ARTIST'S ARTICLE

Composing Perceivable Time

JENN KIRBY

ABSTRACT

Time is an integral element in music. The chronometric duration of a piece of music often differs from the duration perceived by the listener. This paper presents a composition that aims to manipulate the listener's perception of time and presents the research findings that influenced the compositional decisions.

Music, as Edgard Varèse put it, is "organised sound" [1], and sound is acoustic vibrations that travel through a medium [2]. These vibrations are time dependent, and composers organize and arrange these sound vibrations in time. Time is an element that cannot be removed from music. Through the musical revolution of the 20th century, composers such as Stockhausen, Xenakis and Cage changed how we discuss music. We no longer need to rely on form, harmony, melody, counterpoint, etc. This has encouraged us to think of music in new terms, with more focus on timbre, space, etc. However, time has always remained an integral element in our discussions of music.

Time can be thought of in two ways: as chronometric time and as perceived time. We think of chronometric time as being absolute in music, for example, 4 beats at a tempo of 88 beats per minute in one score is the same as in another score. Einstein's theory states that time and space are related [3]. Time from my perspective differs from time from your perspective, and, depending on how you spend your day, your day may indeed be experienced as longer or shorter than mine. The knowledge that time is relative and that our experiences of time are unique poses interesting questions for the perception of time. If chronometric time can be manipulated by space and speed, then the perception of time can be manipulated by context.

Measuring time perception can be done retrospectively and prospectively. The retrospective paradigm relates to remembered duration, whereas the prospective paradigm relates to experienced time [4]. These two measurement paradigms are significantly different from each other. For example, as you wait for a bus, time seems to pass slowly. You may check your watch expecting to see five minutes passed when in fact it has been only one or two. In subsequent reflection on the wait, it may not seem that long at all. This difference between experienced and remembered duration results from a lack of stimulus while waiting. Because nothing significant occurred, there is little to nothing to recall about that time period, making it appear to have been a shorter amount of time.

Composers typically focus on experiential time, within the prospective paradigm. Messiaen, for example, in *Quatuor pour la fin du temps*, creates a backward motion of time with his innovative non-retrograde rhythms [5]. By encouraging the listener to perceive time standing still, or indeed moving backwards, he elongates time as chronometric time is still passing. He also creates a stasis in subjective or perceivable time in *Chronochromie*. The chaos in the sixth movement, *Épôde*, evokes a circular motion of time. The movement is in a constantly excited state and moves around only within that state. The movement circles for approximately four minutes before abruptly ending. The duration of the movement is almost irrelevant, as the movement exists in one moment of time, which the composer has specified as approximately four minutes in chronometric time. My experiential duration of this movement is much longer than my remembered duration, hence demonstrating the composer's ability to modify my perception of time.

Philip Glass uses extended time periods to create a new mode of listening. He describes this in talking about his 4½-hour work *Music in Twelve Parts*.

> The music is placed outside the usual time-scale substituting a non-narrative and extended time-sense, in its place. . . . When it becomes apparent that nothing "happens" in the usual sense, but that, instead, the gradual accretion of musical material can and does serve as the basis of the listener's attention, then he can perhaps discover another mode of listening [6].

Jenn Kirby (composer), Music Department, 5 Trinity College, Dublin, Ireland.
Email: <msjennkirby@gmail.com>.

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This new mode of listening, which can be likened to the Schaefferian theory of reduced listening [7], also leads to an altered perception of time. When nothing appears to happen, the listener can rest and pay less attention than with a highly active piece. This lesser attention reduces the perceived length of the piece [8]. At 4½ hours, a highly active piece would exhaust not only the performers but also the listeners. It is no coincidence that many durational pieces promote another mode of listening.

Our perception of time is influenced more by quality than quantity. Content is more important than duration. The content within a time span is also perceived differently. The performers who interpret the score, the listeners who have heard it before, the listeners who have read the score and the listeners experiencing it for the first time will all have a different experience of the content and thus a different experience of time. Grisey says we compose perceptible time [9]. We control perceptible time through the degree of change, through movement and stasis.

I am concerned with how to compose perceptible time in both retrospective and prospective paradigms. I have composed a piano trio in three movements, each with an equal duration of 3 minutes. There is little significance to the 3-minute figure; I merely wanted to use a short duration. The chronometric time is only important in its relation to perceived time. As noted above, many composers have consciously or unconsciously manipulated the perception of time. Here, however, I set a goal of composing perceivable time, something that can be measured, not as an aftereffect of the composition but as the purpose of the composition.

