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A Transformational Approach to Gesture in Shō Performance [*]

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ABSTRACT: Through an analysis of contemporary shō performance practice, this article explores the relationship between instrumental gesture and modal theory in contemporary gagaku. I demonstrate that the idiosyncratic arrangement of the pipes on the shō is closely related to the pitch structure and tonal function of the *aitake* pitch clusters.

My analysis synthesizes two approaches. First, I adopt David Lewin's (1987) transformational attitude to conceptualize the *aitake* not as static musical objects but as processes of motion enacted by the *te-utsuri*—standardized fingering movements for shifting between two *aitake*. Second, I treat the *aitake* as sonic byproducts of a performer's instrumental gestures to examine how the *aitake* are related to one another kinesthetically, and whether these relationships correlate with the pitch structures of the *aitake*.

I argue that relatedness between *aitake* is determined by the parsimony of *te-utsuri*. The most parsimonious movements can be enacted between four *aitake*: *bō*, *kotsu*, *ichi* and *otsu*. These *aitake* are identical to the clusters that accompany the fundamental tones of five of the six modes: *Ichikotsu-chō*, *Hyōjō*, *Taishiki-chō*, *Oshiki-chō* and *Banshiki-chō*. These findings demonstrate that the pipes of the shō, while seemingly arranged in no discernable order, prioritize parsimonious *te-utsuri* between each of the *aitake* accompanying the fundamental modal degrees. An analysis of the pitch structure of *aitake* through the lens of *te-utsuri* reveals a striking correlation between gestural parsimony and tonal function.

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[1.1] Post-war scholars have challenged the conceptualization of *gagaku* (雅楽) as a musical practice that has been largely unchanged since its importation into Japan in the eighth century, engaging in comparative analyses of historical and contemporary melodies in tōgaku (唐楽)—a genre of *gagaku* (雅楽) court music that originated in Tang China.[(1)] Through studies of historical notation, initial research undertaken by Hayashi Kenzō and Laurence Picken's Tang Music Project in the mid-twentieth century has identified a disjuncture between modern *tōgaku* and its predecessors (Hayashi 1969; Picken et al. 1981, 1985, 1986, 1987, 1990, 1997, 2000).[(2)] Building upon their work, more recent studies have sought to reconstruct and decipher scores from the Heian period (794–1185) (Endō 2005; Nelson 1986, 1988; Ng 2017; Terauchi 1996), trace the historical modification of *tōgaku* melodies (Endō 2004; Marett 1985, 1986; Ng 2011; Terauchi 1993; Tsukahara 2009), and examine similarities and inconsistencies between contemporary Japanese practice and Chinese theories of mode (Gamō 1970; Hayashi 1954; Masumoto 1968; Ng 2007; Ono 2016; Terauchi 2011).

[1.2] While this monumental body of research has been invaluable for tracing the historical development of *tōgaku* and dismantling the characterization of gagaku as a timeless tradition carefully preserved over centuries, few existing studies have examined the relationship between modal theory and performance practice in contemporary *tōgaku*, a concern that has been raised by Robert Garfias (1975) and Terauchi Naoko (2007). In particular, Garfias has suggested that the *aitake* (合竹)—five- and six-note pitch clusters played by the shō (笙) in *tōgaku* repertoire—can illuminate our understanding of how performance practice and theory interact with one another. *Aitake* is produced by covering five or six of the shō's seventeen pipes, and sound can be generated by either inhaling or exhaling into the mouthpiece. For Garfias, the *aitake* is essential for understanding the principles of modality in gagaku:

> Ordinarily, discussions of theory in the traditional sources in Chinese and Japanese limit themselves to the consideration of scale and modal structures. These subjects have provided fodder for the theorists for hundreds of years and have enabled them to ensconce themselves in the complexities of theory while comfortably avoiding the problems of defining practice. One of these neglected aspects of practice, the harmonic structure executed by the mouth organ, shō, provides a convenient link between theory and practice. (1975, 63)

Using Garfias's hypothesis as a starting point, this article explores the relationship between the performer's *instrumental gestures*—physical movements necessary for generating sound from an instrument (Montague 2012)—and modal theories of *tōgaku*. Through an analysis of *te-utsuri* (手移り), the standardized ordering of fingerings to move from one *aitake* to another, I demonstrate that the idiosyncratic arrangement of the pipes on the shō is closely related to the pitch structure and function of the *aitake*.

[1.3] This article, inspired in part by my experience as a member of the Columbia University Gagaku Ensemble, synthesizes two approaches.[(3)] First, I adopt David Lewin's (1987) transformational attitude to conceptualize the *aitake* not as static musical objects but as processes of motion enacted by the *te-utsuri*. Transformational theory offers a particularly fruitful framework for theorizing the role of *te-utsuri* in connecting each of the *aitake*. I draw upon Lewin's oft-cited question "I am at s; what characteristic transformation do I perform in order to arrive at t?" (xxxi) to conceptualize *te-utsuri* as an operator of musical transformation, focusing on the process of *change* between the *aitake* rather than the *distance* between them. A transformational perspective therefore situates performers "inside the music," in the words of Lewin (159). Rather than *observing* the distance between two static musical objects, a performer *experiences* the motion from one hand position to another when acting out the *te-utsuri* movements to arrive at the new *aitake.* As such, transformational theory offers an ideal methodology for demonstrating how pitch structures and bodily gestures are intertwined in contemporary shō performance.

[1.4] Second, by treating the *aitake* as sonic byproducts of a performer's instrumental gestures, my analysis examines how each of the *aitake* is related to the others kinesthetically, and the ways in which these physical relationships correlate with the pitch structures of *aitake*. A transformational analysis of *te-utsuri* quantifies the motion between *aitake* in two ways: 1) the number of finger holes a performer must traverse to get from one *aitake* to another; and 2) the number of fingers that are in motion. The first part of the article argues that relatedness between different *aitake* is determined by the gestural proximity of *te-utsuri*—as opposed to that of voice leading in pitch space.[(4)] This framework is consistent with gagaku performance practice: shō players refer to each tone of the *aitake* by the name of its pipe, rather than by the name of its sounding pitch.[(5)] In the second part of the article, I demonstrate that patterns of *te-utsuri* can help illuminate Garfias's (1975) criteria for "consonance" and "dissonance" in gagaku. By analyzing kinesthetic relationships between *aitake*, I draw attention to the correlation between gestural proximity of *te-utsuri* and underlying tonal functions of *aitake*.

The Shō: An Overview

[2.1] Descending from the Chinese *sheng* (also written as 笙) and introduced to Japan from Tang China between the seventh and eighth centuries, the shō is a free-reed mouth organ comprised of seventeen bamboo pipes, each made from tubes of equal thickness but with different lengths (Miki 2008, 64).[(6)] As shown in **Example 1**, the seventeen pipes are attached to a wind chamber at the bottom and laid out in a circular fashion. Sound is produced by covering the finger holes above the reed and inhaling or exhaling into the mouthpiece, a mechanism similar to that of a Western harmonica (**Video Example 1**).[(7)]

[2.2] Each pipe of the shō is assigned a different pitch with the exception of two muted pipes, *ya* (也) and *mō* (毛), as shown in **Examples 2a** and **2b**.[(8)] There are specific ergonomically designed rules for fingerings, and the performer must be aware of which fingers should cover which holes. The *kotsu* (乞) pipe, for example, should only be covered by the left-hand ring finger. There are ten *aitake* in total, with eight six-pitch *aitake* and two five-pitch *aitake* (**Example 3**). Each *aitake* contains a fundamental tone, as indicated by the black noteheads in Example 3. Usually the lowest note of the *aitake*, the fundamental tone determines the name of each *aitake* and functions as a melodic cue for the *hichiriki* (篳篥; double-reed flute) and *ryūteki* (龍笛; transverse flute) during the shō's process of *te-utsuri*.

