An Analytic Study of Hangeul-Based Algorithmic Compositional Techniques in *Prelude for Orchestra*

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Abstract

This thesis is an analytic study of a series of compositional processes that translate the letters and contents of twentieth century poet Yun, Dong Ju's poem *Prelude* into music, as depicted in the author's piece, *Prelude for Orchestra*. This thesis consists of two main components: the methodology of pre-composition that precedes the actual composition process, and the analytic study of the composition process itself.

The musical material used in the piece is derived from the Hangeul letters with which the poem is written. A pitch matrix is constructed by implementing an algorithm that substitutes the principles of creating Hangeul characters and utterances into pitches. This matrix is analyzed numerically from the perspective of set theory and discussed from an algorithmic standpoint that arises from the relationship between Hangeul and pitch. I discuss various composition techniques that use the principles of letter combinations in a musical context. The matrix created from Hangeul is applied to various musical elements of the piece, and *Prelude for Orchestra* is ensured musical unity and cohesion through the application of the rules and principles of Hangeul.

During the pitch matrix construction process, the algorithm generated by matching Hangeul characters with pitches exhibits a nondeterminate characteristic. This arises from the subjective musical decisions made by the composer throughout the entire process, from the initial creation to the composition stage. These nondeterministic algorithms foster artistic possibilities and inspire diverse ideas in music. Additionally, particular attention is given to analyzing the relationship between music and language due to the inherent connection between the piece and

the poem in *Prelude for Orchestra*. Specifically, this study focuses on analyzing the musical form that relates to the text of the poem, exploring the inherent musicality within the language, and examining the musical application derived from the poem's content. Furthermore, the thesis explores the possibilities of music composition techniques that emerge through the application of algorithms based on the principles and rules of Hangeul, in conjunction with the text of poems.

Excerpt from Section 1 of the Main Body of my thesis (Introduction omitted)

The *Prelude for Orchestra* is an orchestral piece composed with a three-movement structure in mind. Divided by the punctuation marks within the poem, it is segmented into three parts: lines 1-4, lines 5-8, and the final sentence of the second stanza, line 9, each becoming individual movements. The first movement, the subject of this analysis, encompasses the content representing the past tense of the poem from lines 1 to 4, denoted by the past tense[1] "했다." This movement stands independently as a piece of music. The complete text of Yoon Dong-ju's poem, Prelude[2], can be seen in Table 1 below.

Table 1 Full Text of *Prelude*

Korean version (한글)	English version[3]
서시(序詩): 죽는 날까지 하늘을 우러러	*Prelude* Let me have no shame under heaven, 'til I die.

[1] Regarding *Prelude*, it can be broadly divided into three parts based on tenses: past (1-4), future (5-8), and present (9)." - Jung-jae Lee, "Structural Analysis of *Prelude for Orchestra*," Dongguk Language and Literature 2 (1987), 91.
[2] Composition and analysis were based on a modern version, which, although not the original written by Yun Dong-ju, had been altered in part by the publishing company.
[3] The translation is used by Byun Man-Sik's translation. From an article, David Bannon, "Unique Korean Cultural Concepts in Interpersonal Relations," Translation Journal, 12(1), (2015).

한 점 부끄럼이 없기를 잎새에 이는 바람에도 나는 괴로워했다. 별을 노래하는 마음으로 모든 죽어가는 것을 사랑해야지 그리고 나한테 주어진 길을 걸어가야겠다. 오늘 밤에도 별이 바람에 스치운다.	Even wind in the leaves pained my soul. With a heart that sings of stars I must love all dying things. And I must walk the path given to me. Tonight also, the wind sweeps over the stars.

1. Algorithmic Composition Techniques

1.1. Character-based Composition in *Micrologus*

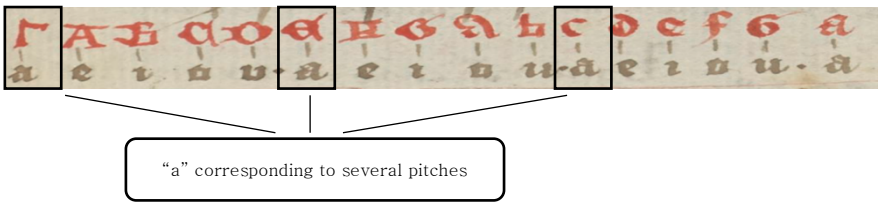
In relation to algorithmic composition techniques, which involve applying predefined or established rules to composition, Guido devised an algorithm associating characters with musical notes. The first attempt at algorithmic composition through characters was detailed extensively in his work *Micrologus* as the first documented instance in history of formalizing a compositional method based on specific rules.[4] Guido's algorithmic composition method involves creating a table that correlates certain sounds with Latin vowels and substituting them accordingly. Gareth Loy, when discussing Guido's method of creating music from Latin sacred lyrics, explained that Guido selected Latin words, extracted vowels from each word, and began matching them to pitch

[4] Gareth Loy, Musimathics, Volume 1: The Mathematical Foundations of Music (Cambridge: The MIT Press, 2006), 286.

values from his table.[5] He pre-associated sounds and vowels in the table to devise an algorithm for composition.

Guido's alphabet algorithmic composition method is specifically as follows: When singing lyrics written in Latin, he excluded consonants that composed the words and used only the vowels as the material for the algorithm. By substituting a set of sounds corresponding to each vowel, he introduced variations in the music on a vowel-by-vowel basis during the composition process. Starting from the Latin vowels a, e, i, o, u, which he related to a range of 15 notes encompassing two octaves of the G note (G, uppercase, and g, lowercase) starting from Γ (gamma, G)[6], he assigned three consecutive pairs of five vowels to these notes (see Figure 1).

Figure 1 Guido's Algorithm Model[7]

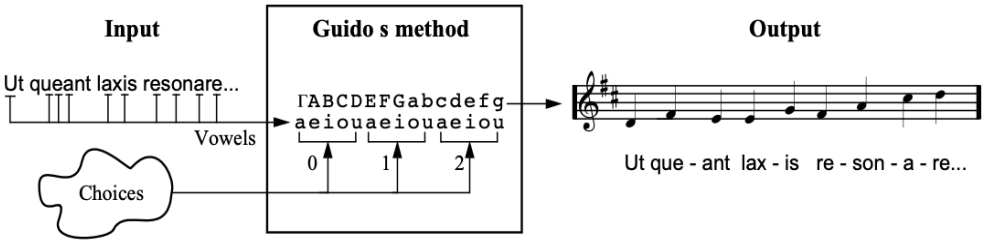


Therefore, it becomes possible to obtain three different sounds for a single vowel. For example, the vowel "a" can produce the notes Γ, E, and c likewise, the vowel "e" can produce A, F, and d notes (see Figure 2, as depicted in Loy's explanation of the output derived from extracting pitches from actual Latin text). Guido's algorithmic approach does not have a one-to-one correspondence between pitches and characters, hence, as the words in the lyrics increase,

[5] Loy, Musimathics, Volume 1: The Mathematical Foundations of Music, 287.
[6] Lowercase letters were intentionally used in accordance with Guido's model to distinguish between the same G note in different octaves.
[7] Guido of Arezzo [Aretinus], *Anonymi breviarum de musica* ; Guidonis arctini opera (i.107), https://opac.kbr.be/LIBRARY/doc/SYRACUSE/17341855, accessed April 4, 2023.

the options for pitches expand, leading to a greater potential for various tonal possibilities. Simultaneously, his algorithmic approach limits the choices to three when translating characters into music in terms of pitch. Consequently, artistic value can be discovered through the non-deterministic yet restricted choices of the composer's pitch selection.