I conducted research in the fields of psychology and consumer research, which greatly influenced the composition's musical parameters. Although this may seem a strange approach to another composer, I see this piano trio as an experiment first and a composition second. The purpose of the experiment is to determine to what extent time perception is controllable in composition. The results will influence my future compositions and determine whether or not the manipulation of perceived time is a skill that I can develop.

First I present my research findings and then discuss the composition and how these findings influenced the composition.

RESEARCH

The psychology and consumer research I investigated discusses music at a very general level. Its application to contemporary music is no doubt questionable; however, it does present an objective view of musical parameters and the individual effect of musical parameters on the perception of time. First I would like to highlight briefly the research that has illustrated the effect of different tempi on consumers. Zakay et al. found that a very slow tempo of 30 bpm produced a shorter perceived duration than a faster tempo of 120 bpm [10]. Biasutti and Pattaro also tested the effect of different tempi on the perception of time [11]. Although the results were not significant, the slowest tempo, 50 bpm, produced the shortest perceived duration, while 70 bpm produced the longest perceived durations. While the results from Zakay et al. support Ornstein's density of information theory [12], Biasutti and Pattaro's study seems to contradict it. They hypothesize that the reason for this contradiction is that 70 bpm is close to chronometric time. Given that 50 bpm is no further from chronometric time than 70 bpm, this reasoning remains questionable. North et al. investigated whether tempo had an effect on time perception in a gymnasium [13]. Their study showed no correlation between fast/slow tempo and longer/shorter estimations; however it did show that a slower tempo led to greater inaccuracies of estimation. Although these authors' findings are often contradictory, they do provide a general indication of the influence of tempi on the perception of time in music.

The knowledge that time is relative and that our experiences of time are unique poses interesting questions for the perception of time.

Kellaris and Kent investigated whether "time flies when you're having fun" [14]. They created three versions of a composition—in major, minor and atonal modalities. All other parameters—tempo, loudness, instrumentation, etc.—were identical in each version. I question the validity of this experiment, however, as modifying one parameter of a piece of music will no doubt impact the perception of other elements. For example, manipulating the tempo may change how we perceive the melody. These authors' reason for the isolation is a general assumption that a major key is positive, whereas a minor key is negative. Although many would disagree with this assumption, they have considered the impact that changing one parameter may have on the music. I still see this as a greater manipulation of the music and take issue with comparing three instances of one piece with differing modalities. This research remains relevant to my composition, although I am composing three individual movements as opposed to changing parameters within a previously composed piece.

Kellaris and Kent's study was retrospective; participants were asked to estimate the duration of the music in minutes and seconds after having heard it. They found music in a major key to have a longer perceived duration and also the greatest disparity between chronometric time and perceived duration. Perceived duration of the music in a minor key was shorter, and the atonal music was perceived as the shortest. They hypothesize that the major and minor keys, due to their familiarity, are easier to store in memory, and going by Ornstein's model [12] there is much more remembered in retrospective duration estimates. Kellaris and Kent's generalization that major is positive and minor and atonal

modalities are negative may have pertained to pop music at the time of the study. However, this may not translate to contemporary music, where listeners are much more familiar with atonal music and the associations between positive and negative in modalities may not be the same.

Kellaris and Mantel examined the influence of loudness on time perception on young female participants [15]. They defined soft music as having a decibel value of no more than 60dB and loud as 90dB or more. An original composition was played at different volumes. The results showed that softer music was perceived as shorter than louder music. This may be linked to the theory of information density, with louder music containing more information than quieter music.

Time in composition can be thought of in intervals: a starting point, an ending point and the interval or space in between. The interval, while having a chronometric time, can seem shorter or longer depending on how that interval is filled [16].

Fraisse's model states that time is measured by environmental stimulus [17]. A greater number of changes in a time interval will lead to a greater perceived duration. This could offer insight into longer durational works. Gyorgy Ligeti's *Lontano,* for example, due to its static characteristics [18], stretches our perception of time and even stops it entirely. While John Cage's *Fontana Mix* may suspend the flow of time [19], Louis Andriessen's *De Tijd* attempts to suspend time by making the music stand still [20]. These pieces are considered longer pieces only because we know their chronometric time durations. In listening to these pieces we may consider them much shorter or longer than their chronometric times—or even timeless, where chronometric duration would be difficult to estimate as well as seem irrelevant to the listeners.