[2.3] In order to perform the shō at a high level, the performer must perfect the timing of the *te-utsuri*—the ordering and timing in which the fingers shift between holes to move from one *aitake* to another—and *kigae* (気替)—the changing of breath. As replicated in Western notation in **Example 4**, *te-utsuri* and *kigae* work in tandem to execute controlled dynamics, smooth out the melody, and create continuity between *aitake* (Masumoto 1968, 22). Each *aitake*, which typically lasts four beats, begins quietly and gradually crescendos into the fourth beat, followed by the *te-utsuri* motions that transition the fingerings into those of the new *aitake*. In **Video Example 2**, I demonstrate *te-utsuri* from *aitake kotsu* to *aitake ichi*. The left side of the screen captures movements in the left hand, whereas the right side of the screen displays the right hand. The diagram in the center of the video gives a bird's-eye view of the wind chamber, showing all seventeen pipes. The yellow circles indicate the covered finger holes. As I execute the *te-utsuri* to move from one *aitake* to another, the yellow circles also shift to track the fingering movements involved in the process.

[2.4] Whereas *te-utsuri* is completed between the fourth and first beats, *kigae* occurs on the arrival of the first beat.[(9)] In some cases, the *te-utsuri* occurs over two phases (**Example 5**): the first step immediately before the changing of the *aitake* (i.e., between the fourth and first beats) and the second step one or two beats after the new *aitake* has taken over, a technique called *ato-uchi* (後打ち; literally meaning "hitting after"). *Ato-uchi* usually occurs when the *te-utsuri* involves the shifting of three or more fingers. The *te-utsuri* not only functions as a systematized performance technique, but also as an aesthetic process that dictates the timbre and dynamics for playing the shō.

Analyzing Instrumental Gesture in Shō Performance

[3.1] Given the diverse contexts in which the term "gesture" has been used by music theorists, I will first specify the type of gesture to which I refer in my analysis. Jane Davidson (2005, 218), along with Manfred Nusseck and Marcelo Wanderley (2009, 335), classify gestures into 1) biomechanical movements that are necessary for producing sound from an instrument; and 2) movements used for expressive effect.[(10)] My analysis focuses primarily on gestures that function as a form of physical movement necessary for performance, referred to by Claude Cadoz as "instrumental gestures" (1988).[(11)] I analyze contemporary shō performance practice through the lens of instrumental gesture for two reasons. First, gagaku musicians are discouraged from drawing attention to themselves in performance, a hallmark of aesthetics in a variety of traditional Japanese performing arts. Gagaku performances, according to Alison McQueen Tokita and David W. Hughes (2008, 25), are characterized by a "lack of strong expressiveness" and an "excessively severe or solemn attitude," which diminishes the possibility of overtly expressive gestures on the part of the performer.[(12)] Second, instrumental gestures for shō performance are tightly controlled through the rules of *te-utsuri*: unlike fingerings on the piano or violin, *te-utsuri* does not allow for any flexibility or individual discretion; a performer must follow the exact fingering procedures dictated by the *te-utsuri* when moving between *aitake*.

[3.2] My aim is to model the instrumental gestures of shō performance as transformational operations and explore the ways in which the kinesthetic relationships between *aitake* correspond with pitch relationships. My primary objective in drawing upon Lewinian transformational theory is to theorize the principles of *te-utsuri*—a core technique of shō performance in *tōgaku*—through the perspective of a contemporary shō player. By providing a theoretical grounding for investigating a performer's musical actions, the transformational attitude effectively foregrounds the performer's experience in navigating *te-utsuri* gestures in instrumental space. When learning *te-utsuri*, shō players must first memorize the required fingering movements (i.e., the number of finger holes traversed by each finger) and then build embodied knowledge of the physical distance between holes, since the performer is unable to see the finger holes for themselves when performing. In my own experience of learning *te-utsuri*, I often found myself thinking ahead to the upcoming *aitake* and asking the following questions: Which fingers do I need to move and where do they need to go? How far do the fingers need to move in order to reach the finger hole of the next *aitake*? Transformational theory provides a method for quantifying degrees of kinesthetic labor needed to move from one *aitake* to another. By situating the analyst as an active performer and thinking through *te-utsuri* as the performer's motion through an instrumental space, transformational theory presents an amenable mechanism for addressing such inquiries. While issues of historical organology are certainly essential in examining the relationship between the arrangement of the pipes, gestural proximity of *te-utsuri*, and tonal construction of *aitake*, my analysis is conducted from the perspective of a contemporary performer. My aim is to model the experience of a twenty-first century shō player through a transformational model, rather than to speculate whether the construction of *aitake* was informed by the arrangement of the pipes.[(13)] By focusing on contemporary performance practice, I seek to challenge the narrative of gagaku as a "preserved fossilized remnant of the Heian period" and instead elucidate "how *gagaku* exists at present" (Harrison 2017, 22–24).

[3.3] In this article, I deliberately use Western pitch names to make the concepts of gagaku theory more accessible to a general readership. Because I do not assume any background in the Japanese language or knowledge of gagaku notation, pitches and *aitake* will be transcribed into Western notation as necessary. While the gagaku tone system is not entirely commensurate with that of Western music—the pitch A4 is tuned to 430hz on the shō, and pitches in the gagaku system are generated by stacking successive fifths—Western notation nevertheless offers an acceptable approximation for my purposes.[(14)] Language commonly associated with Western art music has been used frequently in discourse on gagaku, ranging from assigning "beats" and "measures" to the *hyōshi* rhythmic pattern as well as transcribing melodies into Western notation (Masumoto 1968; Shiba 1969, 1971).

[3.4] The potential controversy of analyzing non-Western music through an apparatus originally designed for Western art music has been addressed by a number of scholars. Challenging the limiting and essentialist framework of ethnotheory, Kofi Agawu (2017, 51) calls for analysts of African music to use the "sharpest tools irrespective of origin," arguing that the cultural lineage of an analytical methodology should not disqualify its use in cross-cultural contexts. For Agawu, the central issue is "not who invented [theory] or for what initial purpose but whether it can be put to intelligent use in areas not initially envisioned by its first users" (2003, 195). Marc Perlman (2004, 3) observes two contrasting perspectives regarding the study of non-Western music adopted by scholars working within Western cultural and institutional contexts. On the one hand, Perlman notes that Western scholars studying non-Western musical forms have emphasized the importance of adopting an insider point of view. On the other hand, he observes that scholars have concurrently adopted a view of analysis as an act inevitably mediated by the culture within which the analyst is grounded (4). Taking a position which synthesizes these two viewpoints, Michael Tenzer has suggested that non-Western music should be studied using a "mixture of local and the researcher's own terminology and techniques" (2006, 11). By analyzing my own embodied experience of *te-utsuri* through the lens of transformational theory—an analytical apparatus devised and developed within Western music theoretical discourse—my methodology follows Tenzer's approach. By adopting transformational theory, I propose that Euro-American music theoretical techniques can be tailored to theorize contemporary shō performance in a way that highlights—rather than overwrites—perspectives and practices of gagaku musicians.

Transformational Perspectives of Shō Performance

[4.1] Readers accustomed to Western instruments may find it peculiar that the pitches of the shō (Example 2b) seem to be arranged in no particular order. Commenting on the idiosyncratic design of the instrument, William Malm (2000, 111) notes that the pipes of the shō cannot be "arranged like piano keys, in a scalewise order," due to physical restrictions posed by the fingerings. Unlike on a piano, moving from one pipe to its adjacent hole on the shō does not necessarily present us with a "nearby" pitch in pitch space, as shown in **Example 6**. For instance, moving the left-hand ring finger from *kotsu* to its adjacent hole *bō* takes us from A4 to D5, whereas moving the right-hand thumb from *jū* three finger holes away to *ku* shifts the pitch within a much smaller range, from G5 to C♯5. Using Jonathan De Souza's (2017, 60) terminology, the shō exhibits an irregular *place-to-pitch mapping*, in which an operation in instrumental space yields a variety of intervals in pitch space.[15] This unique characteristic of the shō requires us to abandon the assumption that minimal physical movement on an instrument corresponds to an equally minimal movement in pitch.