Figure 2 Guido's Technique Diagram[8]



The limitation of musical elements in composition is not a prerequisite, but it has been frequently argued as useful by artists. For example, in his book, *Poetics of Music*, Igor Stravinsky (1882-1971) mentioned, "My freedom will be so much the greater and more meaningful the more narrowly I limit my field of action and the more I surround myself with obstacles."[9] This assertion implies that certain restrictions and norms foster coherence and cohesion in music, making it more unified and meaningful. Similarly, serialism restricts the use of pitches but, within those limitations, achieves diverse compositional possibilities and musical uniformity, akin to the characteristic of limiting musical elements generated by algorithms.[10]

[8] Loy, *Musimathics, Volume 1: The Mathematical Foundations of Music,* 287. Figure 9.3 Block diagram for Guido's method.
[9] Stravinsky, in his book *Poetics of Music* (Cambridge: Harvard University Press, 1970), 65, describes his pursuit not of limitless freedom in creation but rather of overcoming the constraints he imposed on certain scales and chromaticism, as discussed on pages 63–64.
[10] Loy, *Musimathics, Volume 1: The Mathematical Foundations of Music*, 289-290.

I agree with Loy's characterization of Guido's approach being a "nondeterministic algorithmic compositional technique," a concept he introduced. Guido's method doesn't solely entail mechanical production via algorithms; it involves subjective considerations of the composer. Consequently, algorithms achievable based on the composer's aesthetic choices aren't deterministic and, instead, could be more artistic.

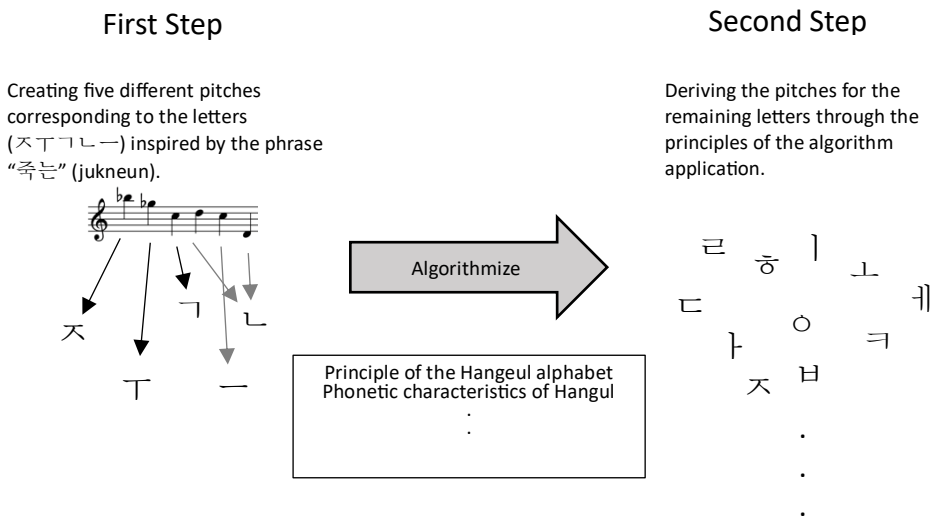
The effective limitation inherent in algorithms like this resembles characteristics found in serialism. Serialism similarly confines the use of pitches but concurrently achieves diverse compositional possibilities and musical coherence within those constraints. Hence, by incorporating the composer's intentions, it becomes a methodology that secures musical unity through effective limitations, akin to an organism. The algorithm employed in *Prelude* (in Korean 서시(Seosi)) *for Orchestra* also exhibits this non-deterministic nature. However, a Hangeul algorithm[11] I developed and utilized in *Prelude* inherently produces one output for one input, differing in methodology from Guido's algorithm in acquiring both indeterminacy and non-determinism.

In the Hangeul algorithm, specific characters correspond to specific pitches. This process is accompanied by the subjectivity and non-deterministic nature inherent to the composer. Figure 3 illustrates the application process of the Hangeul algorithm. Initially, before the entire set of characters corresponds to pitches, a few characters are selected as the basis for determining the pitches. These character's pitches are determined by the composer's subjective inspiration based on significant specific phrases (e.g., the initial line "죽는" (jukneun) in *Prelude for orchestra*). This forms the first stage of Figure 3. In the second stage of the algorithm's application, the

[11] The Hangul algorithm maps the consonants and vowels of Hangul to pitches and is represented in a matrix form similar to a tone row matrix.

undetermined pitches of the characters are determined by various approaches the composer deems significant, such as the principles of Hangul and its phonetic characteristics. Based on the interrelationships between characters according to various principles, the algorithm generates a pitch matrix represented in diagram form.

Figure 3 Creation Process of the Hangul Algorithm



The algorithm can be shaped by various parameters depending on the composer. Therefore, the Hangeul algorithm system always produces different results, influenced by the time of application or the composer using the algorithm, as well as various principles and parameters applied to the algorithm.

Moreover, while Guido's algorithm offers multiple choices for a single vowel, the total number of tones used in music is determined by the text (see Figure 2). In contrast, composition through the Hangeul algorithm uses melodies derived from characters that are repeatedly and diversely applied through repetition and variation. Although characters and pitches are mapped in a one-to-one correspondence by the algorithm, the actual pitches derived are used diversely when utilized in music. In conclusion, *Prelude* involves subjective uncertainty embedded in the

formation stage of the algorithm that shapes the Hangeul matrix, and this subjective uncertainty is applied within the artistic domain during the utilization in the composition process.

1.2. The Compositional and Analytical Tool Use of Set Theory

The use of numbers instead of traditional musical notes to represent pitch, specifically as a means of denoting sounds in the Hangul algorithm, is effective. Utilizing numbers to denote principles applied in the algorithm and variations in pitch, rather than musical note names, enhances clarity in their relationship. Moreover, employing numbers is more convenient when populating the pitch matrix.

Guido's method represented vowels as corresponding to musical notes using alphabets such as A (La), B (Si), C (Do), and so on. Just as the long-standing tradition of using alphabets to represent musical notes exists, the practice of transcribing tones and their relationships into mathematical forms has also become an established convention. Particularly in more mathematically inclined music, such as serial music or set theory composition, set theory has been employed for analysis and composition to better understand the relationships between tones.

The usage of set theory in *Prelude* is conducive to creating matrices of tones that correspond to each Hangul alphabet used in the algorithm. Numbers are applied in the pitch matrix derived from the algorithm, following the system of integer notation to represent twelve tones from 0 to 11, associating letters with sets of pitches. Specifically, as Hangul principles in the *Prelude* algorithm manifest in an additive or subtractive manner, employing the pitch set makes it more straightforward for analysis.

The set theory applied to the Hangeul matrix differs significantly from the conventional use in general pitch sets or serial music. There are three primary reasons for this distinction: Firstly, Hangeul characters are formed by combining consonants and vowels. Secondly, the initial consonants and final consonants in the combined word's consonants and vowels have different octaves in pitch sets. Lastly, different consonants and vowels share the same pitch. Consequently, it deviates from the commonly assumed octave equivalence and rule of the modulo 12[12] in set theory.

Additionally, in the Hangeul algorithm, the order in which sets are created by dividing chords or tone groups according to characters is crucial. Enumeration methods in set theory divide sequences based on whether it discerns the high and low pitches between tones, separating ordered pitch intervals over unordered pitch intervals.[13] Moreover, it does not employ standard forms or prime forms, which are simple forms of sets that use pitch classes as elements. Instead, it emphasizes the relationship between initial consonants, medial vowels, and final consonants[14]

[12] Modulo 12 refers to the remainder obtained by dividing by '12' in the context of the 12-tone scale, as values exceeding the octave are unnecessary in the currently commonly used pitch class set. For example: -2 = 10, 13 = 1, 14 = 2... (modulo operation by 12).