Ornstein's theory is based on density of information and indicates that the amount of information processed in a given time period is proportional to the perceived duration of that time period [12]. Fraisse's model is based on change or stimulus, regardless of whether or not that information is changed or repeated. This difference is highlighted when analyzing composition. For example, Terry Riley's *In C* is texturally dense but presents little change, in comparison to LaMonte Young's *The Second Dream of the High-Tension Line Stepdown Transformer*, which could be considered more texturally spacious. However, both pieces could be considered to suspend time.

COMPOSITION

In composing this piece, I made certain assumptions. The listener is defined as an audience member intending to listen to a performance, thus allotting an unspecified amount of their time and attention. This space in time is thus opened and is to be filled by the performance.

I made many of the compositional decisions in the early stages of the compositional process based on the research I have discussed. The musical parameters that the research mostly influenced are tempo, dynamics, modality and density. Because much of the research was psychology based and not music based, other musical elements, such as form, rhythm, harmony, melody, etc., were not investigated directly. However, I took some observations and generalizations from the research and translated and represented them musically. In certain cases I thought of musical elements not in terms of their musicality but in relation to their influence on perceived duration. For example, I used repetition to remind listeners of previous events within the music and also to increase expectancy and invite an overestimation of durations [21]. Rhythm was thought of in terms of its complexity and how this could require more or less processing by the listener, thus influencing the listener's perception of time.

Movement I: The Shorter Movement

In the shorter movement the first thing of note to the listener is the staggered entrance of instruments; the piano begins, followed by the violin and finally the cello. The purpose is to imply that the piece only truly begins when all three instruments are together, and the introduction is not counted.

Dynamics in this movement are quite soft. Softer or quieter sounds contain less information than louder sounds. A complex tone is made up of a fundamental frequency and a number of partials; if the fundamental is quieter, some partials will be so quiet they are not audible. Figure 1 shows the spectral content of A 440Hz on the piano with a soft dynamic. Figure 2 shows the spectral content of the same note, A 440Hz, with a louder dynamic. The louder dynamic has possibly twice the number of partials than the softer does. Figure 1 shows partials up to approximately 5kHz, whereas Fig. 2 has partials up to 12KHz. The theory of time perception and density of information holds that the amount of information processed in a given time period is proportional to the perceived duration of that time period. Therefore softer dynamics, containing less information, should induce a shorter perceived duration. On this reasoning, timbral complexity is also subject to the theory of information density and thus would influence perceived duration.

Tempo was decided based on the density of information theory, with a slower tempo likely to have fewer notes and thus less information than a faster tempo. There is a balance to be found, however, as too slow a tempo could bore the listener and cause his or her perception of time to be longer. Similarly, too fast a tempo could provide too much information to process and thus disengage the listener. The density must be carefully controlled. This is a general assumption, and although there is no direct mapping between tempi and density, this generalization is useful when deciding on a tempo for a movement.

The tempo at the beginning of the movement is 75 bpm but slows to 55 bpm at mm.15. I chose 55 bpm because it is just slower than chronometric time. If the slower tempo had been introduced initially, the listener might have experienced the movement as drawn out, so introducing a slower tempo later on would hopefully go unnoticed, as a tempo had already been established. As a composer I find it difficult to predict how an audience might experience the piece for the first time. The composer-composition relationship can be

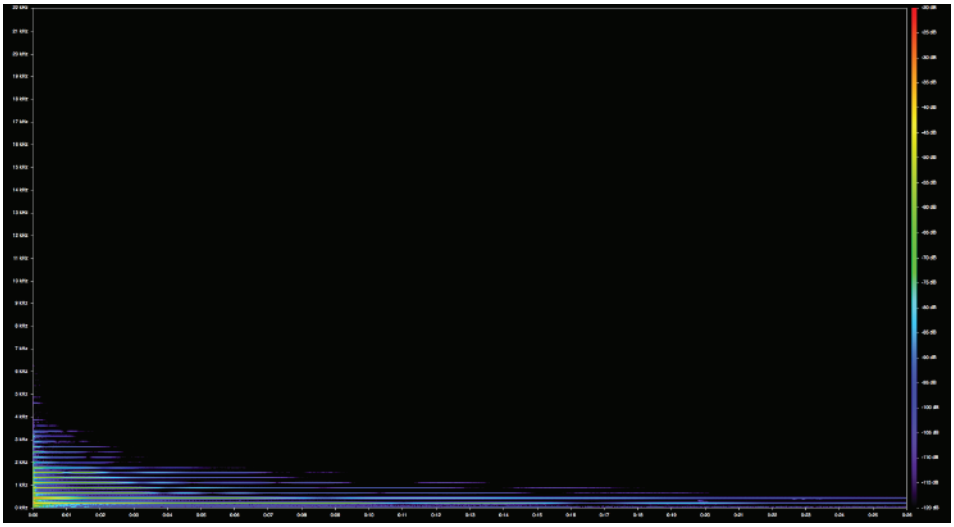

Fig. 1. Spectral analysis of A 440Hz piano *p*. (© Jenn Kirby)

