought about an interactive, tablet-based experience with headphones where users could play different instrument sounds or compositions paired with the paintings, therefore, making it more of a personalized experience and less of an ekphrasis.

7. A synesthesia inspired gallery exhibition could be created based on the experiences I've gathered from chromesthetes, with the addition of others, showcasing synesthesia and synesthetes. This would help raise awareness of the phenomenon. Attendees could be given promotional materials upon exiting pushing them to the synesthete.org site to find out if they are synesthetic.

Future Research

Although my results did not affirm that people hear color in a particular sound, I would like to further understand how we can pair sound with color and shape. I think it would be beneficial to survey people on just color itself, when it does not form into a shape. This could be verbalized (speaking the word “red”) or in written word. However, in written format, letters are shapes. Results could be interesting and moderated in terms of typographic choice, color, and sound. Tone of voice can also affect how someone hears the word red and in turn perceives how red sounds. Virtual reality headsets may be a useful solution to this, flooding screens with colors in attempts to not formulate a particular shape. This could limit the participant base however, excluding people who suffer from motion sickness.

I would like to understand how to pair shape with sound. Wassily Kandinsky said different weights of lines sounded like different timbres of string instruments. Additional research into painting and compositional techniques could be beneficial in understanding how to pair sound with shapes. In Question 8 of my study, participants were more likely to pair the blue square with the French horn over the synesthetic control, the cello. I’m wondering if this is because a square has sharp edges, and a French horn is piercing in pitch (in my opinion), like sharp edges. An additional area of research relating to sound theory could help us to understand whether pitches with shorter wavelengths, i.e., higher pitches, correspond to colors with higher wavelengths, i.e., Blue, indigo, violet, etc.

Synesthesia is an interesting phenomenon to me. I would like to understand it more. Some theories propose synesthesia is linked to areas of the brain that produce emotional responses.²² This emotional response could affect how we perceive art according to research conducted by Gerald Cupchik who observed that “when we view visual images in everyday life, our perception is oriented toward object identification” but in contrast “when viewing visual images as artworks, we tend to experience subjective reactions to their stylistic and structural properties.”²³ Further research could be conducted in pairing full artworks with sound as opposed to individual elements.

The methodology created for the purposes of this study could be used as data collection method for museum visitors as they enter the space, in which pending their responses, a personalized multisensory experience could be created for them on the fly. As they walk around and experience the paintings, with headphones, they would hear sounds matched to the paintings based on their survey responses, for a visitor-centered experience.

Conclusion

The objective of this thesis aimed to explore a methodology in which we pair sound to abstract paintings by extracting compositional elements in the form of color and shape from those paintings and pairing them with sound elements of pitch and timbre. The selection of sound choices were based on experiences from a select number of chromesthetes to use as a control to discover if the general public will make the same sound to color associations as those select chromesthetes in order to raise awareness of synesthesia and apply this knowledge in creating multisensory experiences and environments. A testing environment was created using compositional elements (color and shape) from abstract paintings in which 5 sound options relating to pitch or instrument were provided. One of these options was used as the synesthete control option. Based on participant responses, each question was evaluated to determine if the majority of participants chose the synesthete control. If a synesthete control was not the majority chosen option, additional analysis was completed to understand if there was an accord for one option over others. Ultimately, results were low, in most instances below 40% unanimity. Sound choices were dispersed for many questions, of which the highest agreement in sound choice was 20%.

While the data does not support my theory and precisely answer my question of how to pair sound with paintings, a multisensory gallery experience can still be created with the data I obtained. A synesthesia inspired gallery exhibition could be created showcasing synesthetes, help raise awareness of the phenomenon, and potentially even be therapeutic

as previously mentioned on how synesthesia and multisensory experiences can be. The methodology I designed could be used to create a personalized gallery experience via individualized sound delivery through headphones.

The research conducted for the purposes of this thesis combined several areas of research together (exhibition design, design and art theory, neurology, psychology, multisensory design, music and sound theory, and more) with a focused center on synesthesia that can continue to be useful to these fields and more. Additionally, the overarching topic of this research — understanding how to pair sound with visuals — can, with additional research, help us understand how to create accessible experiences and immersive gallery experiences through multiple sensory stimulations — universal design.

Appendix A



Kandinsky, Wassily, 1866-1944. Impression 3 (concert). 1911. Artstor, library.artstor.org/asset/ARTSTOR_103_41822000863975

Inspired by a concert Kandinsky attended in Munich by composer Arnold Schoenberg. ("Music and Art: Schoenberg and Kandinsky." Interlude.Hk, 21 Feb. 2016, <http://www.interlude.hk/front/music-art-schoenberg-kandinsky/>.)

Appendix B



"1002, Taste of Music, 2011." Cooper Hewitt, Smithsonian Design Museum, <https://collection.cooperhewitt.org/objects/1159162397/>. Accessed 18 Mar. 2019.

Appendix C

Claude Monet (French, Paris 1840-1926 Giverny). Garden at Sainte-Adresse. 1867. Artstor, library.artstor.org/asset/SS7731421_7731421_11264593

Appendix D

Claude Monet, French, 1840-1926. Jean Monet (1867-1913) on His Hobby Horse. 1872. Artstor, library.artstor.org/asset/MMA_IAP_1039651959

Appendix E

Synesthesia Battery Preview Questionnaire

The Synesthesia Battery



[Home](#) | [Login](#)

Please indicate your responses to the questions below

Do numbers or letters cause you to have a color experience? Example: Does the letter J "mean" yellow to you? Or does "5" make you perceive purple?

Yes, I have had similar experiences
 No, I have not had such experiences

Do weekdays and months have specific colors? Example: Does July always mean Navy Blue to you? Is Wednesday always orange?

Yes, I have similar associations
 No, I do not have such associations

Do you imagine or visualize weekdays, months and/or years as having a particular location in space around you? Example: Is September always located two feet in front of you to the left?

Yes, I have always felt these specific spatial locations
 No, I have never had this kind of association

Does hearing a sound make you perceive a color? Example: Does a shrill car horn cause you to see the color green? Does C sharp make you see pink?

Yes, I do have such experiences
 No, I have not had such experiences

Do certain words trigger a taste in your mouth? Example: Does the name 'Derek' taste like earwax?

Yes, this is familiar to me
 No, I have never felt like this

Do you feel a sense of touch when you smell things? Example: Does the smell of coffee make you feel as though you are touching a cold glass surface?

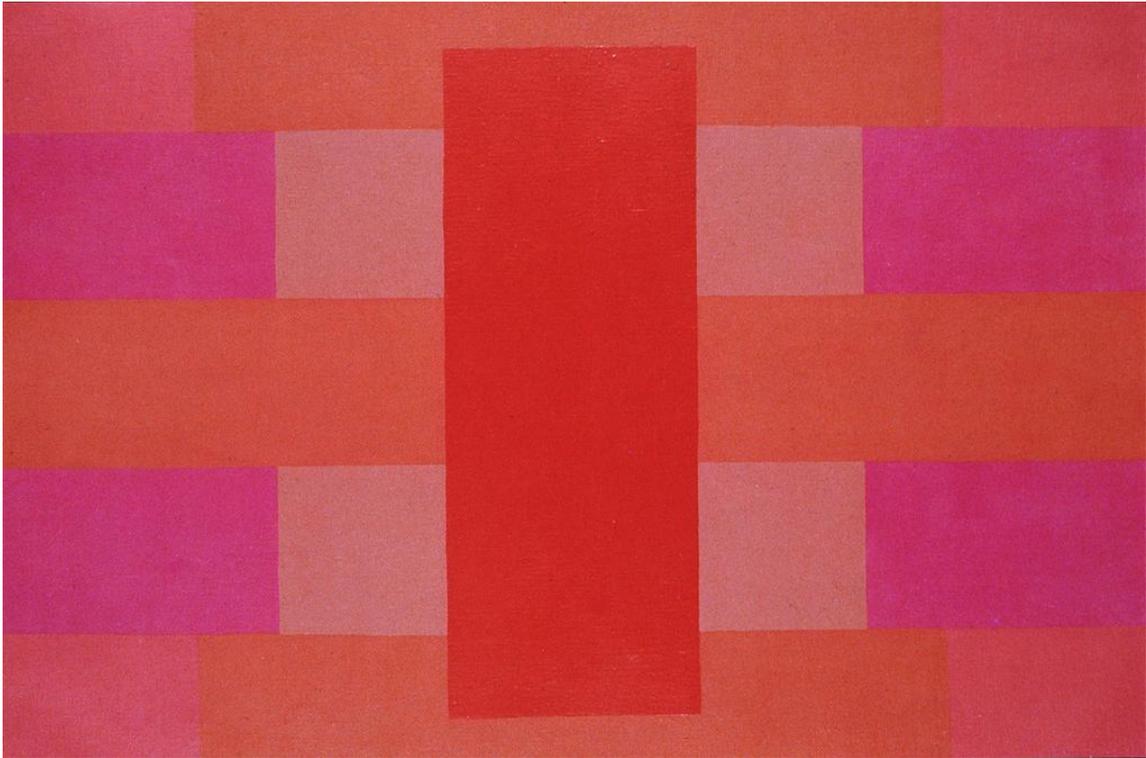
Yes, I have had such experiences
 No, this doesnt happen with me

We have described a few types of synesthesia. Many other unusual blendings of the senses have been reported. Do you suspect that you experience an unusual blending that other people do not have (other than the ones listed above)? These could include automatically hearing a sound when you see movement, or the sense of a shape being triggered by a taste, or experiencing a color when feeling pain.