[13] Jae-sung Park, in "A study on the historical background and basic principles of set theory," Journal of the Science and Practice of Music, 7(0) (1993), 337, discusses the concept of "ordered pitch interval" as follows: The interval-class set refers to an interval that represents the direction of pitch intervals, specifically the 'interval class of pitch intervals.' The notation involves adding a plus sign (+) or a minus sign (-) in front of the numerical value of the interval. Through interval-class sets, it becomes possible to indicate the 'contour of a melody' and the 'balance of ascending and descending movements.' The mathematical definition is as follows: 'An ordered pitch interval set between two pitch classes 'a' and 'b' is the numerical value of b-a (mod 12): ordered pitch interval (oi) <a,b> = b-a (mod 12).' This citation is a reiteration from John Rahn's *Basic Atonal Theory* (New York: Longman, 1980), 25, and Park Jae-sung's work, re-cited in page 335. This mathematical formula is used in pitch-class sets to represent vertical characteristics of pitch-class sets found in the combinations of the Hangeul algorithm.

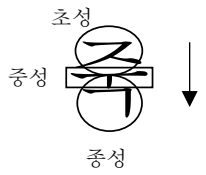
[14] The initial, vowel, and final consonants are distinctions made in the dimension of phonetics to break down characters into individual components. Doo-hyun Paek's paper explains their origin: 'King Sejong recognized syllables as the fundamental unit of realization in the Korean language's phonetic structure, and divided the components of this basic unit into initial consonants, vowels, and final consonants. This is what we call the syllabic triad.' Doo-hyeon Paek, "An Examination of the Stages and Principles of Hunminjeongeum as a Work Process," Han-geul, 301 (2013), 91.

in Hangeul, forming sets based on pitch itself rather than grouping them according to octave equivalence.[15]

The Hangeul algorithm differentiates and assigns pitches based on the initial, medial (vowel), and final consonant of Hangul characters used in *Prelude for Orchestra*, creating harmonies and scales accordingly.[16] It distinguishes between consonants and vowels, forming a separate matrix of pitches, thereby concretizing the algorithm into pitch. This process effectively reflects various aspects of the Hangeul language.

In representing Hangul through the method of pitch-class sets, it adopts a sequential stacking from the initial consonant, vowel, to the final consonant, from top to bottom.[17] Figure 4 explains the order of combinations, descending from top to bottom in the order of initial consonant, vowel, and final consonant.

Figure 4 initial consonant (초성), vowel (중성), final consonant (종성) of Hangeul



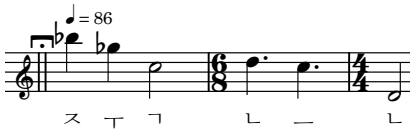
[15] The characteristic of the Hangeul algorithm, where specific pitch classes can be assigned to different consonants and vowels, is also the reason why standard and original forms of set theory are not used in the pitch class set in *Prelude for Orchestra*.
[16] As is well known to all, Hangul does not simply arrange individual letters (such as ㄱㄴㄷ) but combines them according to specific principles to form words and phrases. For example, instead of writing ㄱㅏㅇㅅㅏㄴ, it is written as "강산" (gangsan). Chang-seok Gang, "The Principles of Hangul and Typeface," 22.
[17] Drawing inspiration from the tradition of writing vertically during the Joseon Dynasty when Hangeul was used, the idea emerged to position vowels and final consonants below the initial consonant, based on the convention of writing vertically. This concept was centered around the initial consonant as the starting point.

1.3. Hangeul Matrix Principle and Production

1.3.1. Development Principle of Hangeul-Based Algorithm

The process of creating an algorithm based on consonants and vowels in Prelude was as follows. Naturally, the initial step in the composition process was reading the poem. Through this process, there was an interpretation of what parts of the poem were significant, engaging in dialogue with the poet Yoon Dong-ju and his poetry, while grasping the musical aspects. Yoon Dong-ju stated that the line "죽는 날까지" (Until I die) became the overarching theme of the entire poem.[18] Regarding this passage, the author regarded the word "죽는" (die) spanning from the first to the fourth line of the poem as the most impressive word signifying the intensity of his determination. Therefore, the author created a melody expressing the word "죽는" based on the inspiration from the beginning of the poem, which became the primary foundation for creating the Hangeul matrix (See Score 1). This melody became a significant motive throughout the music and served as a fundamental basis for constructing the Hangeul matrix.

Score 1 Melody of "죽는," Orchestra Abbreviated Score (mm. 3-5)



The poem begins with "죽는 날까지 하늘을 우러러..." (Until I die, I'll gaze at the sky...), and the music starts as presented in Score 1. Using this melody as a basis, one can determine the corresponding sounds (Bb, Gb, C, D, C, D) for the characters (ㅈ, ㅜ, ㄱ, ㄴ, ㅡ, ㄴ) (see Score 1 and Figure 1 for an example of Guido's algorithm).

[18] Joong jae Lee, "Structural analysis of Yun Dong-ju's 'Prelude'," Dongguk of Korean Language and Literature 2 (1987), 92.

The principal melody (Bb, Gb, C, D, C, D) of the music, which is also the theme of *Prelude*, serves as the basis for the corresponding sounds of the characters in Hangeul, each separated by consonants and vowels. For instance, "죽는" is a word that encompasses the initial consonant, the vowel, and the final consonant without exception. By aligning the sounds of the "죽는" melody with Hangeul characters, Bb corresponds to ㅈ, Gb to ㅜ, and C represents ㄱ. This algorithm establishes a correspondence between characters and sounds, where sounds take on the meaning associated with characters, and each character represents a specific sound. The sounds derived from "죽는" become the foundational sounds for constructing the Hangeul algorithm, enabling the determination of pitch for other characters from these sounds.

Therefore, aside from "죽는" in *Prelude,* other parts are composed structurally through a predetermined algorithm that corresponds to the sound system. In the process of composing a melody consisting of six notes for "죽는" from the poem *Prelude,* the five derived notes undergo a series of steps to create a matrix for production.[19]

1) Differentiate and construct separate matrices for consonants (initial and final consonants) and vowels (medial vowels), the constituent elements of Hangeul, in distinct charts.
2) Utilize the five notes obtained from the "죽는" melody as the foundational basic tones for the matrix.
3) Explore rules regarding consonants and vowels based on the relationships among Hangeul characters, derived from the principles of Hangeul's structure and articulation.

[19] In determining the pitch for consonants and vowels based on the six notes, excluding the repeated final D note among the two ㄴ (D sounds), results in obtaining five distinct notes.

4) Determine the pitch for consonants and vowels in the matrices using the tones of the characters from "죽는" as a basis and apply these pitches to the consonant and vowel matrices according to the rules established in 3).