[4.2] Hayashi (1954), Masumoto Kikuko (1968), and Garfias (1975) have all suggested that the alignment of the pipes on the instrument is closely related to the fingering techniques of the *aitake*. Can we discern a relationship between the physical arrangement of the pipes and the pitch structure of the *aitake*? How can we determine whether, for example, if the *aitake otsu* is more closely related to *jū* or to *ichi*? Because of the way in which the pipes are arranged on the instrument, relationships between *aitake* are best revealed through an examination of *te-utsuri* rather than through pitch-class relationships. Instead of analyzing the pitch content of the *aitake* and attempting to explain its connection with the *te-utsuri* rules, I reverse the methodology: I will first establish how relatedness between different *aitake* is determined by degrees of gestural proximity in *te-utsuri*, and then explore the possible ways in which these kinesthetic relationships correlate with the pitch content of the *aitake*.

[4.3] First, I will demonstrate how the rules of *te-utsuri* facilitate a parsimonious movement of the fingers to get from one *aitake* to another. For clarity, **Example 7** summarizes each of the finger types used in shō performance. Recall that each of the pipes is assigned to a specific finger. As summarized in Example 6, the left-hand thumb covers four pipes—*gon* (言; C♯6), *hachi* (八; E6), *ichi* (一; B4) and *bi* (美; G♯5)— the left-hand ring finger three pipes—*jō* (上; D6), *bō* (凢; D5), and *kotsu* (乞; A4)—the right-hand thumb three pipes—*ku* (工; C♯5), *jū* (十; G5), and *sen* (千; F♯6)—and the right-hand index finger three pipes—*otsu* (乙; E5), *ge* (下; F♯5), and *hi* (比; C6).[16] The left-hand middle finger and index finger are always placed on the pipes *gyō* (行; A5) and *shichi* (七; B5), respectively. Because the rules of *te-utsuri* are based on the assumption that each finger always moves to the nearest hole (and not necessarily the nearest pitch in pitch space), motion between two *aitake* is characterized by its retention of common tones and the tendency for the fingers to move by the shortest possible distance on the instrument. There are no fingering changes for pitches that the two *aitake* have in common, and any required fingering change is enacted by a motion to the nearest pipe. To illustrate the parsimonious nature of *te-utsuri*, I demonstrate changes in pitch and the *te-utsuri* "finger leading" between clusters *kotsu* and *ichi* in **Example 8**. The two *aitake* share pitches E5, A5, B5, and F♯6, which means that *kotsu* (A4) and *hachi* (E6) must find a way to *bō* (D5) and *ichi* (B4). The common tones between the two *aitake* are shaded in orange, whereas the two tones that are involved in *te-utsuri* are shaded in green. According to the rules of *te-utsuri*, the performer must shift their fingers from *kotsu* and *hachi* to their nearest respective hole. Since *bō* and *ichi* are each one hole away from *kotsu* and *hachi* respectively, the fingers take the shortest path possible from the *kotsu* cluster to *ichi*. As demonstrated by the *te-utsuri* between *aitake kotsu* and *aitake ichi*, some *te-utsuri* are characterized by *minimal gestural parsimony*, which I define as minimal motion of *te-utsuri* involving movement over one or two finger holes. This article argues that *te-utsuri* movements exhibiting minimal gestural parsimony indicate a high degree of *gestural proximity*, whereas *te-utsuri* involving a high number of finger hole movements are considered to have lower degrees of gestural proximity.

[4.4] Lewin's transformational attitude is particularly useful for theorizing shō performance, given that the performer experiences the music as movement between *aitake* rather than as static intervallic distances in pitch space.(17) Put another way, a performer who follows the rules of *te-utsuri* experiences a embodied process of shifting their fingers towards the finger holes of the new *aitake.* The analyst therefore experiences musical relationships from within the music, rather than as external neutral observer of musical objects (Lewin 1987, 158–59; Rings 2011, 10). As shown in Example 2a, each finger hole is numbered clockwise from 0 to 16.(18) We are now able to express each of the *aitake* in the form of (*R1*, *R2*, *L1*, *L4*)—*kotsu*, for instance, can be stated as (1, 4, 8, 15). The entire list of six-finger *aitake* in (*a, b, c, d*) form is provided in **Example 9**. To quantify the performer's *te-utsuri* motions, I calculate the number of finger holes that each finger must traverse to get from one *aitake* to another. The process for playing *aitake* can be expressed as a permutation of four fingers pressing down on the pipes:(19)

$$A = \left\{(R1, R2, L1, L4) : R1 \in \{1, 2, 5\}, R2 \in \{0, 3, 4\}, L1 \in \{6, 7, 8, 10\}, L4 \in \{13, 14, 15\}\right\}$$

A in the formula above represents the *aitake* as a set (*R1, R2, L1, L4*), in which *R1* is the right thumb, *R2* is the right index finger, *L1* is the left thumb, and *L4* is the left ring finger.(20) While the index and middle fingers on the left hand are also necessary for forming *aitake,* as shown in Example 2a, the expression above excludes these two fingers as they are present in every *aitake* and thus are never taken off the *gyō* and *shichi* pipes during performance. In the interest of modeling the process of motion between clusters, each *aitake* is expressed as a combination of four finger holes rather than six. Applying this expression to Lewin's STRANS function OP(*s*) = *t*, I reformulate *te-utsuri* as a transformational operation involving the movements of four fingers: (*R1, R2, L1, L4*): the *s* on the left-hand side expresses the first *aitake*, the *t* on the right-hand side represents the *aitake* to which the performer is moving, and the OP represents the *te-utsuri* expressed as operation $TU_{(a,b,c,d)}$, in which the *a, b, c,* and *d* values quantify the motions each finger must enact to reach the next *aitake* $(a = R1^t - R1^s, b = R2^t - R2^s, c = L1^t - L1^s, d = L4^t - L4^s)$. Based on the formalization of *A*-set, we can now identify space S as the set of pipes $\{0, 1, 2, \ldots 16\}$ and the group STRANS as the *te-utsuri*, expressed in the form $TU_{(a,b,c,d)}$.

[4.5] Despite the abstract shō space being theoretically infinite, actual performance practice limits the number of transformational operations that are allowed in this space. First, strict systematization of the fingerings restricts motion between certain pipes. For example, since fingering rules are non-negotiable in *tōgaku* performance, there is no way to move from *jū* to *ge* since the two finger holes are not only held down by different fingers but also located on different sides of the pipe.(21) Moreover, since the *gyō* and *shichi* pipes are present in every *aitake*, motion from *gyō* to *jō* is similarly ruled out in practice. Second, the shō space S is non-modular, meaning that it cannot be wrapped around the face of a clock as per twelve-tone pitch-class space. Although the pipes *sen* and *hi* are theoretically adjacent to each other in shō space, for example, motion between them is not possible since the two are held down by different fingers. The only instance in which fingers can wrap around the clockface is the motion from *hi* to *ge* and *otsu,* since all three pipes use the right-hand index finger. As such, not all intervallic motions in shō space are conceivable in *tōgaku* given the restrictions of the systematized fingerings. A clockwise movement by four holes from *sen* to *ku,* both of which are played by the right thumb, cannot be replicated from *jū* to *bi*, since the former is played by the right thumb and the latter by the left thumb. The physical constraints of the systematized fingerings therefore limit the extent to which a formal transformational approach can be applied to shō space, since all intervallic motions must be theoretically conceivable when working within a GIS. Rather, the instrumental shō space closely resembles Lewin's (1987, 37–46) *direct-product GIS*, which models *aitake* as a composite of multiple networks that operate independently from one another. There are four networks that each represent an individual finger—R1, R2, L1, and L4—which taken together form a single *aitake*. While the fingering rules of *tōgaku* performance impose limitations on modeling shō space as a GIS, Lewin's transformational attitude nevertheless remains valuable for modeling *te-utsuri* from the performer's perspective.