Yes, I believe I may have other forms of unusual sensory experiences
 Not that I know of

Appendix F

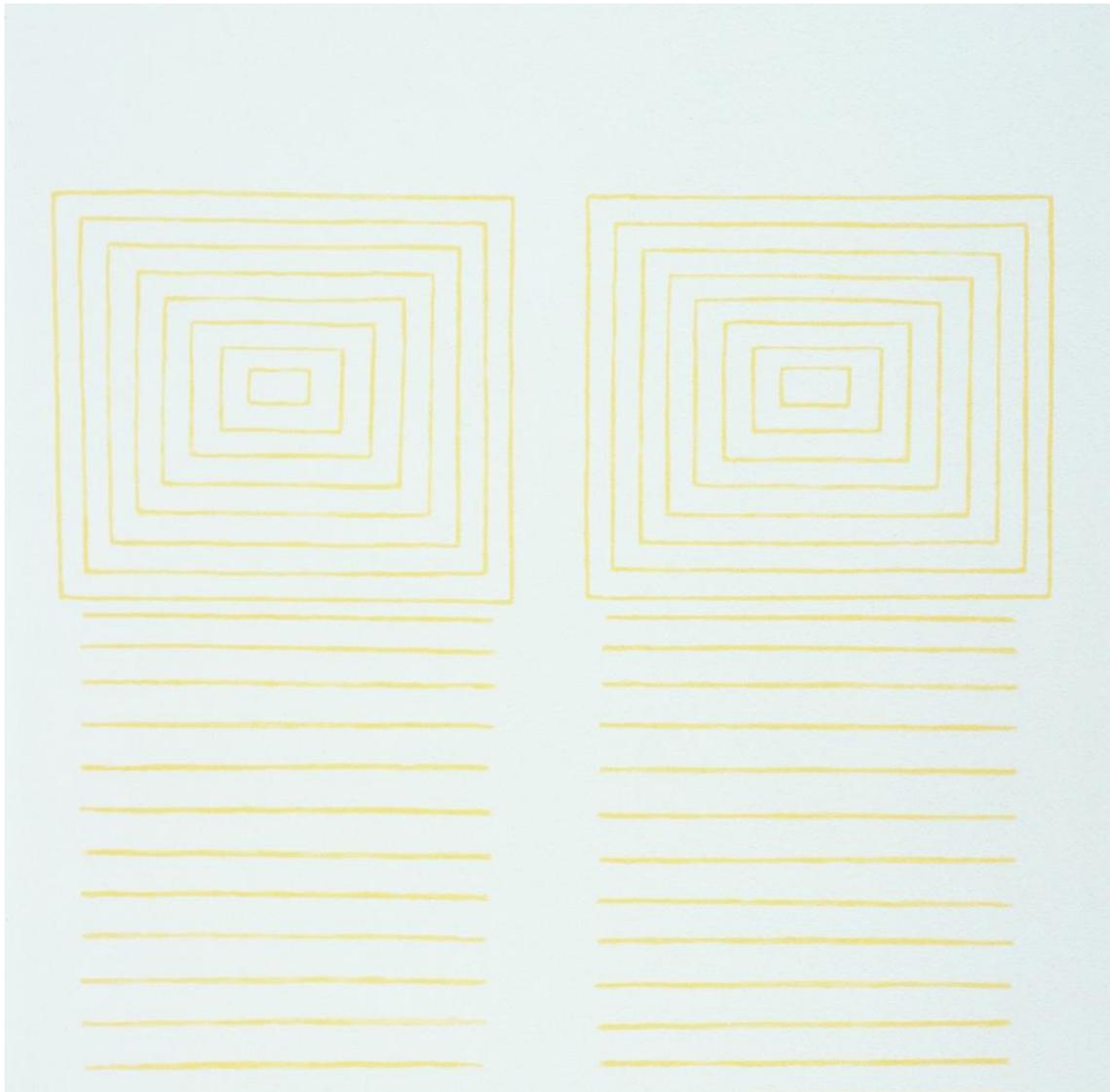
Core Question 1: Artwork



Reinhardt, Ad, 1913–1967. Abstract Painting, Red. 1952. Artstor, library.artstor.org/asset/ARTSTOR_103_41822001175742

Appendix G

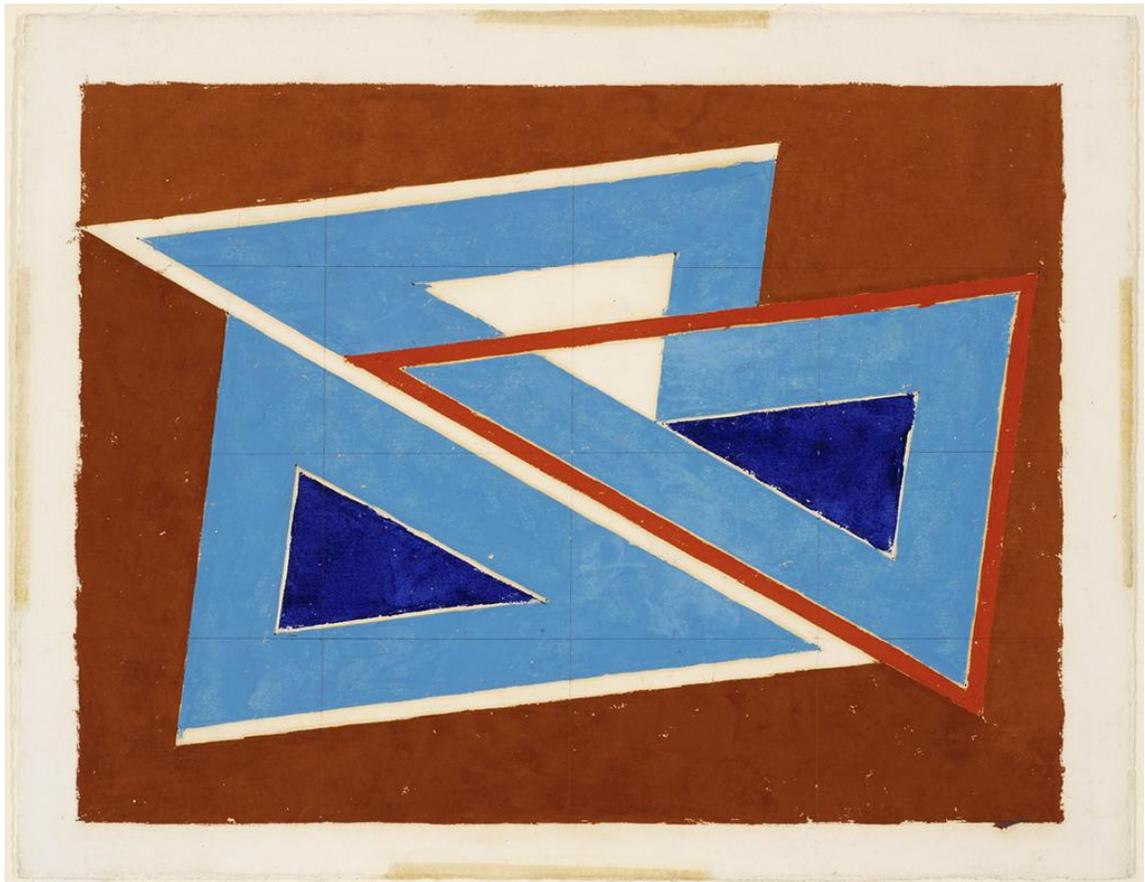
Core Question 2: Artwork



Walsh, Daniel, 1958-. Reflector. 1995. Artstor,
library.artstor.org/asset/ARTSTOR_103_41822003860564

Appendix H

Core Question 3: Artwork



Albers, Josef (German-American painter, theorist, 1888-1976). Abstract. 1941 (ca.). Artstor, library.artstor.org/asset/AALBERT_10311266757

Appendix I

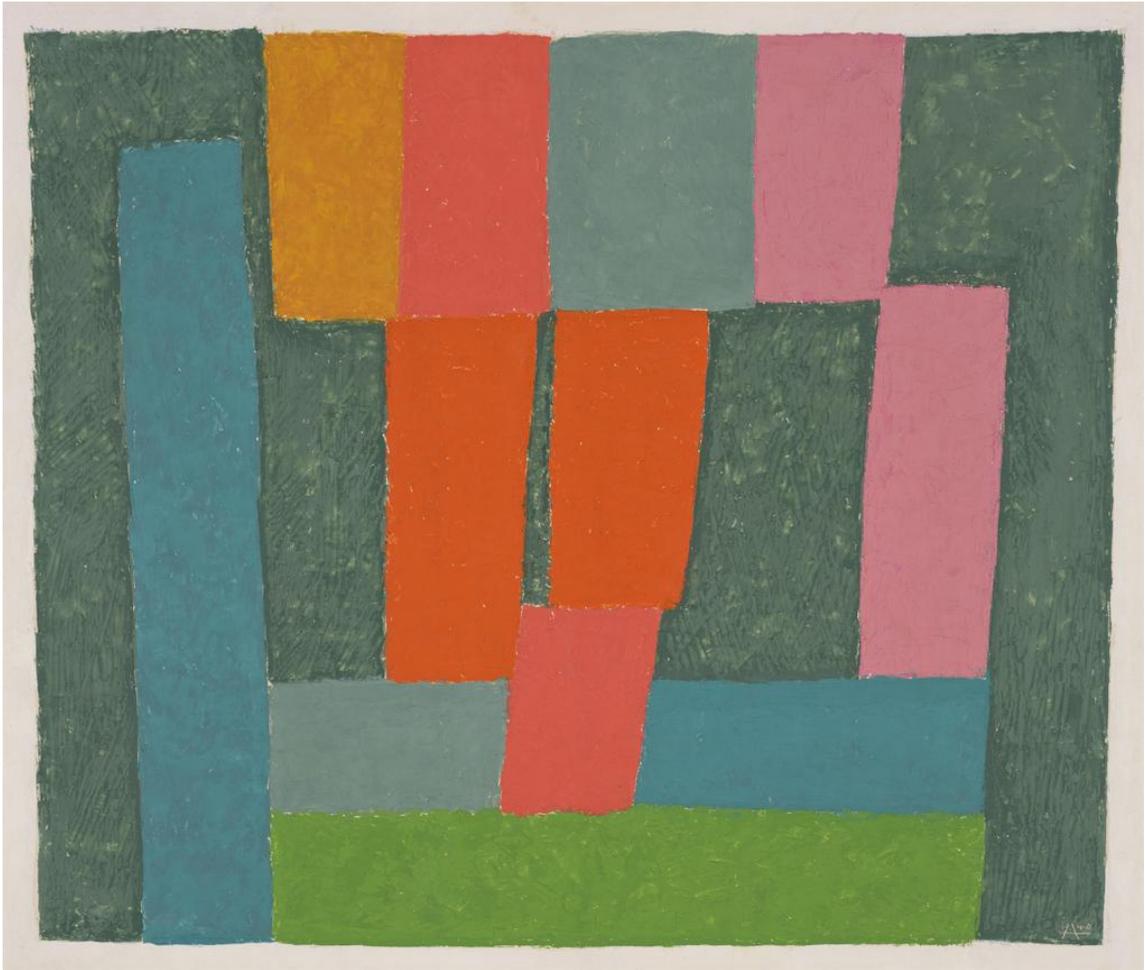
Core Question 4: Artwork



Victor Vasarely. Mindanao. 1952-1955. Artstor,
library.artstor.org/asset/AWSS35953_35953_40439726