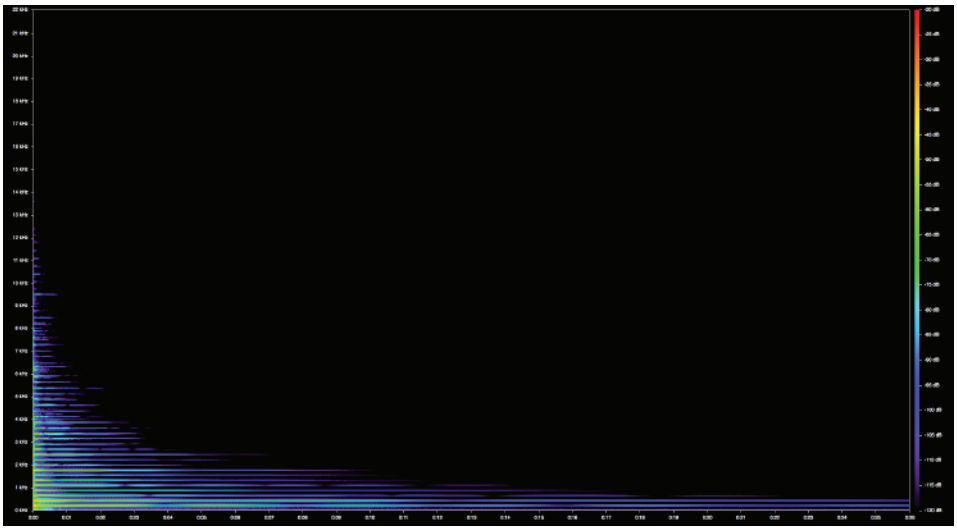

Fig. 2. Spectral analysis of A 440Hz piano *f*. (© Jenn Kirby)

so intimate that it is almost impossible to listen with fresh ears. For this reason, I made many decisions very early in the compositional process.

Kellaris and Kent found that a piece in major modality was perceived as longer than minor, and minor longer than atonal [14]. I therefore decided that this movement would be atonal. However, it contains many minor sections. By not solely using a minor key signature it has an unpredictable structure, where the listener might only hold onto or remember certain sections that they understood or predicted.

Movement II: The Longer Movement

The number of bars in the second movement is almost double that of the first (99 compared to 51). The duration is the same in chronometric time but its score information is almost doubled. In terms of information density, it is fair to say that this movement is much denser. Unlike the first movement, there is little or no introduction. The sustain pedal is used heavily here to emphasize louder moments and to increase spectral density. As mentioned, there is a balance to be found with information density: too much could overload the listener, so there are many "breathing" moments to allow the listener a mental break from processing. Composers use this breathing technique extensively, but here I use it for the specific purpose of influencing time perception. There are slight rhythmical changes during this movement, adding complexity and thus requiring more mental processing from the listener. For example, Fig. 3 shows the lack of synchronicity between the instruments up to the time signature change, which could be thought of as a breathing moment.

I composed the balance between the information and the breathing moments carefully, using the breaths only where necessary, as these moments suspend time [22] and would not be counted by the listener. In this movement, with the aim that the perceived duration be longer than the chronometric duration, any chronometric time that is not counted in perceived time must be used as little as possible. Rests are rarely used; instead a longer-duration note is used. The decay allows the listener a break.

The faster tempo in this movement allows more information in a shorter time. As with a slow tempo there is a balance that must be found. Too fast a tempo could be hectic and too much for the listener to process. As this movement contains more complexity than the first, a change in tempo might overload the listener, so the tempo remains the same throughout.