During the process outlined in 3), significant scientific principles based on King Sejong's rule for the creation of Hangul and the method of combining Hangul characters were applied. Regarding the principles behind the creation of Hangul, Chang-seok Gang stated, 'The principles of creation cannot be discussed in just any writing system. It is a concept that is both possible and necessary only in Hangul. This is because the term 'creation principles' does not suitably apply to other writing systems that have evolved from modifications of existing scripts over a long period.'[20] He emphasized that Hangul is the only character that can comprehend and serve the purpose of the creation principles. The principles of creation, observable in exemplary texts that illustrate the process of Hunminjeongeum (훈민정음)[21], became a fundamental principle shaping the Hangul algorithm. The mathematical nature inherent in Hangul's creation principles is inherently linked to the mathematical nature contained within the sound system, filling out the pitch matrix.[22]

1.3.2. Process of Creating the Consonant Matrix

The consonant matrix directly applies the principles of Hangul creation. Hangul establishes consonant characters by adding strokes to basic characters ㄱㄴㅁㅅㅇ based on a criterion of

[20] Chang-seok Gang, "The Principles of Hangul and Typeface," New Korean Life 6 2 (1996), 20.
[21] The book for interpretation about Hunminjeongum which is the old name of Hangeul.
[22] The mathematical aspects can be found in theoretical examples of mathematical ratios discovered by Pythagoras and Boethius. While mathematics may not be overtly apparent in music, aspects such as structure, rhythm, and harmonies often reveal mathematical elements. Similarly, although the mathematical nature of Hangul may not be explicitly evident, it is inherent and analogous to this concept.

sound positions.[23] In Hangul, the definition and principles of basic characters designate soft sounds as the fundamental characters. Doo-hyeon Paek, in his paper, stated, “The basis for determining the basic sound of each sound position is the least intense sound.”[24] This reflects the intensity of sounds in the added strokes of consonants in the creation process, reflected in the font. For strokes associated with relatively intense sounds, the more strokes added, the greater the intensity of the sound compared to the basic character. Consequently, in forming the Hangul algorithm, considerations can be made regarding how to express these characteristics of consonants in terms of pitch. The approach devised by the author involves elevating the pitch with each added stroke from the basic character or utilizing all the pitches from the previous stage.

Different additional strokes to basic characters are categorized into 1st and 2nd level strokes based on the number of strokes. These categorized strokes shape the algorithm differently. When applying the algorithm to characters, the fundamental sounds are the consonants ㄱㄴㅈ (0, 2, 10) obtained from “죽는” (Bolded in Table 2). In the case of the first-level added stroke, if a consonant results from a melodic progression, one adds 1 to the basic character’s pitch or subtracts 1 if the consonant originates from the added stroke. For instance, ㄱ has a confirmed pitch of 0 from the matrix before and ㅋ is the first-level stroke of ㄱ, resulting in a pitch of 1 after adding 1 to the original pitch of 0. In the case of ㅅ, originating from ㅈ with a pitch of 10, subtracting 1 results in a pitch of 9. Following the rules for added strokes, applying the described

[23] Regarding the principle of added strokes, Doo-hyeon Paek stated, ‘In creating Hangul, King Sejong devised another principle after crafting the font for the five basic characters. This principle is known as the added stroke principle, applied to each of the five basic characters. Furthermore, the added strokes were implemented in two stages.’ Doo-hyeon Paek, “An Examination of the Stages and Principles of Hunminjeongeum as a Work Process,” Han-geul, 301 (2013), 102.
[24] Doo-hyeon Paek, “An Examination of the Stages and Principles of Hunminjeongeum as a Work Process,” 101.

rules to the consonant matrix in Table 2, each basic character ㄱㄴㅁㅅㅇ with pitches (0, 2, 7, 9, 4) undergoes adding a semi-tone to each pitch in ㅋㄷㅂㅈㅎ through adding strokes to the basic characters, yielding pitches (1, 3, 8, 10, 6).

Table 2 Consonant (Initial, Final) Matrix

Five sound (오음)[25] / Added stroke (가획)	Molar sound (아음)	Tongue sound (설음)	Lip sound (순음)	Teeth sound (치음)	Throat sound (후음)	Half tongue sound (반설음)
Basic character	ㄱ	ㄴ	ㅁ	ㅅ	ㅇ	
	0	2	7	9	4	
First-step added stroke character	ㅋ	ㄷ	ㅂ	ㅈ		
	1	3	8	10		
Second-step added stroke character		ㅌ	ㅍ	ㅊ	ㅎ	
		2 3	7 8	11	5	
						ㄹ
						6

For the 2nd level stroke characters ㅌ, ㅍ, and ㅊ, "ㅊ" (11) follows the rule of the previous stroke and adds 1 to become the 1st level stroke ㅈ (10). However, ㅌ and ㅍ utilize the pitch of all the preceding characters, forming their pitches differently. ㅌ comprises ㄴ (2) and ㄷ (3), thus becoming ㅌ (2, 3), while ㅍ comprises ㅁ (7) and ㅂ (8), resulting in ㅍ (7, 8). These exceptions found in the pitch assignments of added strokes in the matrix creation process stem from the constraints of fitting 14 consonants into twelve pitches.

[25] A five sound (오음(五音)) literally means five basic sounds that are produced based on the placement of articulation.

Furthermore, the exceptional consonant ㄹ, termed as the “transfer sound” uniquely in Hangul and treated as an exception, has been separately addressed in the matrix. For this particular ㄹ considered exceptional in Hangul, the author assigned it to F# (6), a perfect fourth interval from the 12 C pitches. Additionally, obsolete characters ㆁ and ㅿ, not in contemporary use and absent in poetry, were excluded from the matrix. In the case of double consonants, using two consecutive pitches represents both sounds, with the initial sound indicating the voiced sound, while the following sound reflects the normal pronunciation (refer to the usage of ㅆ in 했 (haet) in Ex. 1).

Consonants of the initial and final positions share the same matrix without distinct matrices. Doo-hyeon Paek stated, The conclusion of the final position methodology is no separate creation of final positions, rather a reapplication of the initial positions. King Sejong stipulated that final positions should be rewritten using the initial positions without creating separate rules for finals.[26] Following the methodology for final positions in Hunminjeongeum, the final position matrix also utilizes the initial position matrix directly.

The pitches derived from the consonant matrix maintain octave equivalence for the initial position (except for finals). Thus, one has the liberty to freely choose the octave for the pitches. The pitch sets forming characters through the Hangul matrix constitute a sequence of pitches for initial, medial, and final positions. The pitches for medial and final positions must always be lower than the preceding pitches, thereby having limited octave equivalence. This characteristic emerges as a result of arranging characters from top to bottom to represent pitch sets.

[26] Doo-hyeon Paek, “An Examination of the Stages and Principles of Hunminjeongeum as a Work Process,” 101.

1.3.3. The Process of Creating a Vowel Matrix

The pitch of vowels was shaped by variable features influenced by the sounds generated during vowel pronunciation. A distinct tone was identified during the consecutive recitation of vowel arrays, focusing on the intonation and articulation of vowels.[27] From the rhythmic characteristics generated by vowel intonation, the author identified potential applications of the pitch within a vowel matrix. Relative high and low pitches were constructed based on the intonation observed while reciting vowels in sequence.

Discussion is necessary concerning how intonation changes depending on the vowels preceding and following a vowel when reciting vowels and considering the order of vowel arrays. Furthermore, there needs to be a discussion on applying pitch matrices to designated basic vowels and how to apply pitch to complex vowels that fall outside this range.

The target of applying the algorithm containing vowel sound rules is the 10 vowels specified in the Hangeul Orthography and Standard Language Regulation's 4th clause ㅏ ㅑ ㅓ ㅕ ㅗ ㅛ ㅜ ㅠ ㅡ ㅣ.[28] The order of these letters originates from the sequence of letters described in the phonetic letters quoted in the Hunmongjahoe, written by the linguist Se-jin Choi.[29] This order differs from the sequence of vowels in the ㆍㅡㅣㅗㅏㅜㅓㅛㅑㅠㅕ sequence, which reflects the principle of creation (a Hangeul traditional principle of ordering

[27] For example, the method of learning Japanese Hiragana, Western alphabets, or reciting the names of the kings from the Joseon Dynasty (such as 태정태세문단세 etc.) is a rhythm similar to reciting the sequence of vowel arrays.

[28] The National Institute of the Korean Language, in the explanation of the Standard Hangeul Orthography in the National Institute of the Korean Language's Interpretation of the Hangeul Orthography Regulations (2018), Chapter 2, Clause 4, referencing the Ministry of Culture, Sports and Tourism Notice No. 2017-12 (March 28, 2017), also explained in Attachment 2, regarding 'Vowels Included in the Dictionary' (ㅐㅒㅔㅖㅘㅙㅚㅝㅞㅟㅢ), for these vowels that are listed in the dictionary, their pitch is determined by combining the pitch of previously established vowels (e.g., ㅐ = ㅏ + ㅣ).