[4.6] To derive the *te-utsuri* operation that takes the performer from one *aitake* to another, I first reformulate each *aitake* as a set (*R1*, *R2*, *L1*, *L4*) and calculate the fingering motions necessary to reach the next *aitake*. To do this, we must subtract the *a*, *b*, *c*, and *d* values of the second *aitake* from those of the first. In these calculations, a positive value represents a movement of the finger in clockwise motion whereas a negative value corresponds to a movement in counterclockwise motion.(22) To present one example, moving from the *aitake kotsu* (1, 4, 8, 15) to *ichi* (1, 4, 7, 14) results in the following calculation:

$$\begin{array}{rll} \textit{kotsu} & (R1, R2, L1, L4) & = (1, 4, 8, 15) \\ \textit{ichi} & (R1, R2, L1, L4) & = (1, 4, 7, 14) \\ \text{Difference} & & = (0, 0, -1, -1) \end{array}$$
$$TU_{(0,0,-1,-1)}[\textit{kotsu}] = \textit{ichi}$$

Based on this calculation, moving from *kotsu* to *ichi* requires the performer to shift their left-hand ring finger counterclockwise by one hole and left-hand thumb one counterclockwise by one hole. Similarly, the motion required between *ichi* (1, 4, 7, 14) and *ku* (5, 4, 6, 14) can be calculated as follows:

$$\begin{array}{rll} \textit{ichi} & (R1, R2, L1, L4) & = (1, 4, 7, 14) \\ \textit{ku} & (R1, R2, L1, L4) & = (5, 4, 6, 14) \\ \text{Difference} & & = (+4, 0, -1, 0) \end{array}$$
$$TU_{(+4,0,-1,0)}[\textit{ichi}] = \textit{ku}$$

The motion from *ichi* to *ku* requires the performer to shift two fingers: right-hand index finger (moving clockwise by four holes) and left-hand thumb (moving counterclockwise by one hole). Combining these two operations yields a new operation, as shown below:

$$\begin{array}{rll} \textit{kotsu} & (R1, R2, L1, L4) & = (1, 4, 8, 15) \\ \textit{ku} & (R1, R2, L1, L4) & = (5, 4, 6, 14) \\ \text{Difference} & & = (+4, 0, -2, -1) \end{array}$$
$$TU_{(+4,0,-1,0)}\{TU_{(0,0,-1,-1)}[\textit{kotsu}]\} = TU_{(+4,0,-2,-1)}[\textit{kotsu}] = \textit{ku}$$

[4.7] Combining the *te-utsuri* between *kotsu* and *ichi* [$TU_{(0,0,-1,-1)}$] and between *ichi* and *ku* [$TU_{(+4,0,-1,0)}$] generates the *te-utsuri* operation required to move directly from *kotsu* to *ku* [$TU_{(+4,0,-2,-1)}$]. This process of binary combination applies to any of the *te-utsuri* operations between six-note *aitake*, as shown in **Example 10**. I have noted earlier in the article that there is only one possible way to move between any two *aitake*, since the technique of *te-utsuri* only allows for parsimonious finger movements. Put another way, there exists only one *aitake t*, which is operation $TU_{(a,b,c,d)}$ away from *aitake s*. Moreover, combining the *te-utsuri* operation required to move from *kotsu* to *ku* [$TU_{(+4,0,-2,-1)}$] and from *ku* to *kotsu* [$TU_{(-4,0,+2,+1)}$] results in the identity operation $TU_{(0,0,0,0)}$, which indicates no movement in any of the fingers.

Aitake, Te-utsuri, and Theories of Mode

[5.1] Having outlined the methodology for calculating the size of *te-utsuri*, I will now generalize a set of rules for comparing the size of *te-utsuri* operations. Modeling kinesthetic relationships between different *aitake* through calculations of *te-utsuri* reveals that some *aitake* are farther apart than others. I suggest that the relative gestural proximity of the *te-utsuri* is one way to measure the relatedness between *aitake* from a performer's perspective. In order to do so, we must take into consideration two aspects of *te-utsuri*: the *number of fingers* involved in the *te-utsuri* and the *number* *of finger holes* traversed by each of the fingers. I will begin with an examination of the former. While some *te-utsuri* require the performer to move just one finger, others require the movement of all four fingers. The shift from *aitake bō* (凢) to *aitake ichi* (一), for example, requires an operation of $TU_{(0,0,-1,0)}$ with the performer shifting their left thumb from *hachi* (八) to its adjacent hole *ichi*, as shown in **Example 11** and in **Video Example 3**. This shift is gesturally more proximate than that between *bō* and *ge* (下), which requires an operation of $TU_{(0,-1,-2,-1)}$ and therefore a shifting of three fingers: the left ring finger must move from *bō* to its adjacent hole *jō* (上), the left thumb two holes from *hachi* to *bi* (美), and the right index finger one hole from *otsu* (乙) to *ge* (**Video Example 4**). From a kinesthetic standpoint, we can conclude that *aitake ichi* is related more closely to *aitake bō* than to *aitake ge* for two reasons: the motion from *bō* to *ichi* involves fewer fingers in the *te-utsuri* and requires only one finger hole shift, whereas the motion from *bō* to *ge* requires a movement of three fingers in total.

[5.2] So far, I have presented examples in which one *te-utsuri* operation unequivicolly requires more fingering motions than the other. Some relationships between *aitake*, as shown in **Example 12**, present an ambiguous case of whether a shift by two finger holes in one finger (e.g., $TU_{(0,0,0,-2)}$ from *kotsu* to *otsu*) is larger or smaller than a shift by one finger hole each in two fingers (e.g., $TU_{(0,0,-1,-1)}$ from *kotsu* to *ichi*).[(23)] I suggest that two fingers each moving by one finger hole is more gesturally proximate than one finger moving by two finger holes. As such, the *te-utsuri* from *kotsu* to *ichi* [$TU_{(0,0,-1,-1)}$] (**Video Example 5a**) is more gesturally proximate than the *te-utsuri* from *kotsu* to *otsu* [$TU_{(0,0,0,-2)}$] (**Video Example 5b**). This theory is consistent with the performer's experience of playing the shō, since shifting by two finger holes demands a greater finger extension or contraction compared to moving by a single finger hole. Given the difficulty of visually locating finger holes while performing, the gesture of moving a single finger by two holes is more difficult to master than the gesture of moving the same finger by one hole. I have summarized the rules for determining the gestural proximity of *te-utsuri* in **Example 13**. In sum, determining the relative gestural proximity of *te-utsuri* requires us to take into consideration both the number of finger holes that are traversed and the number of fingers involved in the motion.

[5.3] To further illustrate the rules in Example 13, I assess the gestural proximity of *te-utsuri* between *aitake jū* (2, 3, 8, 13) and *aitake ichi* (1, 4, 7, 14), *kotsu* (1, 4, 8, 15), and *hi* (1, 0, 8, 13), as shown in **Example 14**. STEP 1 alone cannot distinguish between the motion from *jū* to *ichi*, *kotsu*, and *hi* since all three operations require a traversal of four total finger holes. Following STEP 2 shows that the *te-utsuri* from *jū* to *ichi* is the most gesturally proximate operation since the operation distributes the four finger hole shifts evenly among the four fingers, each moving by one finger hole [$TU_{(-1,+1,-1,+1)}$]. Next in line is the *te-utsuri* from *jū* to *kotsu*, which involves the motion of three fingers, two shifting by one finger hole each and one shifting by two finger holes [$TU_{(-1,+1,0,+2)}$]. The least gesturally proximate of the three is the the *te-utsuri* from *jū* to *hi*, which requires the shifting of two fingers: the right thumb shifts by one finger hole and the right index finger traverses three finger holes [$TU_{(-1,-3,0,0)}$].

[5.4] With a methodology for quantifying *te-utsuri* firmly in place, I will now assess the size of each *te-utsuri* to determine the degree of relatedness between *aitake*. Taking *ichi* (1, 4, 7, 14) as an example, **Example 15** shows the *te-utsuri* between *ichi* and each of the other *aitake*, ordered according to their degree of gestural proximity. *Te-utsuri* with equal degrees of proximity are indicated by brackets to the left of the table. The first step is to identify the *te-utsuri* operations that require the fewest number of finger hole movements in total. The *te-utsuri* from *ichi* to *bō* requires the fewest number of finger hole traversals (one finger hole), followed by the *te-utsuri* to *kotsu* and *otsu* (two finger holes). The *te-utsuri* from *ichi* to *ge* (three finger holes), *jū* (four finger holes), *ku* (five finger holes), *bi*, and *hi* (six finger holes each) are therefore less gesturally proximate than the *te-utsuri* between *ichi* and *bō*, *kotsu*, and *otsu*. The *te-utsuri* from *aitake ichi* to *aitake bō*, *kotsu*, and *otsu* is minimally parsimonious, spanning just one or two finger holes in total.