Appendix J

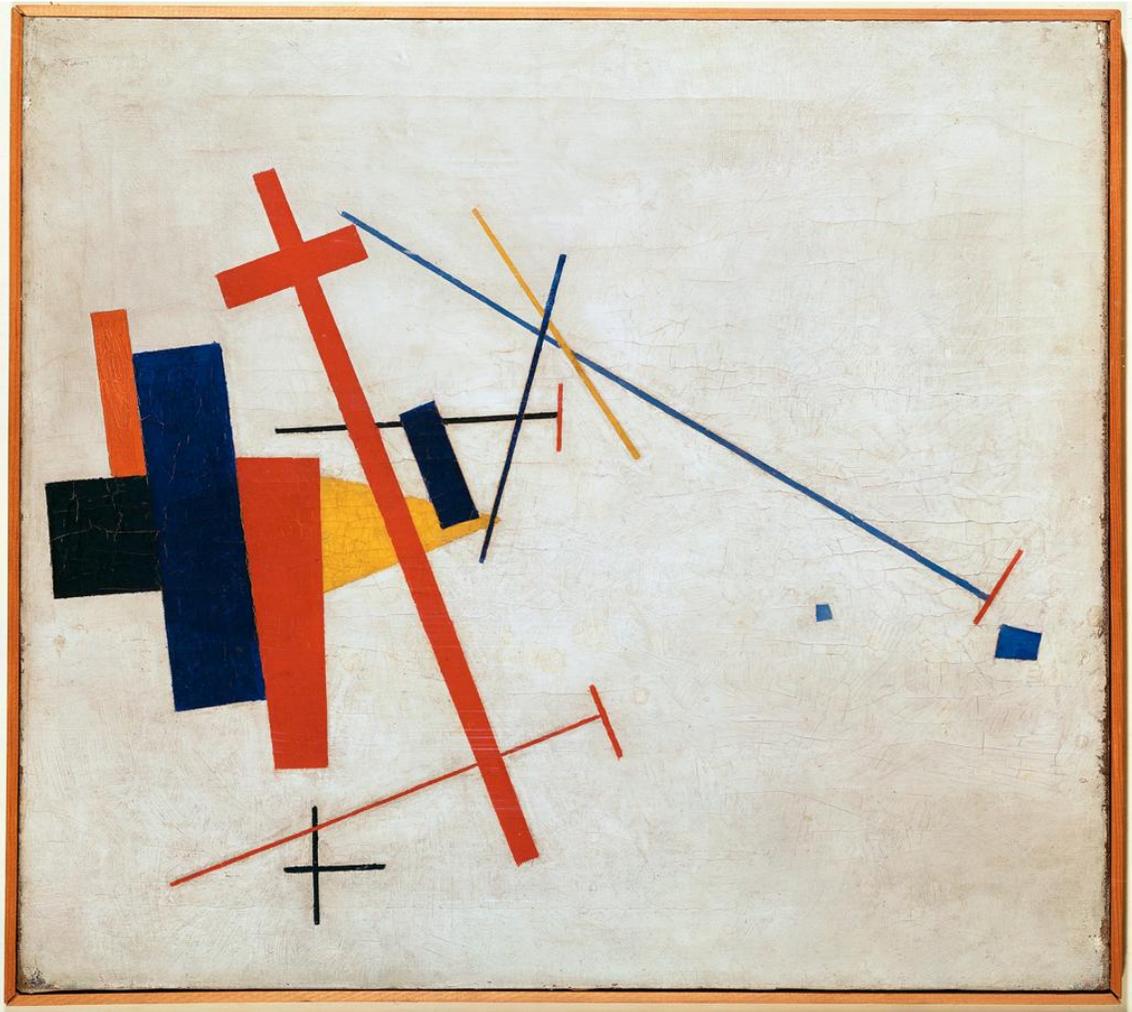
Core Question 5: Artwork



Josef Albers, (Bottrop, Germany, 1888 - 1976, New Haven, Connecticut), American, born Germany. El Condor, Ecuador, Growing. 1940. Artstor, library.artstor.org/asset/ASFMOMAIG_10313976467

Appendix K

Core Question 6: Artwork



Kazimir Malevich. Suprematist Composition. 1915. Artstor, library.artstor.org/asset/LESSING_ART_10310752772

Appendix L

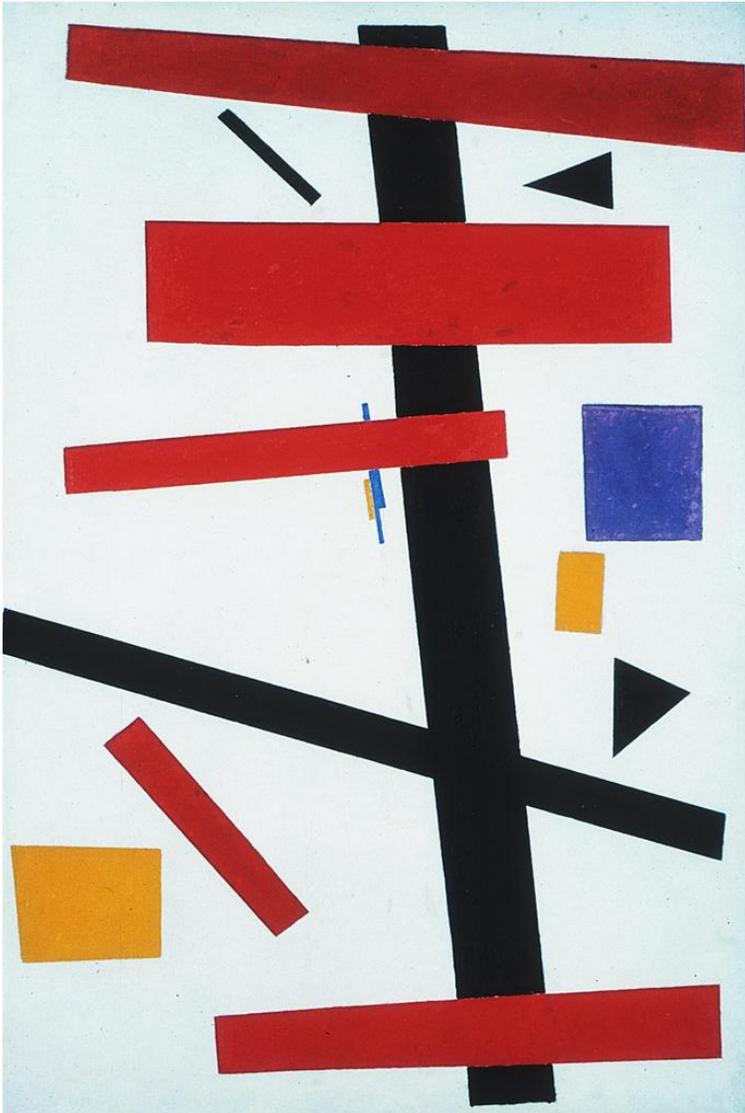
Core Question 7: Artwork



Batuz. Variant Botond (Yellow and Gray). 1977. Artstor,
library.artstor.org/asset/AWSS35953_35953_40530339

Appendix M

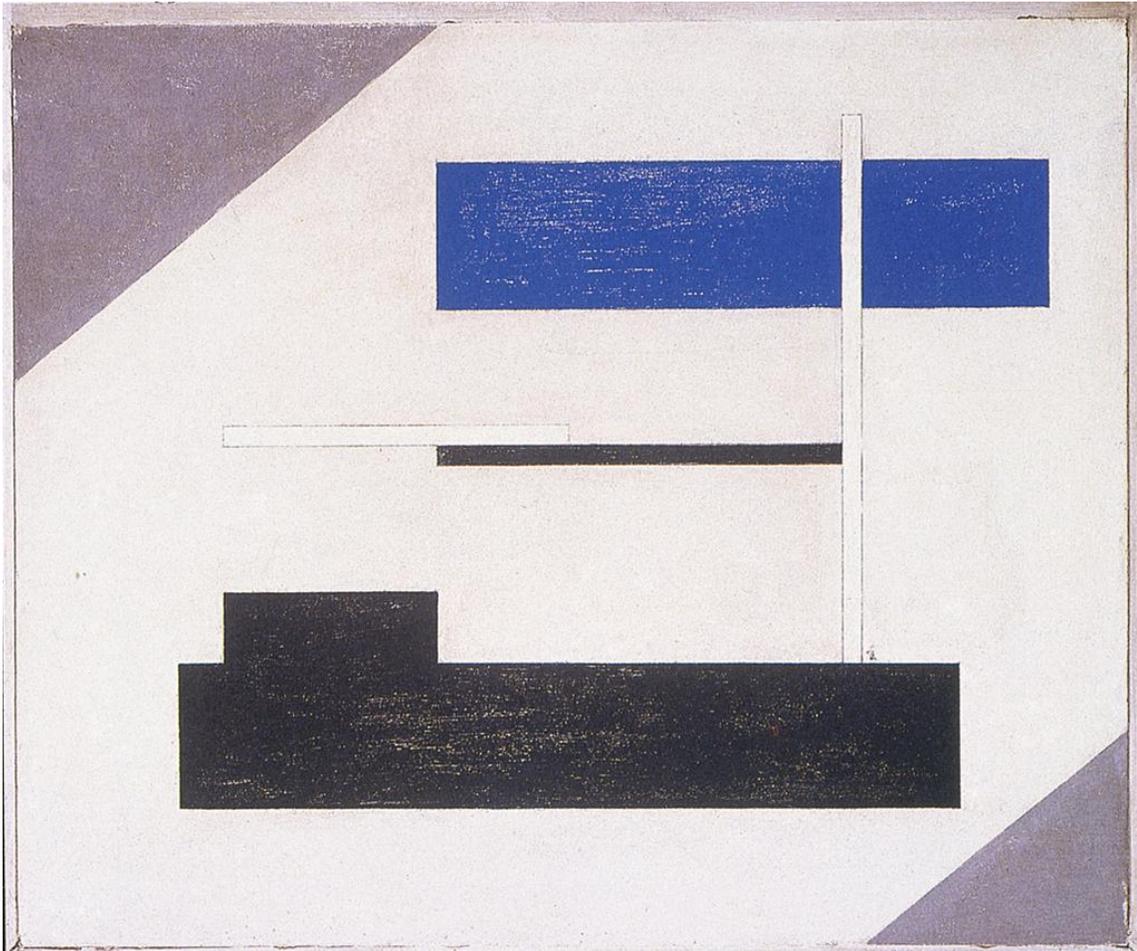
Core Question 8: Artwork



Malevich, Kazimir Severinovich, 1878-1935. Suprematism No. 50. 1915.
Artstor, library.artstor.org/asset/ARTSTOR_103_41822000869451