[29] The National Institute of Korean Language explains that the names and order of the letters are derived from Choi Sejin's "Hunmongjahoe" (훈몽자회) from 1587. The National Institute of Korean Language, Standard Hangeul Orthography, 17.

letters).[30] Yun-pyo Hong remarked about this new vowel sequence in the Hunmongjahoe, stating that the four letters ㅏ ㅑ ㅓ ㅕ are characters with wide opening, while the four letters ㅗㅛㅜㅠ are characters with narrow opening. Thus, the arrangement of vowels in modern Hangeul orthography can be interpreted as arranged based on the degree of opening. It was emphasized that the placement of the basic characters ㅡ ㅣ ㆍ at the end considers the sound-producing dimension more than the principle of creation. Therefore, the arrangement of vowel arrays that focuses on the actual sound produced by considering how these sounds occur became a principle in creating the vowel matrix algorithm. In particular, it was created by paying attention to the unique characteristics of individual intonations when reciting the sequence of vowel arrays.

Intonation when reciting vowel arrays differs from person to person, and there are no universal rules. The intonation used when reading vowel arrays is used indiscriminately based on individual and regional dialects. To apply these individual intonations to the algorithm, the author's specific intonation is identified. The author, a composer, distinguishes the intonation of uttering vowels in relative highs (H) and lows (L) rather than accurate pitches. In Table 3, the highs (H) and lows (L) of the intonation revealed during the act of reciting vowel arrays are analyzed and presented in tabular form.

Table 3 Intonation of the Composer's Vowels

H	●		●		●		●		●	
L		●		●		●		●		●
Vowels	ㅏ	ㅑ	ㅓ	ㅕ	ㅗ	ㅛ	ㅜ	ㅠ	ㅡ	ㅣ

[30] Refer to Wan Chae, "Hunmongjahoe and Korean Orthography," published in New Korean Life 9 (3) (1999), 25, for information regarding the alphabetical order of Hunminjeongeum characters.

The author's pronunciation of the vowel array exhibits a characteristic of alternating high and low pitches, as observed in Table 3. The 10 vowels ㅏ ㅑ ㅓ ㅕ ㅗ ㅛ ㅜ ㅠ ㅡ ㅣ are directly assigned numbers 1 to 10. The method of reading based on pairs related in the array (e.g., ㅏ ㅑ ㅓ ㅕ …) involves reversing the order from high to low in the vowel matrix, placing the higher number first (e.g., ㅏ = 2, ㅑ = 1). The numbers 1 to 10 are then directly assigned to the vowels in sequence.[31] By incorporating the author's high-low intonation into the vowels, the sequence becomes not 1 2 3 4 5 6 7 8 9 10, but a sequence where high and low pitches alternate: 2 1 4 3 6 5 8 7 10 9. In this context, the numbers obtained through this characteristic algorithm ultimately serve as variables influencing the intonation of vowels rather than pitch. This variable, denoted as ‘a,’ combines with the pitch of the initial consonant, contributing to determining the vowel's intonation. If we denote this variable as ‘a,’ the following equation can be derived.

The pitch of vowels = the pitch of the initial consonant + variable ‘a’

The reason for setting the pitch of vowels as a variable rather than directly determining it from the vowel matrix is a result that reflects the inherent characteristics of Hangeul vowels. For instance, vowels are not used in isolation but are combined with initial consonants. For example, ㅏ changes its sound to either 나 or 라 depending on the accompanying initial consonant ㄴ or ㄹ. This reflects the dependent and relative nature of vowels. Thus, the pitch of the same ㅏ used in 나 and 라 differs for each. If ㅏ is denoted as variable ‘a,’ then 나 becomes (2, (2+a)) and 라 becomes (6, (6+a)), causing the pitch of the vowel to vary relative to the pitch of the initial

[31] The reason the numbers corresponding to the vowels start from 1 instead of 0 is due to the word “죽는”, where ㅜ and ㅡ were fixed with pitches 8 and 10, making it easier to discover regularity in the intonation patterns.

consonant. To aid in understanding this variable ‘a’ with its variable characteristics, a ‘+ symbol’ is placed in front of ‘a.’

The specific method to obtain variable ‘a’ in the vowel matrix is as follows. Firstly, similar to the consonant matrix, ㅜ (8) and ㅡ (10) are initially determined by the melody inspired by the word “죽는.”[32] Secondly, assigning numbers 1 to 10 to the 10 vowels reflects the rising and falling patterns observed by the composer while reciting the basic sequence of 10 vowels covered in the Hangeul orthography (2 1 4 3 6 5 8 7 10 9).[33]

The vowel matrix, like the set theory, is represented using numbers from 0 to 11 as 12 pitches. By assigning the 10 vowels and placing the remaining 11 and 0 as ‘,’ (comma) and ‘.’ (period), respectively. The vowel matrix includes punctuation marks, where the comma and period are placed as pitches themselves rather than variables (see Table 4). The comma is used in the second line of “부끄럼이 없기를” (May there be no shame), while the period, represented by the pitch C in the final measure 314, signifies the period in the phrase “괴로워했다.” (suffered). It appears as the incomplete word “주느” (Bb, Gb, D, C) to create an effect similar to an unfinished word, resembling the song’s main motif “죽는” (Bb, Gb, C, D, C, D) where the final syllable remains incomplete. The pitch C(0) representing the period is assigned as 0 to align with the final pitch of “주느.”

[32] ㅜ and ㅡ, similar to the consonant matrix, have been highlighted in bold in Table 4.

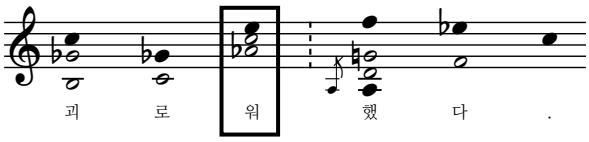
[33] In this case, the predetermined pitches 8 and 10 from the melody of 죽는 were taken into comprehensive consideration to create the algorithm.

Table 4 Vowel (Medial) Matrix

vowel	ㅏ	ㅑ	ㅓ	ㅕ	ㅗ	ㅛ
variable a	+ 2	+ 1	+ 4	+ 3	+ 6	+ 5
vowel	ㅜ	ㅠ	ㅡ	ㅣ	,	.
variable a	+ 8	+ 7	+ 10	+ 9	11	0

In the case of compound vowels created by combining basic vowels such as 과 and 궈 outside of the 10 basic vowels in Table 4, the pitch of the synthesized vowel is expressed using both constituent vowel pitches. For instance, in Ex. 1, the compound vowel '워' (wo) consists of the final consonant ㅇ and the combination of ㅜ and ㅓ, resulting in ㅇ (4) + ㅜ (8), ㅇ + ㅓ (4), hence (4, 12 (4+8), 8 (4+4))[34]. This represents the pitch of the vowels successively according to the combination order in Hangeul, forming the pitch set.

Ex.1 Harmony of "괴로워했다" (I pained)

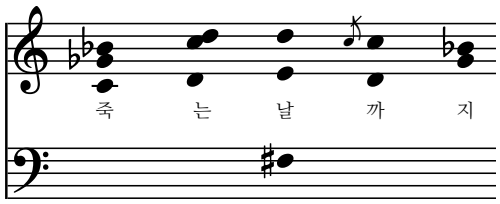


The derived pitches of the vowels should maintain octave equivalence, but they must necessarily be lower in pitch than the initial consonant. For example, in the case of 로 (ro), if the pitch of the initial consonant G is set to 7, the pitch combinations could be (7, 0), (7, -12), and so

[34] The pitch set (4, 12, 8) is a form that doesn't adhere to the rules of the subsequent vertical combination described. According to the rules mentioned later, the pitch set should be (4, 0, -4), not (4, 12, 8).

on. However, (7, 12) cannot be considered based on the basic rule. This is because when the hierarchical order between initial consonants, vowels, and final consonants is applied to the pitches in characters, the pitches follow a vertical sequence.[35] Therefore, unlike typical harmony, which distinguishes between higher and lower notes in chords, a method that distinguishes between strokes in individual characters and constructs harmony is adopted. An example of harmony for "죽는 날까지" (until I die) applied using this method is illustrated in Ex. 2.