[5.5] By modeling *te-utsuri* as kinesthetic motion in instrumental space, it becomes evident that some pairs of *aitake* require more fingering shifts than others. The table in the **Appendix** displays all of the *te-utsuri* options between six-note *aitake* used in *tōgaku* performance, each expressed in the form of $TU_{(a,b,c,d)}$. From the information in the table, we can make a number of observations on gestural proximity in *te-utsuri*. First, the most gesturally proximate relationships can be found in the *te-utsuri* from *aitake bō* to *aitake kotsu*, *ichi*, and *otsu*. Moving from *bō* to each of the three *aitake* only requires a shift by one finger hole in total. This relationship suggests that *aitake kotsu*, *ichi*, and *otsu* are in close kinesthetic proximity to *bō*. Second, the cluster *ku* (工) is relatively distant from many of the *aitake*; the closest *aitake* is *ichi*, which requires a total of five finger hole traversals: four in the right thumb and one in the left thumb. Moving to other *aitake* from *ku* requires a traversal across six (*bō*, *ge*), seven (*kotsu, otsu*), nine (*bi*) and eleven (*hi*) finger holes in total. A similar case can be made for *bi*, which requires a traversal of at least three finger holes in order to reach seven of the eight other *aitake*, and for *hi*, which involves a motion across four or more finger holes to seven of the eight other *aitake*. From these observations, I conclude that while some *aitake* cannot be reached through gesturally proximate *te-utsuri* from any of the other *aitake*, others are easily reached by proximate motion—and in a few instances, minimally parsimonious motion of one or two finger holes—from multiple *aitake*.

Categorization of Aitake

<Category 1>

[6.1] Based on the gestural proximity of *te-utsuri*, I categorize *aitake* into three categories, as summarized in **Example 16**. I posit that the most proximate *te-utsuri* can be enacted between members of what I call the Category 1 *aitake*: *bō*, *kotsu*, *ichi*, and *otsu*. Whereas *aitake* in Category 1 are related to one another through the most proximate *te-utsuri* available to the shō player, *aitake* in Categories 2 and 3 require more fingering shifts when moving to other *aitake*.(24) As previously discussed, *bō* is just one finger hole shift away from *kotsu, ichi*, and *otsu*, and *bō* is the only *aitake* from which another cluster can be reached by shifting one finger hole. The other three members of Category 1—*kotsu, ichi*, and *otsu*—are each related to one another through two finger hole traversals, all in the left hand. The four *aitake* are connected through minimally parsimonious *te-utsuri* and are therefore closely related to one another from a gestural standpoint. Moreover, the four Category 1 *aitake* exhibit similarities in pitch content: each Category 1 *aitake* is a six-note subset of the same two-octave pentatonic pitch collection: A4-B4-D5-E5-A5-B5-D6-E6-F♯6 (Example 16).

[6.2] The four manifestations of the two-octave pentatonic pitch collection—*aitake kotsu*, *ichi*, *bō*, and *otsu*—are connected to one another through minimally parsimonious *te-utsuri*. Although two aitake in Category 2 are similarly subsets of pentatonic collections—*gyō* (A5-B5-D6-E6-F♯6) and *jū (Sōjō)* [G5-A5-B5-D6-E6]—their relatedness with Category 1 *aitake* is weakened in three ways. First, the pitches of *aitake jū (Sōjō)* are based on a different pentatonic pitch collection: G5-A5-B5-D6-E6. Second, while *aitake gyō* is a subset of the two-octave pentatonic pitch collection underlying Category 1 *aitake*, the pitches of *gyō* are concentrated in the upper half of the collection. In other words, unlike the Category 1 *aitake*, *gyō* is not anchored by a fundamental tone—the lowest tone that determines the name of each *aitake*—in the lower-half of the instrument's register. Incidentally, the two-octave pentatonic pitch collection that encompasses all Category 1 *aitake* spans the entire register of the instrument: A4 to F♯6. Whereas the fundamental tones of Category 1 *aitake* (A4, B4, D5, E5) constitute some of the lowest tones available on the instrument, the fundamental tone of *gyō,* A5, is located in the upper half of the instrument's register. Each Category 1 *aitake* can therefore be organized into two parts: the fundamental tone and the remaining notes of the upper register, most of which overlap note-for-note with the pitches of *gyō*.(25) Third, since both *gyō* and *jū (Sōjō)* are comprised of five pitches (rather than six), differences in cardinality inevitably complicate the theorization of *te-utsuri*. At present, a working definition of gestural parsimony between *aitake* of different cardinalities lies beyond the scope of this article.(26) Moving from any six-note *aitake* to *gyō* or *jū (Sōjō)* requires the performer to release their right index finger completely. **Example 17** and **Video Example 6** illustrate the process of *te-utsuri* between *ichi* and *gyō*, with the releasing of the right index finger indicated by the dotted arrow. Conversely, moving from *gyō* to *ichi* requires the performer to press the idle right index finger down onto a new hole. The *te-utsuri* from *ichi* to *gyō* (Example 17) requires three total moves: the left ring finger shifts from *bō* (D5) to *jō* (D6), the left thumb from *ichi* (B4) to *hachi* (E6), and the right index finger is released entirely from *otsu* (E5) to complete the five-note *aitake*. Due to differences in cardinality, there are currently no consistent measures of gestural proximity between *gyō* and the Category 1 *aitake.* For these reasons, I categorize *gyō* and *jū (Sōjō)* as Category 2 *aitake* along with *jū* and *ge*.

<Category 2>

[6.3] Category 2 includes two six-note *aitake: jū* and *ge.* Members of Category 2 exhibit three characteristics. First, unlike the members of Category 1, the Category 2 *aitake* are not connected by minimally parsimonious *te-utsuri* to most of the other *aitake.* For Category 2, gestural proximity of *te-utsuri* is more the exception than the rule. The only exception is *jū,* which can be reached by minimally parsimonious motion from *otsu* through a $TU_{(+1,-1,0,0)}$ operation.[27]

[6.4] Second, despite having similar degrees of gestural proximity, the motion from *otsu* to *jū* differs from *te-utsuri* between members of Category 1 in a crucial way (**Example 18**). While minimally parsimonious *te-utsuri* between members of Category 1 requires only the motion of the left hand (*kotsu* [pitch A4; pipe 15 as per Example 2a], *bō* [D6; pipe 14], *jō* [D5; pipe 13], *hachi* [E6; pipe 8], and *ichi* [B4; pipe 7]), *te-utsuri* between *otsu* and *jū* requires the movement of the right hand (*sen* [F♯6; pipe 1], *jū* [G5; pipe 2], *ge* [F♯5; pipe 3], and *otsu* [E5; pipe 4]) (**Video Example 7**). From a performer's perspective, the physical experience of shifting between Category 1 clusters in the left hand, which involves fingering movements between outward-facing finger holes, is markedly distinct from that of shifting between *jū* and *otsu* in the right hand, which requires a shift between inward-facing finger holes.

[6.5] Third, with the exception of *gyō* and *jū (Sōjō)*, Category 2 *aitake* contain a semitone within their intervallic structure, which creates a "richly dissonant texture against which the *ryūteki* and *hichiriki* perform their melodies" (Marett 2001a). This results in a sonority that contrasts significantly from the pentatonicism of the (02479) pitch-class collection that pervades the Category 1 *aitake*.[28] I will discuss in more detail the omission of *gyō* and *jū (Sōjō)* from the current discussion of Category 2 *aitake* in [9.6].