Appendix N

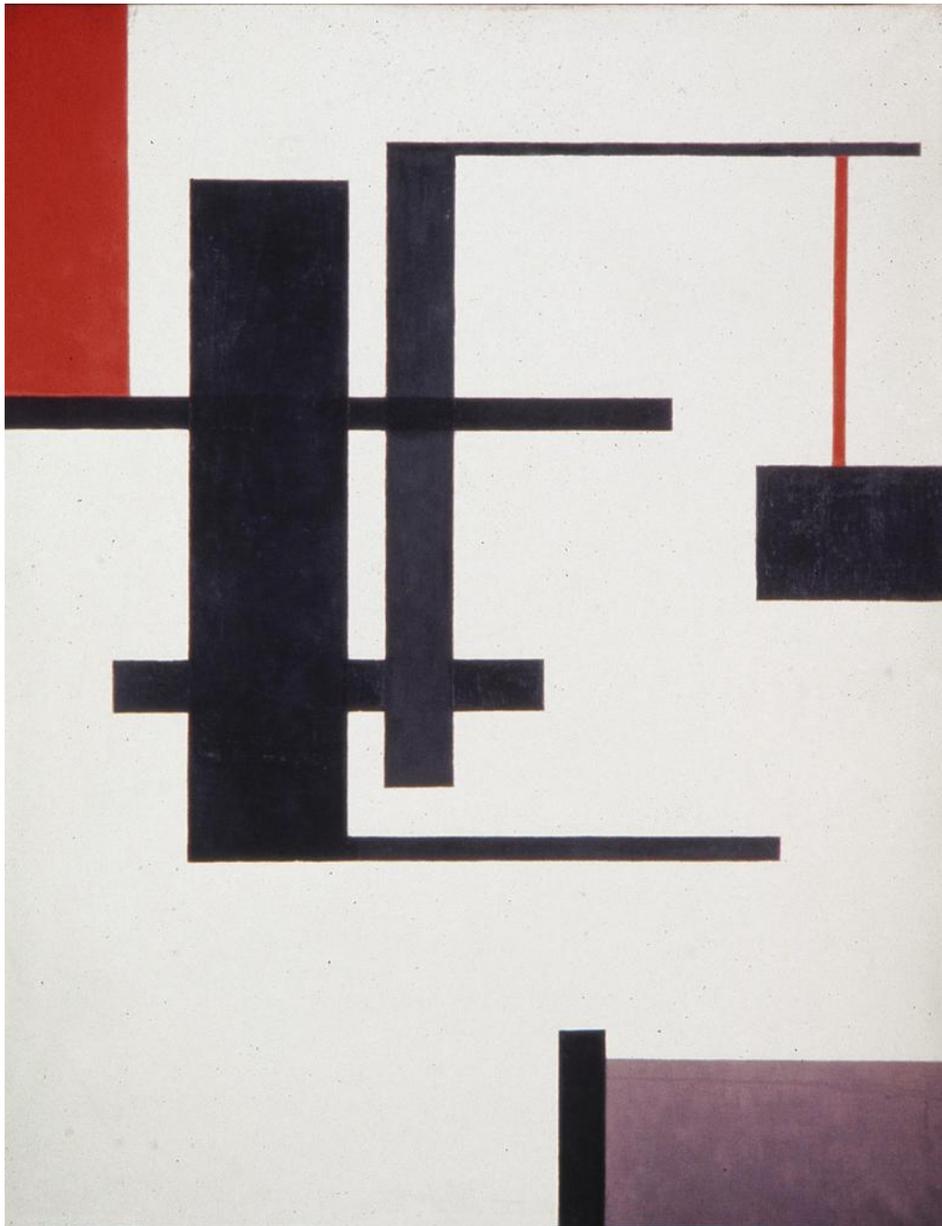
Core Question 9: Artwork



Reggiani, Mauro, 1897-1980. Composition no. 2, Composizione n. 2. 1935.
Artstor, library.artstor.org/asset/ARTSTOR_103_41822003820212

Appendix O

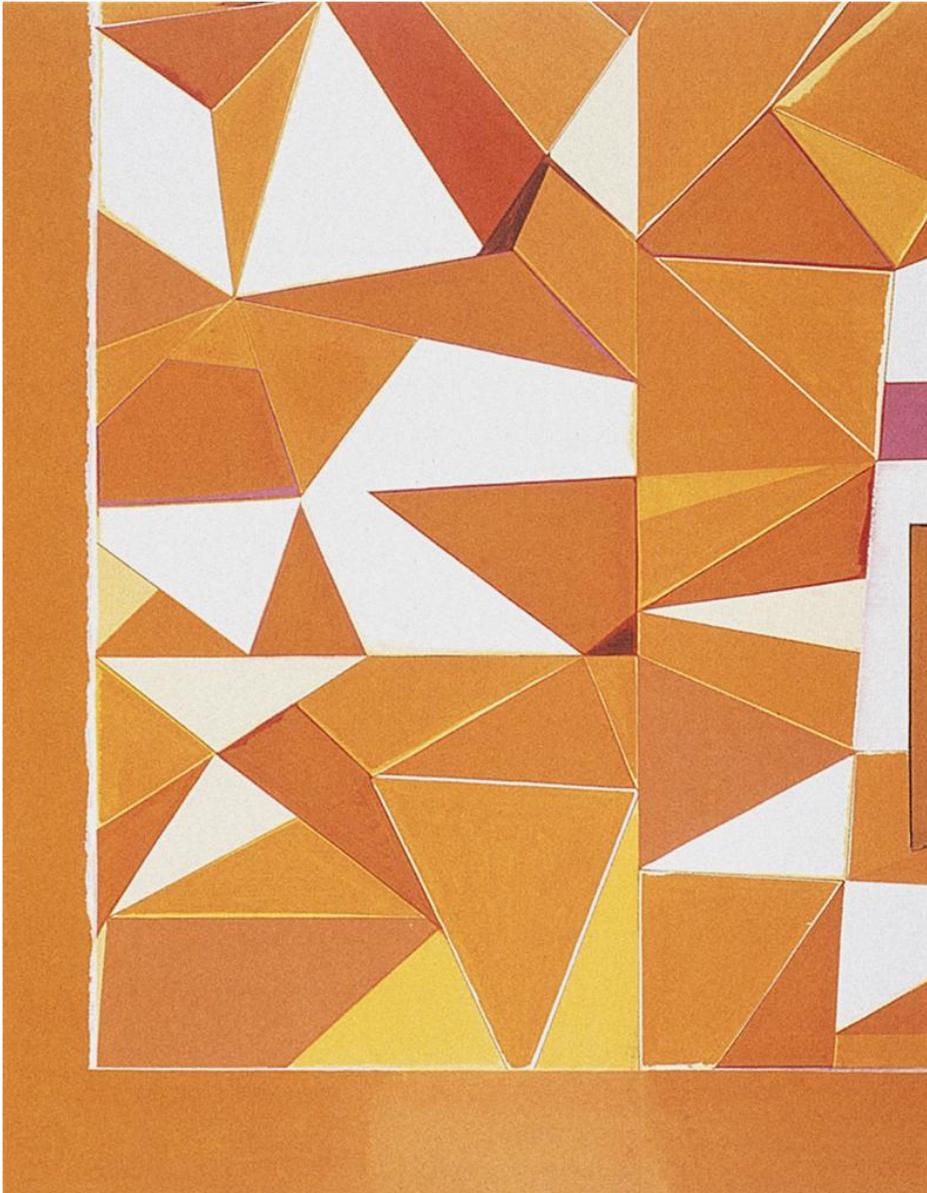
Core Question 10: Artwork



Hélion, Jean, 1904-1987. Abstract Composition. 1932. Artstor, library.artstor.org/asset/ARTSTOR_103_41822000753721

Appendix P

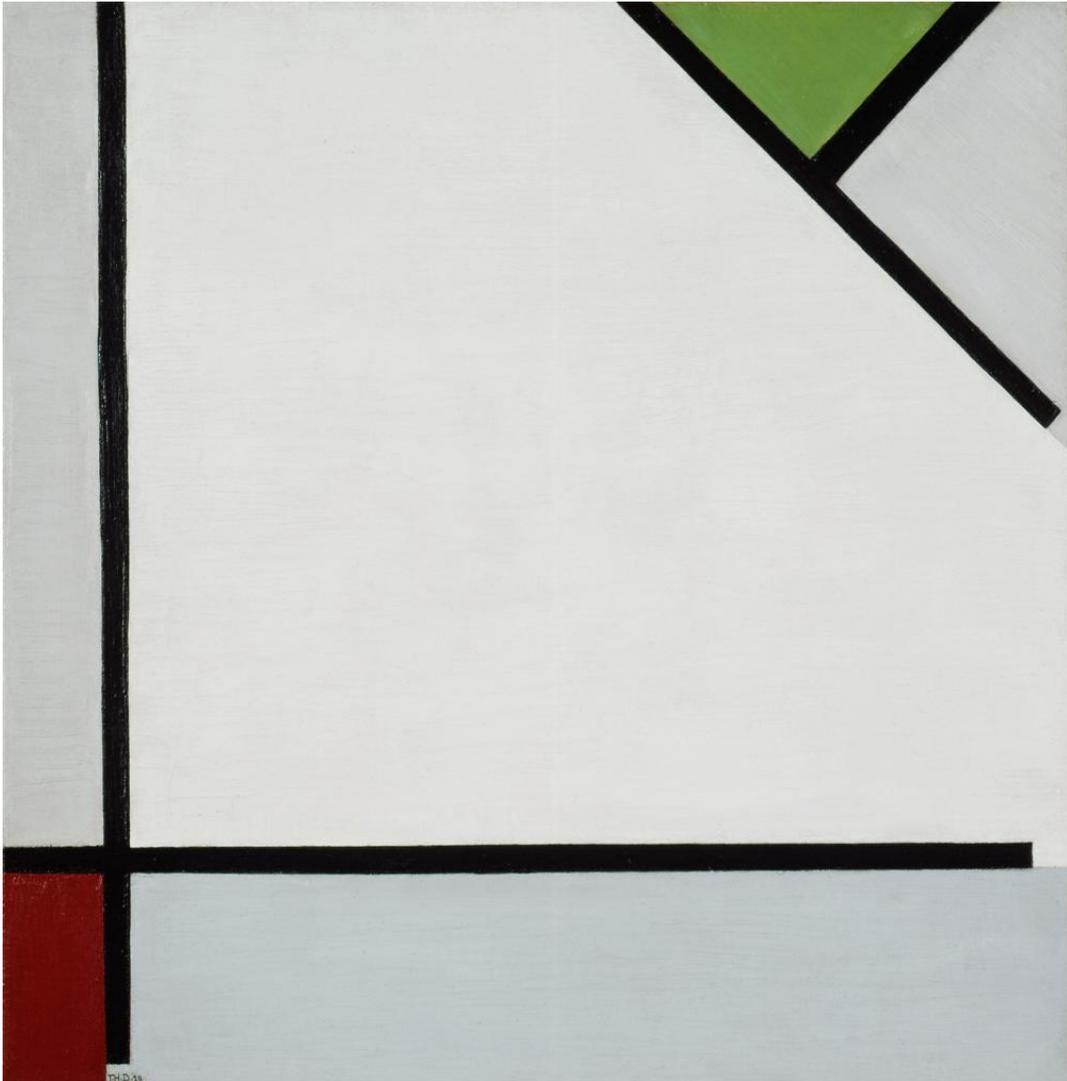
Core Question 11: Artwork



Scheibitz, Thomas, 1968-. 1-geometrica B. 2001. Artstor,
library.artstor.org/asset/ARTSTOR_103_41822003770292