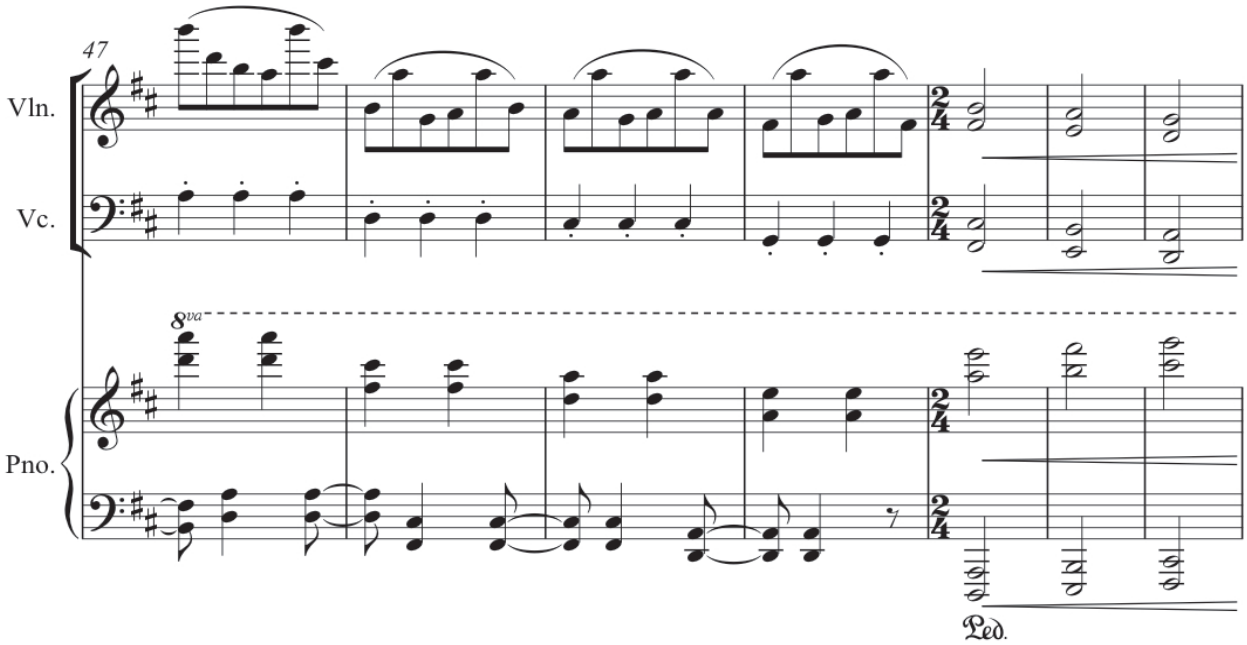

Fig. 3. Score snippet of asynchronous rhythms. (© Jenn Kirby)

I chose a major key for this movement based on the research outlined above. The key of D major was an aesthetic choice.

Movement III: The Exact Movement

This movement was written to be perceived as closely to chronometric duration as possible. The movement combines techniques from the first and second movements to create a balance between shortening and lengthening. This movement has a very prominent pulse that reinforces linear listening and encourages the listener to track the chronometric time, thus encouraging the listener to accurately measure chronometric duration. Another technique I introduced was the use of higher and lower registers, the timbres associated with these notes being slightly less familiar than the middle range, to hold the listener's attention throughout.

Compositionally, this movement is much freer than the previous two. As it balances both shortening and lengthening, anything that could have been thought to lengthen or shorten could be compensated for later on. This movement as a result is more "musical" and has fewer restrictions.

The dynamics in this movement vary more than in the previous two, ranging from as soft as possible to as loud as possible. While they are focused on louder dynamics, as the movement is sparse, much decay is heard.

The tempo is 60 bpm, which equals chronometric time. A listener tracking time, counting each beat as a second, could conceivably count time accurately. I do not expect that a listener would do this consciously but I hoped that they might be encouraged to do so subconsciously. Although this movement is atonal, much of it centers on the minor keys. This is similar to the first movement, although this movement is more tonal than the first.

SURVEY

I conducted a survey twice to measure the listeners' perceptions of duration. The first was the retrospective paradigm, where the listeners were informed that they would be asked a question at the end of the performance. In the second, prospective, paradigm, the listeners were asked to write down at the end of each movement its perceived duration in minutes and seconds. The listeners in this case would use some method of counting or tracking time. There are methods a composer could use to encourage this, such as a prominent pulse that I used in the third movement.

Two small groups of musically trained students (at undergraduate, master's and Ph.D. levels) and lecturers were surveyed for their perceived time estimations. The first survey involved 11 participants and was conducted in Trinity College Dublin, 22 February 2012 (Group A). The second survey involved 12 participants and was conducted in the Punto d'Incontro, Maccagno, Italy, 4 July 2012 (Group B).