<Category 3>

[6.6] Finally, Category 3 contains *aitake* that are further apart from those of Categories 1 and 2: *bi*, *hi* and *ku*. *Te-utsuri* from *bi* to *ichi* and *otsu*, for example, each requires a shifting of six finger holes, and *te-utsuri* from *bi* to *kotsu* and *bō* requires a shifting of seven finger holes, indicating a low degree of relatedness with the Category 1 *aitake*. Similarly, *hi* requires non-proximate *te-utsuri* operations to reach any of the Category 1 *aitake:* a traversal of four finger holes for *otsu*, five for *bō*, and six for *kotsu* and *ichi*. Out of the Category 3 *aitake*, *ku* is the farthest from Category 1, requiring a shifting of five finger holes from *ichi*, six from *bō*, and seven from both *kotsu* and *otsu*. *Ku* requires similar degrees of transformations to reach other *aitake* in Categories 2 and 3: a shift of six finger holes to *ge*, seven to *hi*, and nine to *bi*. As such, motion to and from a Category 3 *aitake* is experienced by the performer as one of the most difficult and effortful *te-utsuri* used in *tōgaku* repertoire.

Pedagogical Connections

[7.1] My categorization of *aitake* based on the gestural proximity of *te-utsuri* is consistent with how *aitake* are taught to beginning shō students.[29] In 2017, I had the opportunity to participate in Miyata Mayumi's courses at the Kunitachi College of Music in Tachikawa, Japan, a suburb of Tokyo. Miyata, one of the most distinguished performers of the shō today, teaches introductory-, intermediate-, and advanced-level classes on shō performance to undergraduate students specializing in Western art music performance. In the introductory course, students first learn the *aitake otsu*, followed by the three Category 1 *aitake* that are connected through minimally parsimonious *te-utsuri*: *bō, kotsu,* and *ichi*. One of Miyata-sensei's exercises involves practicing *te-utsuri* between *aitake* that require a traversal of one finger hole: first from *otsu* to *bō*, then from *bō* to *kotsu*, before retracing the steps back to *otsu* (**Video Example 8a**). Another exercise requires the student to repeat the motion between *bō* and *ichi*, also one finger hole apart from one another, and between *otsu* and *ichi*, which are two finger holes apart (**Video Example 8b**). These exercises, which focus on developing the movement of the left hand, situate Category 1 as the most fundamental *aitake* from the perspective of *te-utsuri*.

[7.2] Once the student has learned the basic *te-utsuri* for shifting between the Category 1 *aitake*, the fingerings for *aitake* in Categories 2 and 3 are then taught in relation to those in Category 1. *Jū* in Category 2, for example, is presented as a variant of *otsu*: the left hand placement for *jū* is identical to that of *otsu*, and the right hand requires each of its fingers to shift by one finger hole (**Example 19a** and **Video Example 9a**). The *aitake hi* in Category 3 is also introduced as a variant of *otsu*, with no change in the left hand and the right index finger placed on *hi* rather than on *otsu* (**Example 19b** and **Video Example 9b**).

[7.3] Miyata's pedagogy finds a parallel in *Gagaku Sankan no Shōkahō* (「雅楽三管の唱歌法」) [Ōno 1996], a two-volume treatise on *shōga* authored by former Imperial Household Agency musician Ōno Tadao (多忠雄; 1911–2005). Although the treatise focuses primarily on the musical intricacies of *shōga*, Ōno's discussion of mnemonics for shō outlines a method of organizing *aitake* based on their *te-utsuri* relationships.(30) I have reorganized the information presented in Ōno's treatise in **Example 20**. Ōno presents a systematic way of learning each of the *aitake* by categorizing them into four groups. As shown in Example 20, Ōno situates *otsu* as the most fundamental *aitake* from which the rest of the *aitake* are derived. Ōno's first group ("Row 1") contains *otsu*, *bō*, *kotsu*, and *ichi*, all of which belong to Category 1. *Bō* is presented as a variant of *otsu*, and *kotsu* and *ichi* as modifications of *bō*. The order in which the *aitake* are presented is based on the gestural proximity of *te-utsuri: bō* is one finger hole away from *otsu*, and *kotsu* and *ichi* are each one finger hole away from *bō*. In other words, the shō player first starts with *otsu*, then learns *bō*, *kotsu*, and *ichi*, in that order. Only after learning the four basic *aitake* of Category 1 can the performer move on to learning the others. Out of the *aitake* in Categories 2 and 3, six (*hi*, *bi*, *ge*, *gyō*, and the two variations of *jū*) are derived from *otsu* and one (*ku*) is derived from *bō*. Miyata's pedagogical method and Ōno's categorization of *aitake* demonstrate that gestural proximity of *te-utsuri* plays a central role in the process of learning the shō.

Transformational Analysis of Te-utsuri in Goshōraku-no-kyū (五常楽急)

[8.1] I now present an analysis of a *tōgaku* piece to demonstrate how a performer might experience a performance through *te-utsuri*, and how *te-utsuri* between different categories of *aitake* exhibit an ebb and flow between tension and release. To illustrate how the *aitake* in each of the three categories appears in the *tōgaku* repertoire, I analyze an excerpt from *Goshōraku-no-kyū* (五常楽急), a frequently performed piece in the *Hyōjō* (平調) mode.(31) The *aitake* and their accompanying *te-utsuri* operations in the piece are shown in **Example 21a** and a Western transcription of mm. 9–26 is provided in **Example 21b.** Although many contemporary gagaku musicians refer to column numbers (e.g., "first column," "second column"; see **Example 22** for an example of how columns are laid out in shō notation) rather than measure numbers when rehearsing a piece, I will refer to measure numbers in my discussion for purposes of clarity.(32) A video of the entire excerpt is also provided in **Video Example 10**. The *aitake* in mm. 17–22 all belong to Category 1, and their *te-utsuri* transformations are in their most parsimonious form: each motion only involves a shift by one or two finger holes. The string of minimally parsimonious *te-utsuri* transformations is momentarily broken up by the *aitake jū* in m. 23, but the Category 1 *aitake* return again in m. 24, lasting until the end of m. 26. This excerpt projects a sense of aural and kinesthetic stability. As previously discussed, each *aitake* in Category 1 is comprised of pitches from the two-octave pentatonic pitch collection A4-B4-D5-E5-A5-B5-D6-E6-F♯6. The sequence of Category 1 *aitake* maintains the pentatonic sonorities of pitch classes A, B, D, E, and F♯ across mm. 17–22. At the same time, motion between the *aitake* in mm. 17–22 and 24–26 can be enacted through minimally parsimonious *te-utsuri* transformations, as shown in Example 21a. This suggests that the gestural proximity of the *te-utsuri* between the four Category 1 *aitake* correlates with the similarity in their pitch-class content. In other words, the arrangement of the pipes of the shō affords minimally parsimonious *te-utsuri* between *aitake* whose pitches belong to the two-octave pentatonic pitch collection. The mechanism behind this correlation will be examined in more detail in [9.1–9.7].

[8.2] So far, I have argued that motion between members of the Category 1 *aitake* yields minimally parsimonious (and as a result, most gesturally proximate) *te-utsuri*. As shown in the Appendix, some of the most laborious (and least gesturally proximate) *te-utsuri* takes place between members of Categories 2 and 3. *Goshōraku-no-kyū* presents a mixture of Category 1 (*otsu*, *bō*, *ichi*, *kotsu*), Category 2 (*jū*, *ge*), and Category 3 (*ku*) *aitake* (Example 21a). Examining the order and frequency in which the *aitake* of the three categories appear in *Goshōraku-no-kyū* reveals an alternation between proximate and distant *te-utsuri* transformations. Measures 10–12 proceed as follows: gesturally distant *te-utsuri* from a Category 1 to Category 3 *aitake* is counterbalanced by an immediate return to a Category 1 *aitake.* These events are then followed by a long sequence of minimally parsimonious *te-utsuri* operations between members of Category 1. In this passage, *otsu* moves to *ku* through a $TU_{(+4,0,-2,+1)}$ operation, a motion that stands out because it requires more fingers and finger hole traversals than any other *te-utsuri* up until this point in the piece. Rather than cycling through other *aitake* in Categories 2 and 3, we are immediately shifted back into *bō* at the end of m. 11, a motion that requires another gesturally distant transformation, $TU_{(-4,0,+2,0)}$. *Ku*, which lasts for just one measure, is followed immediately by a chain of Category 1 *aitake* that continues until m. 22. The gesturally distant *te-utsuri* transformations that accompany the *otsu—ku—bō* motion in mm. 10–12 therefore contrast with the minimally parsimonious *te-utsuri* transformations afforded between members of the Category 1 *aitake* in mm. 12–22.