Appendix Q

Core Question 12: Artwork



Theo van Doesburg (Dutch Primary, Utrecht, Netherlands 1883–1931 Davos, Switzerland). Contre composition simultanee (Simultaneous Counter-Composition). 1929. Artstor, library.artstor.org/asset/AWSS35953_35953_37654893

Appendix R

Social Media Postings

Facebook



LinkedIn



Instagram



Appendix S

Test Group B

Participant	How did you hear about the survey?	Would you visit a museum if you had the chance?	Do you currently play or have you ever played an instrument?	Question 1: Red Key	Question 2: Yellow Instrument	Question 3: Blue Key	Question 4: Violet Instrument	Question 5: Green Key	Question 6: Orange Instrument	Question 7: Yellow Key	Question 8: Blue Instrument	Question 9: Violet Key	Question 10: Red Instrument	Question 11: Orange Key	Question 12: Green Instrument	Are you a synesthete?	Did participant answer "Yes" to any of the Synesthesia Battery questions (Potential Synesthete)?
Participant 1B	LinkedIn	Yes	No, I do not play nor have I ever played an instrument.	Option 4: A	Option 1: Cello	Option 4: D	Option 5: Oboe	Option 3: C	Option 1: Harp	Option 1: B	Option 1: Cello	Option 4: A Sharp / B Flat	Option 2: Clarinet	Option 5: A Sharp / B Flat	Option 2: Violin	Don't Know	No
Participant 2B	Facebook	Yes	I previously played an instrument.	Option 5: C Sharp / D Flat	Option 5: Clarinet	Option 1: B	Option 4: Piano	Option 4: F Sharp / C Flat	Option 5: Cello	Option 1: B	Option 4: Oboe	Option 4: A Sharp / B Flat	Option 3: Cello	Option 5: A Sharp / B Flat	Option 5: Cello	No	No
Participant 3B	Other	Yes	I previously played an instrument.	None	Option 1: Cello	None	Option 4: Piano	None	Option 1: Harp	Option 1: B	Option 2: Cello	Option 2: C Sharp / D Flat	Option 3: Cello	Option 2: E	Option 5: Cello	Don't Know	Yes
Participant 4B	Facebook	Yes	I currently play an instrument.	Option 1: F Sharp / G Flat	Option 1: Cello	None	Option 5: Oboe	None	No Response	No Response	No Response	No Response	No Response	None	Option 2: Violin	No	No
Participant 5B	Other	Yes	I previously played an instrument.	Option 1: F Sharp / G Flat	Option 1: Cello	Option 1: B	Option 4: Piano	Option 5: A	Option 3: C	Option 3: C	Option 4: French Horn	Option 3: French Horn	Option 2: Clarinet	None	Option 5: Cello	Don't Know	No
Participant 6B	Yes	Yes	I previously played an instrument.	None	Option 3: Oboe	None	Option 5: Oboe	Option 3: C	None	None	Option 4: French Horn	None	Option 5: Violin	None	Option 5: Cello	Don't Know	Yes
Participant 7B	University of Baltimore Affiliate	Yes	I previously played an instrument.	None	Option 4: Harp	None	Option 3: Cor Anglais	None	Option 4: French Horn	None	Option 2: Cello	None	Option 2: Clarinet	None	Option 3: Piano	Don't Know	No
Participant 8B	Facebook	Yes	No, I do not play nor have I ever played an instrument.	Option 1: F Sharp / G Flat	Option 3: Oboe	Option 1: B	Option 5: Oboe	Option 3: C	Option 3: Trumpet	Option 3: D	Option 3: French Horn	Option 3: French Horn	Option 2: Clarinet	No Response	Option 3: Piano	No	No
Participant 9B	Facebook	Yes	No, I do not play nor have I ever played an instrument.	Option 4: A	Option 1: Cello	Option 1: B	Option 3: Cor Anglais	None	Option 4: French Horn	Option 3: D	None	Option 4: A Sharp / B Flat	Option 2: Clarinet	Option 5: Cello	Option 5: Cello	Don't Know	Yes
Participant 10B	Facebook	Yes	No, I do not play nor have I ever played an instrument.	Option 1: F Sharp / G Flat	Option 5: Clarinet	Option 3: A	Option 3: Cor Anglais	Option 2: D Sharp / A Flat	Option 2: Clarinet	Option 4: F	Option 4: Oboe	Option 1: A	Option 2: Clarinet	Option 5: A Sharp / B Flat	Option 5: Piano	No	No
Participant 11B	Facebook	Yes	I previously played an instrument.	Option 5: C Sharp / D Flat	Option 3: Oboe	Option 4: D	Option 2: Violin	Option 4: F Sharp / A Flat	Option 4: French Horn	Option 4: F	Option 3: French Horn	Option 2: C Sharp / D Flat	Option 4: Piano	Option 5: A Sharp / B Flat	None	Don't Know	Yes
Participant 12B	Facebook	Yes	No, I do not play nor have I ever played an instrument.	Option 3: A Sharp	Option 5: Clarinet	Option 5: D Sharp / A Flat	Option 3: Cor Anglais	Option 4: F Sharp / A Flat	Option 5: Cello	Option 2: D Sharp / A Flat	Option 2: Cello	Option 2: C Sharp / D Flat	Option 2: Clarinet	Option 1: C Sharp / D Flat	Option 2: Violin	No	No
Participant 13B	Facebook	Yes	No, I do not play nor have I ever played an instrument.	Option 3: A Sharp	Option 1: Cello	Option 2: F	Option 4: Piano	Option 3: C	Option 4: French Horn	Option 4: F	Option 2: Cello	Option 4: A Sharp / B Flat	Option 2: Clarinet	Option 5: A Sharp / B Flat	Option 3: Piano	Don't Know	Yes
Participant 14B	University of Baltimore Affiliate	Yes	I previously played an instrument.	Option 3: A Sharp	None	Option 1: B	Option 2: Violin	Option 4: F Sharp / C Flat	Option 3: Trumpet	Option 2: D Sharp / A Flat	Option 5: Violin	Option 1: A	Option 5: Violin	Option 2: E	Option 2: Violin	Don't Know	Yes
Participant 15B	Facebook	Yes	I previously played an instrument.	Option 5: C Sharp / D Flat	Option 5: Clarinet	None	Option 2: Violin	None	Option 4: French Horn	None	Option 2: Cello	None	Option 5: Violin	Option 5: A Sharp / B Flat	Option 3: Piano	Don't Know	Yes
Participant 16B	UMBC Affiliate	Yes	I previously played an instrument.	Option 3: A Sharp	Option 1: Cello	Option 2: F	Option 3: Cor Anglais	Option 4: F Sharp / C Flat	No Response	Option 3: D	Option 5: Violin	Option 2: C Sharp / D Flat	Option 5: Violin	Option 5: Violin	Option 5: Piano	Don't Know	Yes
Participant 17B	University of Baltimore Affiliate	Yes	I previously played an instrument.	None	Option 1: F Sharp / G Flat	Option 2: F	Option 1: Trumpet	Option 4: F Sharp / C Flat	Option 4: French Horn	Option 3: D	Option 5: Violin	Option 3: C	Option 5: Violin	Option 4: E	Option 3: Piano	Don't Know	Yes
Participant 18B	Facebook	Yes	No, I do not play nor have I ever played an instrument.	Option 3: A Sharp	Option 3: Oboe	None	Option 2: Violin	None	Option 5: Cello	Option 1: B	Option 2: C Sharp / D Flat	Option 3: Cello	Option 3: Cello	Option 1: C Sharp / D Flat	Option 3: Piano	Don't Know	Yes
Participant 19B	Instagram	Yes	I previously played an instrument.	Option 2: C	Option 1: Cello	Option 5: D Sharp / A Flat	No Response	Option 1: A Sharp / B Flat	No Response	None	Option 2: Cello	Option 4: A Sharp / B Flat	Option 3: Cello	Option 3: E	Option 3: Piano	No	Yes
Participant 20B	UMBC Affiliate	Yes	No, I do not play nor have I ever played an instrument.	Option 1: F Sharp / G Flat	Option 3: Oboe	Option 4: D	Option 1: Trumpet	Option 5: A	Option 4: French Horn	Option 2: D Sharp / A Flat	Option 1: Cor Anglais	Option 3: G	Option 4: Piano	Option 4: A Sharp / B Flat	Option 4: Trumpet	No	No
Participant 21B	University of Baltimore Affiliate	Yes	I previously played an instrument.	Option 2: C	Option 2: Piano	None	Option 3: Cor Anglais	Option 2: D Sharp / E Flat	Option 5: Cello	Option 1: B	Option 2: Cello	Option 3: G	Option 2: Clarinet	Option 4: G	Option 2: Violin	No	No