Ex. 2 Harmony of "죽는 날까지" (until I die)



The pitch sequence for 날 (nal) is (2, 4, 6) in standard form, but when considered from top to bottom, following the order of D (ㄴ (2)), E (ㅏ (-8=2+2-12)), F# (ㄹ (-18=6-24)), it becomes (2, -8, -18), aligning with the order of combination in Hangul (refer to Ex. 2 날 harmony). Let's elaborate on the process of obtaining the pitch sequence (2, -8, -18).

As previously mentioned, the pitch of the initial consonant in the pitch sequence representing Hangul characters can be used in any octave due to octave equivalence (ㄴ = 2, 14, -10…). However, for medial vowels, they must always remain lower in pitch than the initial consonant.

[35] The reason vertical combinations are discussed first is due to the derivation of pitches from the complex rules of Hangul. Western music has evolved from monophonic to polyphonic and harmonic structures, transitioning from a horizontal form like monophony to a vertical structure like harmony. Therefore, explanations about music also progress from simpler organizations to more intricate ones. However, the compositional method used in *Prelude for Orchestra* attempts to transform something other than music into music. Due to the nature of Hangul, the discussion primarily focuses on vertical harmony first, and horizontal effects are addressed subsequently.

Similarly, the pitch of the final consonant is also lower in pitch than the vowel. Therefore, 날 can be analyzed as the set (2, -8, -18) while applying the sequential hierarchy between individual characters. If we assign a pitch of 2 to ㄴ, then the pitch for ㅏ was -8 in the previous set, but it could also be -20 or -32, corresponding to octaves lower than the original. This demonstrates that vowels operate within the octave equivalence but remain lower in pitch than the initial consonant. However, choosing pitches like -20 or -32 would result in the pitch for ㄹ being lower than ㅏ in 날, further limiting the available pitches. Therefore, the set with the least intervals is primarily used as the default pitch sequence.

In the orchestration process of *Prelude for Orchestra*, these vertical relational rules are applied variably across different instrument groups in various pitch ranges. For instance, the same pitch sequence derived from a specific character can be used with different octaves in different instrument groups such as woodwinds and strings. Specifically, the pitch sequence (2, -8, -18) could be used in the woodwinds section while (14, 4, -18) might be used in the string section.

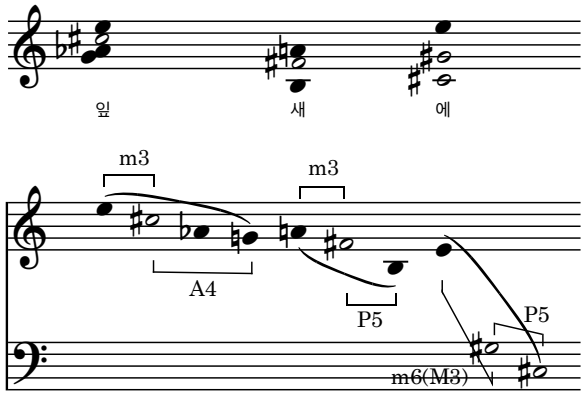
Furthermore, during the compositional process, exceptions might occur where the rules of vertical pitch sequences are altered or deviate based on the musical context. The less flexible pitches of vowels and final consonants might be freely manipulated within the octave or presented diversely in terms of displacement and modulation. The principles and specific rules of Hangul matrix technique may vary based on the composer's musical usage, and the Hangul matrix is employed in various compositional manners by different composers.

1.4. Diverse Applications of Hangul Matrix Technique

1.4.1. Utilization of Vertical Chord Progressions in Horizontal Melodic Sequences

In *Prelude for Orchestra*, the musical representation of characters resonates as chords without simultaneous usage but primarily unfolds horizontally. This approach aligns closely with how characters in Hangul are pronounced in actuality. For instance, considering the character 날 (nal), when read or pronounced, if one elongates the time, it would be heard in the order of ㄴ ㅏ ㄹ (n-a-l), indicating the potential for a vertically constructed word to unfold horizontally. Hence, the obtained pitch sets are not only used harmonically but are actively employed melodically in a horizontal manner.[36] Ex. 3 demonstrates the vertical descending composition of chords for "잎새에" (ipse-e) and its representation in horizontal melody.

Ex.3 Horizontal Melody of Vertical Chord Progressions in "잎새에" (on a leaf)[37]

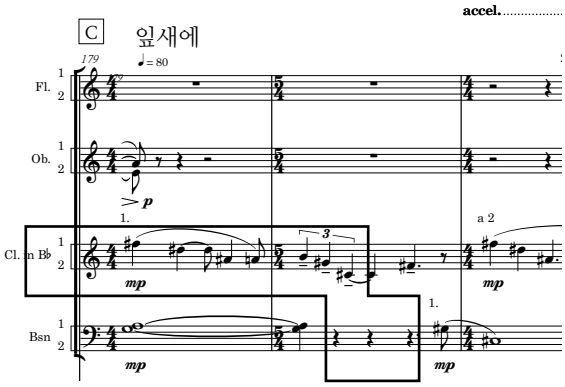


[36] This characteristic bears similarities to the temporal expansion observed when translating the first four lines of *Prelude for Orchestra* into musical form. Even though initially composing only the first four lines, the temporal phase extends to approximately ten minutes, akin to the temporal expansion experienced when this text is translated into music.

[37] To distinguish between vowels and consonants in analysis, if necessary, the pitch of vowels is represented in the form of whole notes.

The pitches obtained from the harmonies in Ex. 4 are exemplified in the horizontal usage as a melody in the clarinet and bassoon depicted in Score 2.

Score 2 Melody of "잎새에", Woodwind Section (mm. 179-181)