[8.3] If the gesturally distant *te-utsuri* for the *otsu—ku—bō* motion establishes a sense of tension in the performer's fingers, then the minimally parsimonious *te-utsuri* between Category 1 *aitake* could be interpreted as a release of tension, given that mm. 12–22 require the movement of just one finger at a time throughout.[33] Category 3 *aitake* are treated similarly in *Sandaien-no-kyū* (三臺塩急), *Etenraku* (越天楽), and *Keitoku* (雞徳) in *Hyōjō* mode: in all three pieces, every appearance of *ku* lasts for just two beats (i.e., half a measure) and is always preceded and followed by a Category 1 *aitake*. The proximity of *te-utsuri* between *aitake* is correlated with similarities in the *aitake*'s pitch content. Motion between *aitake* that are subsets of the two-octave pentatonic pitch collection A4-B4-D5-E5-A5-B5-D6-E6-F♯6 (i.e., those belonging to Category 1) yields the most gesturally proximate *te-utsuri*, whereas motion between *aitake* belonging to different pitch-class sets (and therefore to different categories) requires more laborious (and therefore more gesturally distant) *te-utsuri*.

[8.4] Calculating the frequencies of *te-utsuri* in *Goshōraku-no-kyū* shows that the most common type of motion is that between Category 1 *aitake,* which constitutes 37.5% (15 out of 40) of all *te-utsuri* in the piece (**Example 23**). Including all motion to and from Category 1 *aitake* reveals that the overwhelming majority of *te-utsuri* (80%; 32 out of 40) either depart from or arrive at a Category 1 *aitake*. Other types of motion, such as that from Category 1 to Category 2 and between Category 2 *aitake*, occur less frequently. Moreover, Category 1 *aitake* are held for longer periods of time compared to *aitake* in other categories. Indeed, summing the *duration* (in beats) of each *aitake* type in the piece reveals that Category 1 *aitake* are played for longer durations than members of Category 2 or Category 3: the four Category 1 *aitake* occupy 71.9% (92 out of 128 beats) of the duration of the piece, the most out of any category (Example 23). These findings can be used to make the following generalizations for *Goshōraku-no-kyū*: first, the piece projects a predilection for minimally parsimonious *te-utsuri* motion, as evidenced by the higher frequency of motion between Category 1 *aitake* compared to that between *aitake* of different categories or between Category 2 *aitake*; and second, given that minimally parsimonious *te-utsuri* between Category 1 *aitake* is normalized as the most common type of motion in the piece, gesturally distant *te-utsuri* between members of different categories and within members of Category 2 present contrast and variety in the performer's gestural experience.

Tonal Relationships between Aitake

[9.1] My analysis of *te-utsuri* has shown how the arrangement of the pipes on the shō facilitates a high degree of relatedness between some *aitake* over others. In this final section, I demonstrate how expressing the *te-utsuri* as transformational operations reveals various pitch-based relationships between *aitake*. Why, for example, do movements between Category 1 *aitake* facilitate the most gesturally proximate *te-utsuri*? To address this question, I consider the tonal function of *aitake* within the context of gagaku modes. I suggest that Garfias's (1975) theories of "consonance" and "dissonance" in gagaku can offer a possible explanation. According to Garfias, gagaku assumes a fixed notion of consonance and dissonance that is not "dictated by patterns of contrast, tension and release" as in Western art music (66). Rather, consonance and dissonance are "totally subservient to the fixed structure of each *aitake* and in turn are governed by the tones of the basic series in which the *chōshi* is found" (66).[(34)] Garfias categorizes the following four *aitake* as consonances, regardless of mode: *kotsu* (fundamental note: A4), *ichi* (fundamental note: B4), *bō* (fundamental note: D5), and *otsu* (fundamental note: E5). These four *aitake* are analogous to the members of Category 1. By contrast, Garfias categorizes the other *aitake*—which are analogous to the members of Categories 2 and 3—as dissonances (66–67). The *aitake* in Category 1 have two characteristics in common: first, all four Category 1 *aitake* are subsets of the two-octave pentatonic pitch collection A4-B4-D5-E5-A5-B5-D6-E6-F♯6; second, when each Category 1 *aitake* is expressed as a collection of pitch classes, none of its interval-class vectors contains interval class 1 (**Example 24**).

[9.2] What can the intervallic properties of consonant *aitake* tell us about the relationship between the Category 1 *aitake* and the *te-utsuri* transformations required to move between them? The answer is deeply intertwined with the structure of the tone system in gagaku. The method used for generating the tone system in gagaku offers an explanation for the correlation between the intervallic structures of each of the Category 1 *aitake* and the minimally parsimonious *te-utsuri* necessary to move between them. As Hayashi has observed, the pitch classes of each of the *aitake* can be rearranged into a chain of consecutive fifths, as shown in **Example 25**.[(35)] Hayashi admits that this conceptualization of the tone system is hardly new, as previous theorists such as Ogyū Sorai (荻生徂徠; 1666–1728) and Tayasu Munetake (田安宗武; 1716–71) have already taken note of this property in their respective treatises.[(36)] As Hayashi and others have shown, pitches of the gagaku tone system are calculated through the Chinese *Sanbun son'eki* (三分損益) method, which draws parallels with the Pythagorean tuning system of stacking successive fifths.[(37)] While the tone system consists of twelve pitches generated through this method, musicians use fewer tones in practice.[(38)]

[9.3] As shown in **Example 26**, the six seven-note modes used in contemporary gagaku are categorized into two groups according to their intervallic structure: the *ryo* (呂) modes *Ichikotsu-chō* (壱越調; fundamental tone: D), *Taishiki-chō* (太食調; fundamental tone: E), and *Sōjō* (双調; fundamental tone: G) and the *ritsu* (律) modes *Hyōjō* (平調; fundamental tone: E), *Ōshiki-chō* (黄鐘調; fundamental tone: A), and *Banshiki-chō* (盤渉調; fundamental tone: B).[(39)] The first degree of each mode plays a significant melodic and tonal function, and each seven-note collection can be divided into five main tones and two *pien* tones. These features are a legacy of the tonal system from Tang China on which gagaku theory is founded, which melodically emphasizes the "first five tones of the generating series" and treats the other two tones as "additional" *pien* tones used for "weaker roles" (Garfias 1975, 58).[(40)] The fundamental tone of a gagaku mode is analogous to the tonic degree of a Western scale, functioning as a "point of arrival and/or rest for most melodic lines" and are sustained for longer durations compared to non-fundamental tones (Kapuscinski and Rose 2013b). The intricacies of the gagaku tone system unfortunately cannot be presented in full here. For the purposes of this article, I will limit my discussion to the process through which tones are generated and their connection to the fundamental tones of the six modes.

[9.4] Having contextualized the intervallic structure of *aitake* within the gagaku tone system, I will now discuss the relationship between each of the Category 1 *aitake* and their accompanying *te-utsuri* operations. Recall that all *aitake* possess their own fundamental tone, as indicated by the black noteheads in Example 3. If we compare the fundamental tones of the Category 1 *aitake* with each of the fundamental tones of the six gagaku modes, we find that for *Ichikotsu-chō* (fundamental tone: D), *Hyōjō* (E), *Taishiki-chō* (E), *Ōshiki-chō* (A), and *Banshiki-chō* (B), the *aitake* representing their respective fundamental tones correspond to all four of the Category 1 *aitake*: *bō* (fundamental tone: D), *otsu* (E), *kotsu* (A), and *ichi* (B). In other words, the *aitake* accompanying the fundamental tones of five out of the six modes are connected to each other through a gesturally proximate relationship, requiring at most a shifting of two finger holes in the left hand. In sum, Category 1 *aitake* are similar to one another in two ways: first, they are related kinesthetically through minimally parsimonious *te-utsuri;* second, the four Category 1 *aitake* are analogous to the *aitake* accompanying the fundamental tone of all but one of the six modes, suggesting that members of Category 1 share similar tonal functions.