Participant 22B	LinkedIn	Yes	No, I do not play nor have I ever played an instrument.	Option 3: A Sharp	Option 1: Cello	Option 5: D Sharp / A Flat	Option 2: Violin	None	Option 4: French Horn	None	Option 3: French Horn	None	No Response	Option 2: E	Option 5: Cello	Don't Know	No
Participant 23B	Facebook	Yes	I previously played an instrument.	Option 1: F Sharp / G Flat	Option 1: Cello	Option 2: F	Option 5: Oboe	Option 3: C	Option 4: French Horn	Option 3: D	Option 3: French Horn	Option 3: G	Option 2: Clarinet	Option 5: A Sharp / B Flat	Option 3: Piano	No	No
Participant 24B	UMBC Affiliate	Yes	I previously played an instrument.	Option 4: A	Option 2: Piano	Option 1: B	Option 4: Piano	Option 3: C	Option 1: Harp	Option 2: D Sharp / A Flat	Option 5: Violin	Option 1: A	Option 3: Cello	Option 2: C Sharp / D Flat	Option 2: Violin	No	No
Participant 25B	UMBC Affiliate	No	No, I do not play nor have I ever played an instrument.	Option 3: A Sharp	Option 1: Cello	Option 5: D Sharp / A Flat	Option 3: Cor Anglais	None	Option 5: Cello	Option 3: D	Option 3: French Horn	Option 2: C Sharp / D Flat	Option 5: Violin	Option 5: A Sharp / B Flat	Option 5: Cello	Don't Know	No
Participant 26B	Stevenson University Affiliate	Yes	I previously played an instrument.	Option 2: C	Option 1: Cello	Option 2: F	Option 1: Trumpet	Option 2: D Sharp / E Flat	Option 2: Clarinet	Option 4: F	Option 2: Cello	Option 4: A Sharp / B Flat	Option 2: Clarinet	None	Option 4: Trumpet	Don't Know	Yes
Participant 27B	LinkedIn	Yes	I currently play an instrument.	Option 4: A	Option 3: Oboe	None	Option 1: Trumpet	Option 3: C	Option 2: Clarinet	None	Option 4: Oboe	Option 5: Violin	Option 5: Violin	Option 4: C	Option 3: Piano	Don't Know	Yes
Participant 28B	Instagram	Yes	I previously played an instrument.	Option 3: A Sharp	Option 2: Piano	Option 5: D Sharp / A Flat	Option 1: Trumpet	Option 4: F Sharp / A Flat	Option 4: French Horn	Option 1: B	Option 3: French Horn	Option 4: A Sharp / B Flat	Option 1: Trumpet	Option 3: Piano	None	No	No
Participant 29B	Facebook	Yes	I currently play an instrument.	None	No Response	None	No Response	None	Option 1: Harp	None	None	None	Option 1: Trumpet	Option 5: A Sharp / B Flat	Option 2: Violin	Don't Know	No
Participant 30B	Facebook	No	No, I do not play nor have I ever played an instrument.	Option 4: A	Option 1: Cello	Option 3: A	Option 4: Piano	Option 5: A	Option 1: Harp	Option 2: D Sharp / A Flat	Option 4: Oboe	Option 2: C Sharp / D Flat	Option 4: Piano	No Response	Option 1: Clarinet	Don't Know	No
Participant 31B	Facebook	Yes	No, I do not play nor have I ever played an instrument.	Option 4: A	Option 5: Clarinet	Option 2: F	Option 3: Cor Anglais	Option 2: D Sharp / E Flat	Option 4: French Horn	Option 1: B	Option 5: Violin	Option 4: A Sharp / B Flat	Option 3: Cello	Option 4: C	Option 3: Piano	No	No
Participant 32B	LinkedIn	Yes	No, I do not play nor have I ever played an instrument.	Option 5: C Sharp / D Flat	None	Option 1: B	Option 1: Trumpet	None	Option 5: Cello	Option 1: B	Option 2: Cello	Option 5: E	Option 4: Piano	Option 5: A Sharp / B Flat	Option 2: Violin	Don't Know	Yes
Participant 33B	Facebook	Yes	I previously played an instrument.	Option 4: A	Option 1: Cello	Option 3: A	Option 3: Cor Anglais	None	Option 1: Harp	None	Option 2: Cello	Option 2: C Sharp / D Flat	Option 2: Clarinet	Option 2: E	Option 3: Piano	Don't Know	Yes
Participant 34B	Facebook	Yes	No, I do not play nor have I ever played an instrument.	Option 1: F Sharp / G Flat	Option 2: Piano	Option 5: D Sharp / A Flat	Option 5: Oboe	Option 1: A Sharp / B Flat	Option 2: Clarinet	None	Option 2: Cello	Option 5: E	Option 2: Clarinet	Option 5: A Sharp / B Flat	Option 1: Clarinet	No	No
Participant 35B	UMBC Affiliate	Yes	I previously played an instrument.	Option 3: A Sharp	Option 1: Cello	None	Option 3: Cor Anglais	Option 2: D Sharp / E Flat	Option 4: French Horn	Option 3: D Sharp / A Flat	Option 1: Cor Anglais	Option 1: A	Option 4: Piano	Option 4: C	Option 3: Piano	No	No
Participant 36B	Facebook	Yes	I currently play an instrument.	Option 1: F Sharp / G Flat	Option 3: Oboe	Option 4: D	Option 5: Oboe	None	Option 4: French Horn	None	Option 4: Oboe	Option 1: A	Option 5: Violin	Option 3: Piano	Option 1: Clarinet	No	No
Participant 37B	UMBC Affiliate	Yes	I currently play an instrument.	Option 1: F Sharp / G Flat	None	Option 3: A	Option 3: Cor Anglais	Option 4: F Sharp / C Flat	Option 4: French Horn	None	Option 4: Oboe	Option 4: A Sharp / B Flat	Option 2: Clarinet	Option 2: E	Option 2: Violin	No	No
Participant 38B	Facebook	Yes	I previously played an instrument.	Option 5: C Sharp / D Flat	Option 5: Clarinet	Option 5: D Sharp / A Flat	Option 4: Piano	Option 4: F Sharp / C Flat	None	None	Option 3: French Horn	Option 2: C Sharp / D Flat	Option 5: Violin	Option 5: Cello	Option 5: Cello	No	No
Participant 39B	Other	Yes	I currently play an instrument.	Option 1: F Sharp / G Flat	Option 1: Cello	Option 5: D Sharp / A Flat	Option 3: Cor Anglais	Option 2: D Sharp / E Flat	Option 3: Trumpet	Option 4: F	Option 3: French Horn	Option 4: A Sharp / B Flat	None	Option 2: E	Option 1: Clarinet	No	No
Participant 40B	LinkedIn	Yes	No, I do not play nor have I ever played an instrument.	None	Option 5: Clarinet	None	Option 5: Oboe	Option 1: A Sharp / B Flat	Option 2: Clarinet	None	Option 3: French Horn	Option 2: C Sharp / D Flat	Option 4: Piano	Option 4: C	Option 4: Trumpet	No	No
Participant 41B	Facebook	No	No, I do not play nor have I ever played an instrument.	None	Option 1: Cello	Option 4: D	Option 4: Piano	Option 3: C	Option 4: French Horn	Option 2: D Sharp / A Flat	Option 3: French Horn	Option 4: A Sharp / B Flat	Option 1: Trumpet	Option 1: A Sharp / B Flat	Option 5: Cello	No	No
Participant 42B	Facebook	Yes	I previously played an instrument.	None	Option 3: Oboe	Option 1: B	Option 4: Piano	Option 2: D Sharp / E Flat	Option 5: Cello	Option 3: D	Option 5: Oboe	Option 5: E	Option 1: Trumpet	Option 2: E	Option 3: Piano	No	No
Participant 43B	Facebook	Yes	I previously played an instrument.	Option 5: C Sharp / D Flat	Option 2: Piano	Option 1: B	Option 5: Oboe	Option 2: D Sharp / E Flat	Option 4: French Horn	Option 5: D Sharp / A Flat	Option 1: Cor Anglais	Option 5: E	Option 5: Violin	Option 4: Trumpet	Option 4: Trumpet	No	No
Participant 44B	Facebook	Yes	No, I do not play nor have I ever played an instrument.	Option 2: C	Option 3: Oboe	None	Option 5: Oboe	Option 4: F Sharp / C Flat	Option 4: French Horn	Option 4: F	Option 3: French Horn	Option 2: C Sharp / D Flat	Option 1: Trumpet	None	Option 5: Cello	No	No
Participant 45B	Facebook	Yes	No, I do not play nor have I ever played an instrument.	None	Option 1: Cello	Option 5: C Sharp / A Flat	Option 4: Piano	Option 1: A Sharp / B Flat	Option 5: Cello	Option 3: D	Option 2: Cello	Option 4: A Sharp / B Flat	Option 3: Cello	Option 4: C	Option 2: Violin	Don't Know	Yes