Group A's results favored the third movement as the shortest and the second as the longest. Group B's duration results varied between participants. The estimations for all movements ranged from 2'00" to 5'30". Since perception differed wildly from one listener to another, average times did not yield insightful results. However, comparing an individual listener's first answer with their second answer, rather than how one individual's first answer compared with another listener's first answer, provided better insight. This was a similar approach to that of the first study, and the results correspond with those from Group A.

The combined results in Fig. 4 show that the second movement was strongly favored as having the longest duration and the third movement as the shortest.

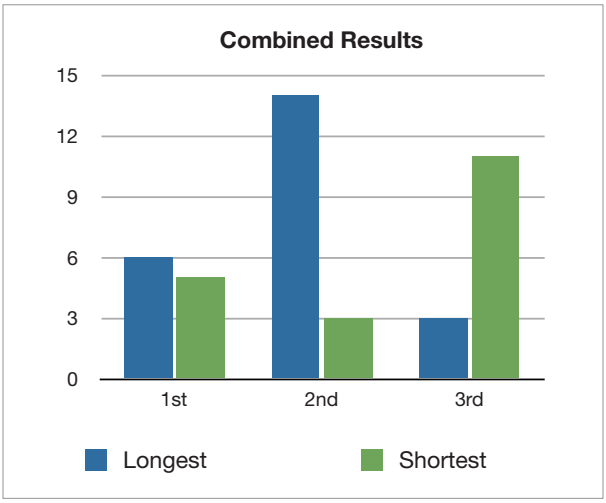

Fig. 4. Combined results of survey, where the left bar represents the number of participants who thought a movement was longest and the right bar represents those who thought it was shortest. (© Jenn Kirby)

DISCUSSION

Of note first is that the results do not fully reflect what I expected and intended. My first goal was for the second movement to be perceived as the longest, and the results reflect that. My second goal was that the first movement would be perceived as the shortest; instead, however, the third movement was perceived as the shortest. I can only speculate as to why it was so perceived. In the third movement, shortening and lengthening techniques were used; however, I put more focus on shortening. According to density of information theory, an empty interval is perceived as shorter than an interval filled with music. I therefore expected that an interval filled with music would be perceived as longer than its actual duration. However, the comparison was not between an empty interval and a musically filled interval but between two musically filled intervals. While other techniques were used, such as exacting, where a prominent pulse was used to help the listener track time, I believe it was the use of the minor key and softer dynamic that led to the shorter perceived duration.

In the first movement the tempo was slowed to 50 bpm after 15 measures. Perhaps this tempo was too slow and the listeners became disengaged with the music, possibly leading to an overestimation of the duration. Rowell suggests that "framing behavior," such as my slow introduction of instruments, may lead to a longer perceived time frame [23]. These are only speculations since this is not an isolated study, with many parameters possibly affecting the outcome, from the order of the movements to the acoustics of the environment, as well as other subjective non-musical factors, such as whether the listeners ate breakfast, for example. It is beyond the control and possibly the ambition of the composer to control these elements.

AESTHETIC IMPLICATIONS

We may question whether or not this approach hinders composition. This composition very strictly adhered to the guidelines I initially set to test whether time perception can be used as a parameter in composition. The composition could be considered a study in itself to determine the effectiveness of the guidelines outlined, but unfortunately aesthetics are compromised in the process. This strictness was necessary to determine compositional validity of the techniques. The experiment through composition enables a composer to understand these techniques so that more aesthetically focused compositions can be written in the future. The composition also forms a platform from which other composers can create new techniques to influence the perception of time in music.

CONCLUSION

I set out to compose a piano trio of three movements to test the malleability of time perception in composition. I conducted a survey measuring the listeners' perceived duration of the composition. My research in contemporary composition influenced my aesthetic approach and general understanding of composers' intentions in manipulating perceivable time and considerations of time perception. I applied psychological and consumer research as directly as possible to my composition, often sacrificing aesthetic choice. In my attempt to gather concrete evidence on the effect of individual musical parameters, I realized that these are not easily isolated. For example, many composers would argue that changing the tempo of a piece does not just change the speed of it, but it affects all aspects, i.e. melody, harmony, rhythm, etc. Rather than choosing these parameters in isolation I combined them and thus avoided this issue. I tested whether I as a composer can manipulate the perception of time, in a more concrete way than has been previously discussed. Although the results of the survey were not fully as anticipated, I believe it is fair to conclude that I have shown the perception of time to be not just malleable, but controllable. I found it possible to manipulate the perception of time and consider it an important factor in composition.

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