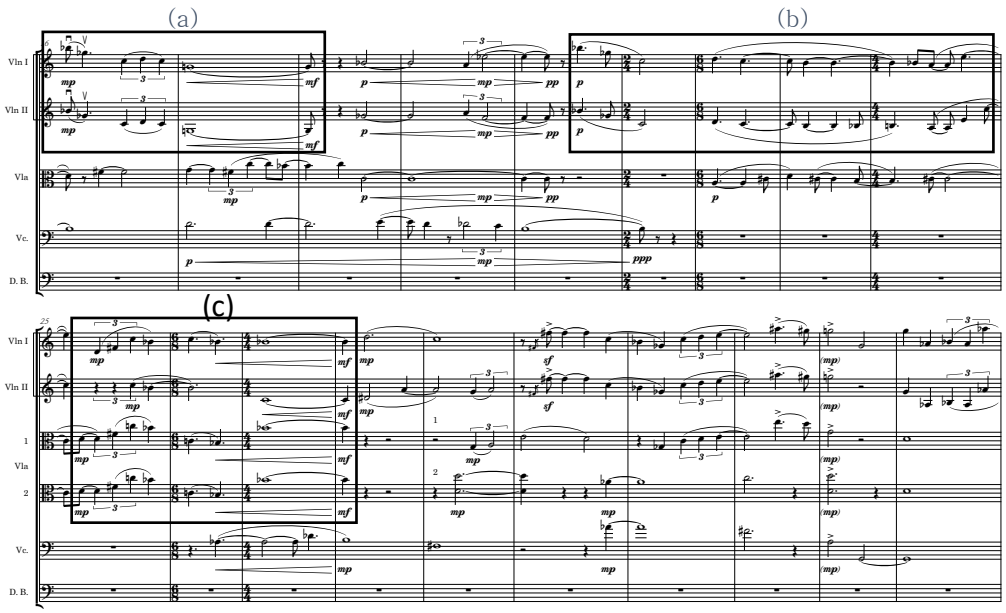


The horizontal use of pitch sets extracted from characters mirrors the method of the tone row technique developed by Arnold Schönberg (1874-1951), wherein each pitch is employed once in a horizontal manner to create characters in Hangul and form words. Similar to the requirement of using each pitch once in a tone row in Schoenberg's serial technique, the principle in the Hangul matrix involves employing pitches corresponding to words or phrases just once, akin to the use of pitches in a tone row. Schönberg, deviating from complete rigidity, also treated repeated pitches as a single use or allowed exceptions to complete the tone row. Similarly, the Hangul matrix composition technique may occasionally involve exceptions under the composer's musical discretion, deviating from the aforementioned rules.

1.4.2. Repetition and Variation in Hangul Matrix Composition Technique

Pitch sets derived from the Hangul matrix are horizontally expanded and employed as the primary melodies in the composition. Within this framework, elements of repetition and variation, pivotal in translating poetry into musical form, are actively incorporated. When textual elements transformed into the language of music are used, they are utilized under rules similar to our use of language, where we freely employ grammar rules and conventions. The derived pitch sets, distinct from linguistic elements and emphasized within the realm of music, are expressed using techniques such as repetition and variation, characteristic of music. Sets of pitches representing words are reiterated multiple times, manifesting as melodies and harmonies, and undergo transformations like transposition and inversion, resulting in various musical renditions. Additionally, these musical renditions possess the potential for diverse variations, such as changing the final notes of the employed melodies, enabling an abstract transformation of the originally derived pitches from Hangul. The notation in Score 3 provides a specific example illustrating three repetitions and variations of the melody derived from the content of "죽는," showcasing the potential for diverse musical variations.

Score 3 The Variations of the Melody "죽는 날까지," String Section (mm. 16-34)



The three melodies derived from "죽는" in Score 3 are all presented in various variations. In (a), although "죽는" should end with the note 'D' (2), it changes to 'G' (7), altering the final consonant of the syllable. Consequently, this results in a word form "죽늠," which does not exist in standard Korean dictionaries. However, similar to how a change in the final consonant or vowel in language does not significantly affect the overall meaning compared to altering other parts of speech, changing the note in the music does not create much dissonance or meaning shift compared to changing other notes. In (b), while the final note should be 'D,' it shifts to 'B,' changing the Hangeul translation to "죽늦." The 'B' note descends chromatically to the 'A' note at Measure 24, resembling the declination of pitch observed in speech, creating an impression similar to the tonal shift in human speech. This musical descent and free variation at the end of the thematic melody derived from *Prelude for Orchestra*'s words are akin to Thrasybulos Georgiades's understanding of Melisma. In his book *Music and Language*, he stated that

"Melisma implies not the 'musical realization of language' (musikalische Sprachverwirklichung) but aims for 'independent musical performance' (eigenständiges Musizieren)."[38] Similarly, throughout *Prelude for Orchestra*, the melodies representing words expand and develop beyond the algorithm's rules through the crucial musical features of repetition and variation. Lastly, (c) is a variation in the interval relation of the "죽는" melody.

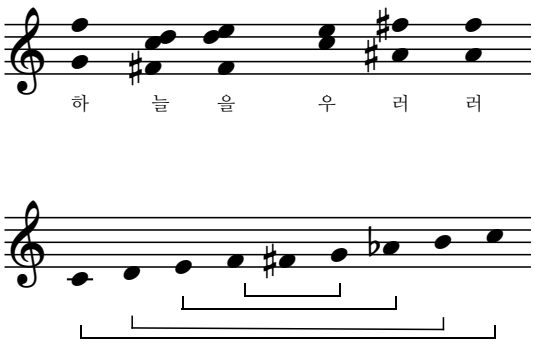
1.4.3. The Scale-Based Use of the Hangul Matrix Composition Method

The set of tones (or harmonies) not only follows the sequence of notes in a melody but is also utilized in a specific scale, producing a unique intervallic combination and scale within the words. As Hangeul characters are formed through combinations, resulting in sets of tones representing letters, words, or sentences, these sets of tones can be utilized in another scale or harmonically.

Ex. 4 demonstrates the use of tones from "하늘을 우러러" (Looking up at the sky), arranged in a scale starting from C. This sentence contains a total of four ㄹ (6), emphasized in the poem and highlighted as F# (6) in *Prelude for Orchestra* according to the Hangeul algorithm. Furthermore, a symmetrical characteristic in terms of intervallic relationships around the scale's center is observed. This approach involves not just deriving a melody from the matrix but also understanding the intervallic relationships and characteristics of the derived notes to use them in a scale. It aligns with the attempt to interpret and express Yun Dong-ju's emphasis on ㄹ, a semi-vowel sound, as a counter melody in a musical fashion through the Hangeul algorithm.

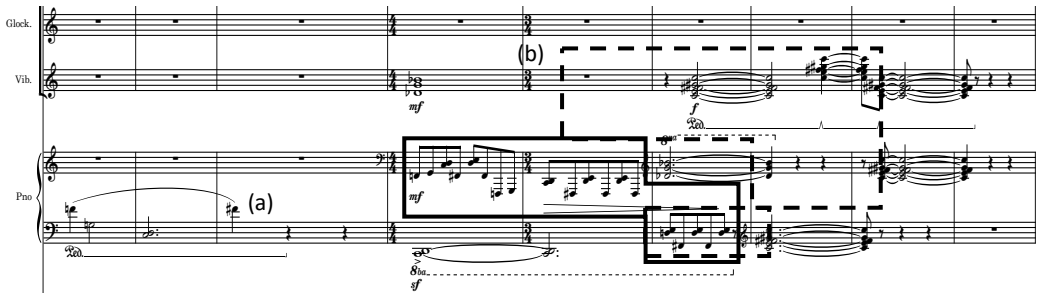
[38] Georgiades, Thrasybulos G. *Music and Language* (Musik und Sprache: Das Werden der Abendländischen Musik Dargestellt an der Vertonung der Messe), translated by Chosunwoo and Kwon O-yeon (Seoul: Sejong, 2000), 41.

Ex. 4 Scale of “하늘을 우러러”



When implementing the pronunciation from the algorithm’s matrix in the order of initial consonants to final consonants, it is used horizontally in terms of melody in the foreground and predominantly used in the middle range or the upper range for the usage of the set of tones obtained from the algorithm. The example in <Score 4> shows that in (a), the pitches derived from “하늘을 우러러” are used horizontally and function as the foreground, while simultaneously in (b), the symmetrical characteristics of the scale from “하늘을 우러러” are applied to harmonies, serving as the background.