Appendix S: Continued

Test Group B: Continued

Participant	How did you hear about the survey?	Would you mind if we have your name listed on our museum?	Do you currently play or have you ever played an instrument?	Question 1: Red Key	Question 2: Yellow Instrument	Question 3: Blue Key	Question 4: Violet Instrument	Question 5: Green Key	Question 6: Orange Instrument	Question 7: Yellow Key	Question 8: Blue Instrument	Question 9: Green Instrument	Question 10: Red Instrument	Question 11: Orange Key	Question 12: Green Instrument	Are you a synesthete?	Did you participate in any of the Synesthesia Battery Questions (Potential Synesthete)?
Participant 445	Facebook	Yes	I previously played an instrument.	Option 2: C	Option 1: Cello	Option 3: A	Option 1: Trumpet	None	Option 4: French Horn	Option 5: D Sharp / E Flat	Option 4: Cello	Option 5: E	Option 3: Cello	Option 2: E	Option 1: Clarinet	No	
Participant 476	LinkedIn	Yes	I previously played an instrument.	Option 3: A Sharp	Option 1: Cello	None	Option 1: Trumpet	None	Option 4: French Horn	None	Option 1: Cello	None	Option 3: Cello	Option 5: A Sharp / B Flat	Option 5: Cello	No	
Participant 448	Facebook	Yes	No, I do not play but have I ever played an instrument.	Option 5: C Sharp / D Flat	Option 1: Cello	Option 4: D	Option 2: Violin	No Response	Option 4: French Horn	No Response	No Response	No Response	No Response	No Response	No Response	Don't Know	Yes
Participant 500	University of Baltimore Affiliate	Yes	I previously played an instrument.	Option 5: C Sharp / D Flat	Option 4: Harp	Option 4: D	Option 5: Oboe	Option 2: D Sharp / E Flat	Option 3: Trumpet	Option 2: C Sharp / A Flat	Option 3: Violin	Option 3: O	Option 4: Piano	Option 3: F	Option 3: Trumpet	No	No
Participant 506	Facebook	Yes	I previously played an instrument.	Option 2: C	Option 1: Cello	None	No Response	Option 4: F Sharp / C Flat	Option 4: French Horn	Option 3: D	No Response	Option 1: A	Option 2: Clarinet	Option 3: F	Option 4: Trumpet	No	
Participant 518	UMBC Affiliate	Yes	I previously played an instrument.	Option 5: C Sharp / D Flat	Option 3: Oboe	Option 5: C Sharp / A Flat	Option 3: Cor Anglais	Option 4: F Sharp / C Flat	Option 2: Clarinet	Option 4: F	Option 2: Cello	Option 2: C Sharp / A Flat	Option 2: Clarinet	Option 4: Piano	Option 4: Piano	Don't Know	Yes
Participant 528	UMBC Affiliate	Yes	No, I do not play but have I ever played an instrument.	Option 5: C Sharp / D Flat	Option 3: Oboe	Option 2: F	Option 3: Cor Anglais	Option 5: A	Option 4: French Horn	Option 3: D	Option 4: A Sharp / B Flat	Option 4: Piano	Option 4: Piano	Option 5: A Sharp / B Flat	Option 2: Violin	Don't Know	No
Participant 538	Facebook	Yes	I previously played an instrument.	Option 2: C	Option 5: Clarinet	Option 3: A	Option 5: Oboe	Option 2: D Sharp / E Flat	Option 1: Harp	Option 4: D Sharp / E Flat	Option 2: Cello	Option 1: A	Option 1: Trumpet	Option 5: A Sharp / B Flat	Option 4: Trumpet	Don't Know	Yes
Participant 545	LinkedIn	Yes	No, I do not play but have I ever played an instrument.	Option 1: F Sharp / C Flat	Option 4: Harp	Option 4: D	None	None	Option 4: French Horn	None	None	Option 1: A	Option 4: Piano	Option 5: A Sharp / B Flat	Option 3: Piano	No	
Participant 558	Facebook	Yes	No, I do not play but have I ever played an instrument.	Option 3: A Sharp	Option 5: Clarinet	Option 5: C Sharp / A Flat	Option 1: Trumpet	Option 4: F Sharp / C Flat	Option 4: French Horn	Option 3: D	Option 3: French Horn	Option 3: C	Option 3: Cello	Option 5: A Sharp / B Flat	Option 2: Violin	Don't Know	No
Participant 568	UMBC Affiliate	Yes	I previously played an instrument.	Option 5: C Sharp / D Flat	Option 4: Harp	None	Option 5: Oboe	Option 2: D Sharp / E Flat	Option 5: Cello	Option 5: D Sharp / E Flat	Option 3: French Horn	Option 4: A Sharp / B Flat	Option 3: Cello	Option 4: C	Option 5: Cello	No	No
Participant 578	LinkedIn	Yes	I previously played an instrument.	Option 2: C	Option 1: Cello	Option 2: F	Option 1: Trumpet	Option 4: F Sharp / C Flat	Option 3: Trumpet	Option 5: D Sharp / E Flat	Option 2: Cello	Option 1: A	Option 4: Piano	Option 3: F	Option 1: Clarinet	Don't Know	Yes
Participant 588	UMBC Affiliate	Yes	I previously played an instrument.	Option 2: C	Option 4: Harp	Option 5: C Sharp / A Flat	Option 5: Oboe	Option 3: D	Option 1: Harp	Option 2: D Sharp / E Flat	Option 2: Cello	Option 2: C Sharp / A Flat	Option 4: Piano	Option 3: F	Option 3: Trumpet	No	No
Participant 588	Other	Yes	I currently play an instrument.	Option 1: F Sharp / C Flat	Option 4: Harp	Option 4: D	Option 3: Cor Anglais	Option 1: A Sharp / B Flat	Option 2: Clarinet	Option 4: F	Option 3: French Horn	Option 4: A Sharp / B Flat	Option 4: Piano	Option 3: Cello	Option 5: Cello	Don't Know	No
Participant 606	Facebook	No	No, I do not play but have I ever played an instrument.	Option 4: A	Option 1: Cello	Option 3: A	Option 4: Piano	Option 5: A	Option 5: Cello	Option 2: D Sharp / E Flat	Option 3: French Horn	None	Option 3: Cello	Option 4: C	Option 2: Cello	No	Yes
Participant 618	Facebook	Yes	I previously played an instrument.	Option 1: F Sharp / C Flat	Option 3: Oboe	None	Option 1: Trumpet	Option 5: A	Option 4: French Horn	Option 3: D	Option 2: Cello	Option 2: C Sharp / A Flat	Option 2: Clarinet	Option 2: E	Option 3: Piano	No	
Participant 628	LinkedIn	Yes	No, I do not play but have I ever played an instrument.	None	Option 1: Cello	None	Option 3: Cor Anglais	Option 2: D Sharp / E Flat	Option 2: Clarinet	None	Option 4: Oboe	None	Option 4: Piano	None	Option 3: Piano	Don't Know	Yes
Participant 638	Facebook	Yes	I previously played an instrument.	Option 3: A Sharp	Option 4: Harp	Option 1: B	Option 3: Cor Anglais	Option 5: A	Option 5: Cello	Option 3: French Horn	Option 2: F Sharp / C Flat	Option 3: Cello	Option 3: Piano	Option 4: C	Option 3: Piano	Don't Know	Yes
Participant 648	LinkedIn	Yes	I previously played an instrument.	None	None	None	Option 4: Piano	None	Option 3: French Horn	None	Option 2: Cello	None	Option 2: Clarinet	None	Option 5: Cello	No	No
Participant 658	Instagram	Yes	No, I do not play but have I ever played an instrument.	Option 4: A	Option 1: Cello	Option 4: D	Option 3: Cor Anglais	Option 3: C	No Response	Option 5: D Sharp / E Flat	Option 3: French Horn	Option 5: E	Option 1: Trumpet	Option 5: A Sharp / B Flat	Option 2: Violin	No	
Participant 688	Yes	No, I do not play but have I ever played an instrument.	Option 5: C Sharp / D Flat	Option 4: Harp	Option 1: B	Option 5: Oboe	Option 3: C	Option 3: Trumpet	Option 5: D Sharp / E Flat	Option 5: Cello	Option 2: C Sharp / A Flat	Option 4: Piano	Option 4: Piano	Option 5: A Sharp / B Flat	No Response	Don't Know	Yes
Participant 678	University of Baltimore Affiliate	Yes	I previously played an instrument.	Option 2: C	Option 3: Oboe	Option 4: D	Option 3: Cor Anglais	None	Option 4: French Horn	Option 1: B	Option 5: Violin	Option 5: E	Option 1: Trumpet	Option 5: A Sharp / B Flat	Option 3: Piano	Don't Know	Yes
Participant 648	Yes	I previously played an instrument.	Option 3: A Sharp	Option 1: Cello	Option 5: D Sharp / A Flat	Option 5: Oboe	None	Option 2: Clarinet	None	Option 3: French Horn	Option 4: A Sharp / B Flat	Option 5: Violin	Option 5: Violin	Option 4: Trumpet	Option 4: Trumpet	Don't Know	Yes
Participant 698	Facebook	Yes	I previously played an instrument.	Option 5: C Sharp / D Flat	Option 1: Cello	Option 2: F	Option 3: Cor Anglais	Option 1: A Sharp / B Flat	Option 4: French Horn	Option 1: B	Option 5: Violin	Option 1: A	No Response	Option 4: Trumpet	Option 4: Trumpet	No	
Participant 708	Facebook	Yes	I previously played an instrument.	Option 1: F Sharp / C Flat	Option 5: Clarinet	Option 5: C Sharp / A Flat	Option 3: Cor Anglais	Option 2: D Sharp / E Flat	Option 3: Trumpet	Option 4: F	Option 2: Cello	Option 2: C Sharp / A Flat	Option 4: Piano	Option 2: E	Option 5: Cello	No	
Participant 718	Facebook	Yes	No, I do not play but have I ever played an instrument.	Option 2: C	Option 5: Clarinet	No Response	No Response	Option 3: C	Option 5: Cello	Option 4: F	Option 3: French Horn	None	Option 2: Clarinet	None	Option 2: Violin	No	
Participant 728	Facebook	Yes	I previously played an instrument.	Option 2: C	None	Option 3: A	Option 3: Cor Anglais	None	Option 5: Cello	Option 2: D Sharp / E Flat	Option 2: Cello	Option 4: Piano	Option 1: Clarinet	Option 1: Clarinet	Option 1: Clarinet	Don't Know	Yes
Participant 738	UMBC Affiliate	Yes	I previously played an instrument.	Option 4: A	Option 1: Cello	Option 3: A	Option 5: Oboe	Option 4: F Sharp / C Flat	Option 2: Clarinet	Option 2: Cello	Option 2: C Sharp / A Flat	Option 2: Clarinet	Option 2: Clarinet	Option 5: A Sharp / B Flat	Option 3: Piano	No	
Participant 748	Facebook	Yes	I currently play an instrument.	Option 3: A Sharp	Option 3: Oboe	Option 5: C Sharp / A Flat	Option 1: Trumpet	Option 5: A	Option 1: Harp	Option 4: F	Option 4: Oboe	Option 4: A Sharp / B Flat	Option 4: Piano	Option 3: F	Option 1: Clarinet	No	
Participant 758	UMBC Affiliate	No	I previously played an instrument.	Option 4: A	Option 4: Harp	Option 5: C Sharp / A Flat	Option 4: Piano	Option 1: A Sharp / B Flat	Option 3: Trumpet	Option 4: F	Option 3: French Horn	Option 3: Cello	Option 3: Piano	Option 3: Piano	No		
Participant 768	Instagram	Yes	No, I do not play but have I ever played an instrument.	Option 5: C Sharp / D Flat	Option 1: Cello	None	Option 2: Violin	None	Option 5: Cello	None	Option 4: Oboe	None	Option 3: Cello	None	Option 5: Cello	Don't Know	No
Participant 778	LinkedIn	Yes	I previously played an instrument.	Option 3: A Sharp	No Response	Option 1: B	Option 2: Violin	Option 1: A Sharp / B Flat	Option 2: Clarinet	Option 4: F	Option 1: Cor Anglais	Option 4: A Sharp / B Flat	Option 3: Cello	Option 4: C	Option 4: Piano	Don't Know	No
Participant 788	Facebook	Yes	I previously played an instrument.	None	Option 5: Clarinet	Option 5: C Sharp / A Flat	Option 1: Trumpet	Option 2: D Sharp / E Flat	Option 5: Cello	Option 4: F	Option 2: Cello	Option 3: Cello	Option 3: Cello	Option 5: Cello	Option 4: Cello	Don't Know	No
Participant 798	LinkedIn	Yes	I previously played an instrument.	Option 1: F Sharp / C Flat	Option 5: Clarinet	Option 4: D	Option 5: Oboe	Option 2: D Sharp / E Flat	Option 2: Clarinet	Option 4: F	Option 2: Cello	Option 2: C Sharp / A Flat	Option 3: Cello	Option 4: A Sharp / B Flat	Option 4: Trumpet	Don't Know	No
Participant 808	Facebook	Yes	No, I do not play but have I ever played an instrument.	None	None	Option 4: D	Option 4: Piano	Option 5: A	Option 1: Harp	Option 1: B	Option 4: Oboe	Option 4: A Sharp / B Flat	Option 4: Piano	Option 3: Piano	Option 3: Piano	Don't Know	Yes
Participant 818	UMBC Affiliate	Yes	I previously played an instrument.	Option 5: C Sharp / D Flat	Option 5: Clarinet	Option 5: C Sharp / A Flat	None	Option 4: F Sharp / C Flat	Option 3: Trumpet	Option 2: D Sharp / E Flat	Option 3: French Horn	Option 2: C Sharp / A Flat	Option 5: Violin	Option 3: F	Option 3: Piano	No	No
Participant 828	Facebook	Yes	No, I do not play but have I ever played an instrument.	Option 3: A Sharp	Option 5: Clarinet	Option 4: D	Option 3: Cor Anglais	Option 2: D Sharp / E Flat	Option 3: Trumpet	Option 5: D Sharp / E Flat	Option 3: French Horn	Option 5: E	Option 5: Violin	Option 1: C Sharp / D Flat	Option 2: Violin	No	
Participant 838	LinkedIn	Yes	No, I do not play but have I ever played an instrument.	Option 4: A	Option 2: Piano	Option 4: D	Option 5: Oboe	Option 3: C	Option 4: French Horn	Option 5: D Sharp / E Flat	Option 3: French Horn	Option 1: A	Option 3: Cello	Option 4: C	Option 2: Violin	Don't Know	Yes
Participant 848	Facebook	Yes	I previously played an instrument.	Option 1: F Sharp / C Flat	Option 5: Clarinet	Option 3: A	Option 5: Oboe	Option 4: F Sharp / C Flat	Option 4: French Horn	Option 4: F	Option 5: Violin	Option 5: E	Option 2: Clarinet	Option 5: A Sharp / B Flat	Option 2: Violin	Don't Know	No
Participant 858	UMBC Affiliate	Yes	I previously played an instrument.	Option 5: C Sharp / D Flat	No Response	Option 2: F	Option 5: Oboe	None	Option 4: French Horn	Option 2: C	Option 1: Clarinet	Option 5: E	Option 4: Piano	None	Option 3: Piano	No	
Participant 868	UMBC Affiliate	Yes	I previously played an instrument.	Option 1: Cello	None	None	Option 5: Oboe	None	No Response	Option 3: Violin	No Response	None	None	None	No	No	
Participant 878	Facebook	Yes	I previously played an instrument.	Option 2: C	No Response	No Response	Option 5: Oboe	Option 1: A Sharp / B Flat	Option 5: Cello	Option 2: C Sharp / A Flat	Option 2: Cello	Option 2: C Sharp / A Flat	No Response	Option 4: Piano	Option 5: A Sharp / B Flat	No	
Participant 888	UMBC Affiliate	Yes	I previously played an instrument.	Option 1: F Sharp / C Flat	None	Option 1: B	Option 1: Trumpet	Option 2: D Sharp / E Flat	Option 1: Harp	Option 2: D Sharp / E Flat	Option 2: Clarinet	Option 1: A	Option 4: Piano	Option 2: F	Option 3: Piano	No	
Participant 898	Facebook	Yes	No, I do not play but have I ever played an instrument.	Option 5: C Sharp / D Flat	Option 5: Clarinet	None	Option 3: Cor Anglais	None	Option 2: Clarinet	Option 2: C Sharp / A Flat	Option 2: Cello	Option 1: A	Option 4: Piano	Option 2: E	Option 2: Violin	Don't Know	Yes
Participant 908	University of Baltimore Affiliate	Yes	I previously played an instrument.	None	Option 1: Cello	Option 3: A	No Response	Option 4: F Sharp / C Flat	Option 4: French Horn	None	Option 4: Oboe	None	Option 1: Trumpet	Option 3: Piano	Option 3: Piano	No	
Participant 918	LinkedIn	Yes	I previously played an instrument.	No Response	Option 1: B	Option 3: Cor Anglais	Option 3: Cor Anglais	Option 2: D Sharp / E Flat	Option 5: Cello	Option 4: F	Option 4: Oboe	Option 5: E	Option 2: Clarinet	Option 5: A Sharp / B Flat	Option 1: Clarinet	Don't Know	No

Appendix S: Continued

Test Group B: Continued

Participant	How did you hear about the survey?	Would you visit or have you ever visited an art museum?	Do you currently play or have you ever played an instrument?	Question 1: Red Key	Question 2: Yellow Instrument	Question 3: Blue Key	Question 4: Violet Instrument	Question 5: Green Key	Question 6: Orange Instrument	Question 7: Yellow Key	Question 8: Blue Instrument	Question 9: Violet Key	Question 10: Red Instrument	Question 11: Orange Key	Question 12: Green Instrument	Are you a natural synesthete?	Did you have answer "Yes" to any of the Synesthesia Battery questions (Statistical Synesthetat)?
Participant 92B	Facebook	Yes	No, I do not play nor have I ever played an instrument.	Option 2: C ***	Option 1: Cello	Option 4: D	Option 3: Cor Angellus ***	Option 5: A ***	Option 2: Clarinet	Option 1: B	Option 5: Violin	Option 4: A Sharp/ B Flat	Option 2: Clarinet	Option 3: F	Option 3: Piano	Don't know	Yes
Participant 93B	Facebook	Yes	No, I do not play nor have I ever played an instrument.	Option 2: C ***	Option 1: Cello	Option 4: D	Option 5: Oboe	None	Option 1: Harp	None	Option 2: Cello ***	Option 1: A	Option 2: Clarinet	None	Option 5: Cello	Don't know	No
Participant 94B	Facebook	Yes	I previously played an instrument.	None	Option 1: Cello	None	Option 3: Cor Angellus ***	None	Option 4: French Horn ***	Option 4: F	Option 3: French Horn	Option 4: A Sharp/ B Flat	Option 3: Cello	None	Option 3: Piano	No	No
Participant 95B	Stevenson University Affiliate	Yes	I currently play an instrument.	Option 5: C Sharp/ D Flat	Option 1: Cello	Option 5: D Sharp/ A Flat	Option 1: Trumpet	Option 1: A Sharp/ B Flat	Option 2: Clarinet	Option 5: D Sharp/ E Flat	Option 3: French Horn	Option 1: A	Option 3: Cello	Option 1: C Sharp/ D Flat	Option 5: Piano	Don't know	Yes
Participant 96B	UMBC Affiliate	Yes	I previously played an instrument.	Option 4: A	None	Option 2: F	Option 3: Cor Angellus ***	No Response	None	None	Option 4: A Sharp/ B Flat	Option 1: Trumpet ***	Option 4: Piano	Option 5: Cello	Option 5: Cello	Don't know	Yes
Participant 97B	UMBC Affiliate	Yes	I previously played an instrument.	Option 1: F Sharp/ D Flat	Option 1: Cello	Option 5: D Sharp/ A Flat	Option 3: Cor Angellus ***	Option 1: A Sharp/ B Flat	Option 2: Clarinet	Option 5: D Sharp/ E Flat	Option 1: C Sharp/ B Flat	Option 1: A	Option 4: Piano	Option 2: E	Option 1: Clarinet	Don't know	No
Participant 98B	University of Baltimore Affiliate	Yes	I previously played an instrument.	Option 4: A	Option 3: Oboe ***	Option 4: D	Option 5: Oboe	None	Option 5: Cello	Option 1: B	Option 2: Cello ***	Option 3: O	Option 5: Violin	Option 4: C ***	Option 4: Violin ***	No	
Participant 99B	Facebook	Yes	I previously played an instrument.	None	Option 2: Piano	Option 3: A	Option 5: Oboe	None	Option 1: A Sharp/ B Flat	None	Option 2: Cello ***	Option 3: G	Option 3: Cello	No Response	None	No	
Participant 100B	LinkedIn	Yes	I currently play an instrument.	Option 2: C ***	Option 3: Oboe ***	None	Option 5: Oboe	Option 5: A ***	Option 5: Cello	None	Option 3: French Horn	None	Option 4: Piano	Option 2: E	Option 3: Piano	No	
Participant 101B	UMBC Affiliate	Yes	I previously played an instrument.	Option 1: F Sharp/ D Flat	Option 5: Clarinet	Option 3: A	Option 1: Trumpet	Option 4: F Sharp/ G Flat	Option 4: French Horn ***	Option 5: D Sharp/ E Flat	Option 5: Cello	Option 5: E	Option 2: Clarinet	Option 3: F	Option 2: Violin ***	No	
Participant 102B	LinkedIn	Yes	I previously played an instrument.	Option 2: C ***	None	Option 4: D	Option 3: Cor Angellus ***	Option 5: A ***	Option 5: Cello	Option 4: F	Option 2: Cello ***	Option 1: A	Option 1: Trumpet ***	Option 5: A Sharp/ B Flat	Option 4: Trumpet	No	
Participant 103B	UMBC Affiliate	Yes	I previously played an instrument.	Option 1: F Sharp/ D Flat	Option 1: Cello	None	Option 1: Trumpet	None	Option 3: Trumpet	None	Option 5: Violin	None	Option 5: Violin	None	No Response	No	
Participant 104B	UMBC Affiliate	Yes	I previously played an instrument.	Option 5: C Sharp/ D Flat	Option 1: Cello	Option 4: D	Option 5: Oboe	Option 4: F Sharp/ G Flat	Option 3: Trumpet	None	Option 3: French Horn	Option 4: A Sharp/ B Flat	Option 2: Clarinet	Option 1: C Sharp/ D Flat	Option 5: Cello	Don't know	Yes
Participant 105B	Facebook	Yes	I previously played an instrument.	Option 2: C ***	Option 5: Clarinet	Option 5: D Sharp/ A Flat	Option 1: Trumpet	Option 3: C	Option 5: Cello	Option 4: F	Option 3: French Horn	Option 4: A Sharp/ B Flat	Option 5: Violin	None	Option 3: Piano	No	

*** SYNESTHETE CONTROL

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