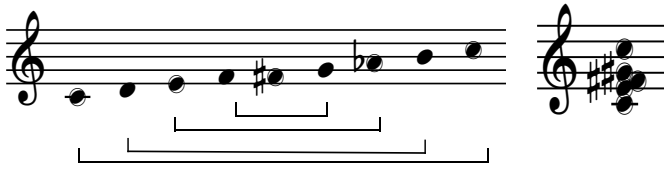
Score 4 Using Foreground and Background of “하늘을 우러러” (mm 158-166)



Ex. 5 displays the pitches used in “하늘을 우러러” in a scale, revealing a symmetrical scale centered around the F# note. This symmetrical scale is constructed using the notes C, E, F#, and

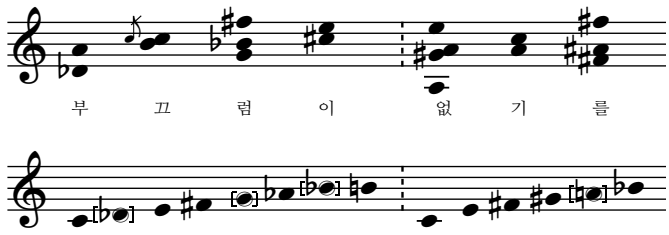
Ab derived from the scale, and these notes have been utilized in composition by creating chords (notated by circles on the notes).

Ex.5 Use of a Symmetrical Scale in “하늘을 우러러”



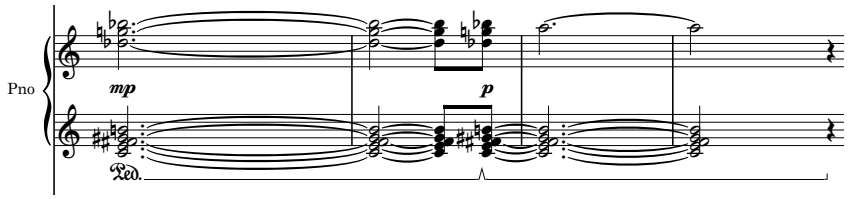
Another example of scale usage involves leveraging the relational characteristics of each phrase’s scale. In the second line of the poem, “부끄럼이 없기를” (may there be no shame), dividing it into “부끄럼이” (shame) and “없기를” (may there be no), examining their scales reveals both shared notes (C, E, F#, Ab, B) and distinct, specific notes (Db, G, Bb, and A, denoted within [ ] in Ex. 6). “부끄럼이” (shame) and “없기를” (may there be no) each possess distinct characteristics with Db, G, Bb, and A notes respectively.

Ex.6 Scale of “부끄럼이 없기를” (no shame)



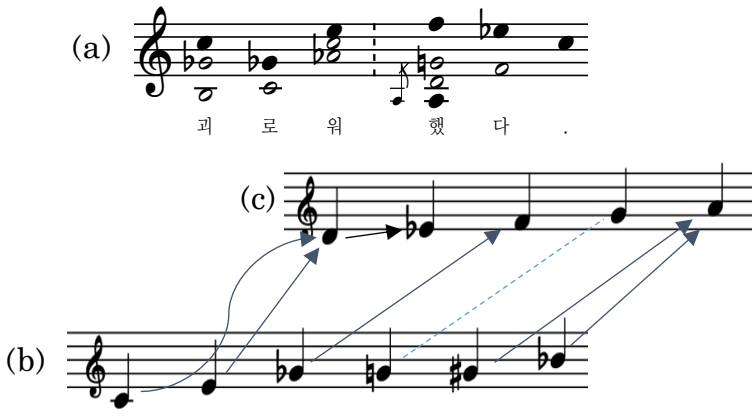
Those characteristics are specifically demonstrated in Score 5 on the piano. It illustrates playing the unique notes of each scale while maintaining the shared notes of the two scales in the left hand. Specifically, the progression of notes in the right hand moves from Db, G, Bb to the A note.

Score 1 “부끄럼이 없기를” Piano Section (mm. 139-142)



The final example demonstrates creating directionalities between scales derived from the produced scale. Ex. 7 portrays the chords (a) appearing in the last phrase of the fourth line, “괴로워했다.” and the subsequent notes generated from the scales ((b), (c)). The author sought to develop directionalities by dissecting the combined “괴로워했다” into “괴로워” and “-했다” to sequentially analyze “괴로워 -> 했다”.

Ex. 7 Directionality of the Pitch Set and Scale of “괴로워했다”

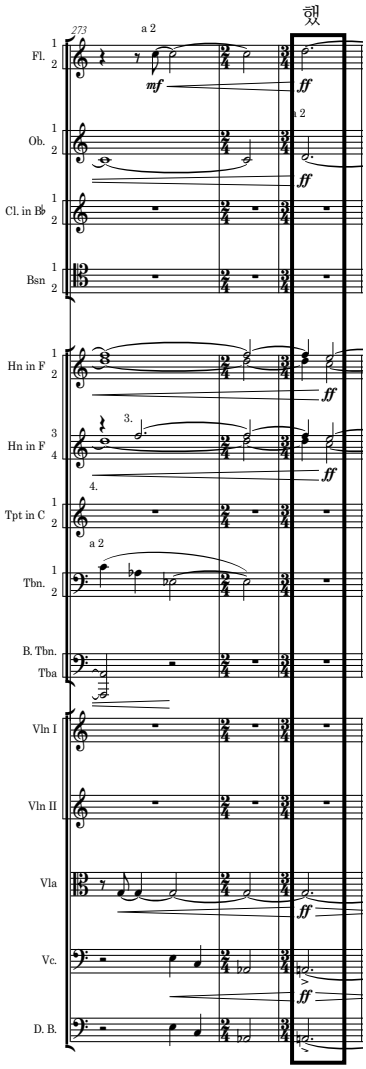


(b) sequentially presents the notes from the word "괴로워" starting from the C note (0, 4, 6, 7, 8, 10), while (c) displays the notes from "했다," starting from a close D note to C (2, 3, 5, 7, 9).[39] As depicted by the arrows in Ex. 7, the notes from "괴로워" transition to the neighboring notes of "했다." C and E move towards D, Gb to F, G# to A, and Bb to A. Additionally, a directional change occurs in "했다." Although "다" consists of F and Eb, because "했" already includes F, the D note from "했" transitions again to Eb note, representing this shift musically.

In *Prelude for Orchestra*, when applying such directional scales in composition, the initial notes from "괴로워" are represented in the form of a pedal tone, gradually transitioning towards the nearby notes of "했다" (Score 6, illustrates the merger of the notes from "괴로워" into "했" in measure 275). The reason for using a pedal tone is to express the persistence of "괴로워", as the constituent notes (b) continuously extend into the pedal tone, eventually reaching the composing notes of "했," which are F, G, D, and A.[40]

[39] To make the movement of notes easier to understand, I organized a standard scale starting from the notes closer to C on the staff.
[40] Embellishment notes are represented in lowercase letters.

Score 6, “괴로워->했,” Wind and String Section (mm. 273-275)



In this chapter, we discussed the non-deterministic algorithmic approach of the Hangeul Matrix and constructing the sound matrix through the algorithm. We explored the scientific aspect of the algorithm's formation, the sound aspects generated when speaking Korean, various sound and tonal relationships derived from it, and specific use cases in scales. We delved into the overall principles and creative processes behind the Hangeul algorithm.

The rules that constitute the order of Hangeul or the arrangement of characters (writing sounds in a vertical order from top to bottom) are transformed due to various musical ideas. In many segments, the sounds composing words are used as harmonies or melodies, forming scales from obtained sounds, not adhering to the traditional order rules but employing them freely in diverse forms. Therefore, the set of sounds derived from the indeterminate matrix is reutilized indeterminately once again, based on the composer's choices. The compositional technique of the Hangeul algorithm restricts sounds or scales from specific words through the algorithm, achieving musical consistency through the text of the poem and providing further compositional ideas.

In the following second chapter, we will examine the characteristics of *Prelude for Orchestra* in which the Hangeul algorithmic composition technique is applied, analyzing the compositional technique using various features of *Prelude for Orchestra* written as a poem and relating them to the Hangeul algorithm. Through this, we aim to explore the musical achievements arising from the use of the Hangeul Matrix composition technique and delve into the relationship between music and language.

(This excerpt concludes Section 1.

Subsequent sections are not included in this document but are part of the full thesis.)