[9.5] There are two implications for this correlation between the Pythagorean construction of the gagaku tone system and gestural proximity of *te-utsuri*. First, each tone of the *aitake* can be generated by stacking successive fifths, which draws parallels with the *Sanbun son'eki* method.[41] The *Sanbun son'eki* method is consistent with the process for tuning the *shō*, which is similarly tuned in successive fifths starting on the pitch *ichikotsu* (analogous to D in the Western system).[42] Second, the pitches of each consonant *aitake* correspond to the five main tones of the mode for which the *aitake* functions as the fundamental tone. Although Garfias echoes this observation, his work does not explore the relationship between the gestural proximity of *te-utsuri* and the tone structure of the *aitake* representing the fundamental degrees of each mode. Recall that each mode is comprised of seven pitches, which can be further divided into five main tones and two *pien* tones. Out of the six-note *aitake*, only the Category 1 *aitake* can be generated by stacking the five main tones of the modes, while *aitake* in Categories 2 and 3 require the use of *pien* tones. *Otsu*, *ichi,* and *bō,* for example, are all comprised of generating tone D and the first four tones produced from it: A, B, E, and F♯. Similarly, *kotsu* is comprised of generating tone A and the first three tones produced from it: B, E, and F♯. To summarize, the consonant Category 1 *aitake* share with one another the following properties: first, all Category 1 *aitake* draw their constituent pitches from the same five-note pitch-class collection (i.e., D, E, F♯, A, B), which is equivalent to the first five tones generated through the *Sanbun son'eki* method; second, Category 1 *aitake* are related to one another through minimally parsimonious *te-utsuri* relationships in the left hand.

[9.6] The reader may notice that the *Sōjō* mode has been left out of the current discussion on the correlation between *aitake* pitch structures and the gestural proximity of *te-utsuri.* The reason for this omission is that *jū*, which is built on the fundamental tone of *Sōjō* mode (G), has two versions: a six-note *aitake* used in all modes (**Example 27a**) and a five-note *aitake* used exclusively in the *Sōjō* mode (**Example 27b**). In this article, I refer to the six-note version of *jū* as "*jū*" and the five-note version as "*jū* (*Sōjō*)," to reflect the latter's specific usage. Both types appear in *Sōjō* mode, and the two versions are differentiated in the notation with a dot on the side of the *jū* character, as shown in **Example 28**. Based on the theoretical framework I have developed in this article, the five-note *jū* (*Sōjō*) meets the criteria for a consonant *aitake*: its pitches are limited to those of the five main tones of *Sōjō* mode (G, A, B, D, E), as shown in Example 25.[43] *Jū*, however, includes one *pien* tone (F♯) in addition to the five main tones (G, A, B, D, E), resulting in an interval-class vector <143250> that includes ic1 (**Example 29**). The semitone between F♯5 and G5 produces a distinct sonority from that of the pentatonic *jū* (*Sōjō*), which does not contain any semitones within its intervallic structure. Following Garfias's definitions of consonance and dissonance in gagaku, the six-note *jū* is considered dissonant, given that the *aitake* can only be generated by stacking five consecutive fifths starting on G. In contrast, *jū* (*Sōjō*) omits the F♯ to limit its tone structure to the five main tones of the mode. As a result, its intervallic structure closely resembles that of the other Category 1 *aitake*. As shown in Example 29, *jū* (*Sōjō*) belongs to the same pitch-class set (i.e., [02479]) as the other six-note *aitake* in Category 1. Moreover, *jū* (*Sōjō*) functions primarily as the *aitake* for the fundamental tone of the *Sōjō* mode, an observation which has also been confirmed by Garfias (1975, 65). While the gestural proximity of *te-utsuri* between *jū* (*Sōjō*) and the Category 1 *aitake* requires further research due to differences in cardinality, the consonant intervallic properties and tonal function of *jū* (*Sōjō*) strongly resemble those of *aitake* accompanying the fundamental degrees of the other five modes.

[9.7] In sum, I have identified three shared features of Category 1 *aitake* that illustrate the close relationship between gestural proximity and tonal function. First, the Category 1 *aitake* correspond to the clusters on the fundamental degrees of five of the six modes—*Ichikotsu-chō* (D), *Hyōjō* (E), *Ōshiki-chō* (A) and *Banshiki- chō* (B). Despite sharing a similar pentatonic pitch structure, the *aitake* built on the fundamental degree of *Sōjō* (G)—*jū* (*Sōjō*)—cannot be considered a Category 1 *aitake* due to differences in cardinality and in the pentatonic scale from which it draws its pitches. Second, the *aitake* accompanying the fundamental modal degrees are comprised exclusively of the five main tones of the gagaku modal system. As such, all Category 1 *aitake* meet Garfias's criteria for consonance in gagaku. Third, the *aitake* requiring the fewest total number of finger hole traversals are also the *aitake* that accompany the fundamental tones of each mode. We now understand that the pipes of the shō, while at first glance arranged in random order, are constructed in a way that allows for and prioritizes the most gesturally proximate *te-utsuri* between each of the consonant *aitake* on the fundamental modal degrees, a striking instance in which the physical structure of an instrument is ergonomically tailored towards the needs of the performer.

Conclusion

[10.1] In this article, I have theorized the performance of the shō as a set of transformational operations that result from instrumental gestures enacted upon the instrument. A Lewinian transformational approach for modeling the technique of *te-utsuri* is compatible with how performers of the shō conceptualize the motion between *aitake*. Moreover, a transformational approach models *aitake* as an aesthetic byproduct of gradual fingering movements rather than as a fixed harmonic entity, a characterization which would certainly seem out of place in gagaku. Incorporating the motion of *te-utsuri* into an analysis of *aitake* enables us to understand the centrality of instrumental gesture in shō performance, an approach that resonates with how gagaku musicians study and internalize the music. By quantifying the motion between *aitake* according to the number of fingers in motion and the total number of finger holes traversed by the performer during the process of *te-utsuri*, I have demonstrated that some *aitake* are more closely related to one another from a gestural standpoint. Furthermore, *aitake* that are related to each another through gesturally proximate *te-utsuri* operations share a number of commonalities: first, each Category 1 *aitake* is a subset of the same two-octave pentatonic pitch collection; second, *aitake* that are related through minimally parsimonious *te-utsuri* simultaneously function as the *aitake* for the fundamental degrees of each mode, revealing a striking correlation between the gestural proximity and tonal function. Examining connections between the pitch structure of *aitake*, gestural proximity of *te-utsuri*, and notions of consonance and dissonance in gagaku sheds light on the relationship between musical syntax and the physical arrangement of the pipes of the shō..

[10.2] By highlighting the intersections between *te-utsuri* and tonal relations in shō performance, this article has foregrounded the rich possibilities of incorporating instrumental gestures into music analysis. An embodied approach to musical analysis builds upon the work of Suzanne G. Cusick (1994), who has demonstrated how an analysis of a performer's physical actions can productively enhance a structural reading of a piece. Critiquing music theory's obsession with the "texts of composers" and neglect of the "presence of the body in music," Cusick advocates for an embodied music theory that centers the performer's role in the production of music (15).[(44)] As Joti Rockwell (2009a, 161) has suggested, the "seemingly pedestrian details of practice" that are essential to learning an instrument can be fruitful for understanding music from a performer's perspective. Moreover, recent work by Timothy Koozin (2011) and De Souza (2017, 2018) has modeled musical performance through instrumental space to reveal insights that cannot easily be accessed through discussions of pitch-based parameters alone. While my use of transformational theory is indebted to their work, my analysis of *te-utsuri* has also exposed the limitations of adopting a formal transformational approach for modeling shō space. The systematized fingerings, non-modular construction of the instrument, and considerations of *aitake* cardinality raise provocative questions about the extent to which Lewin's transformational apparatus—a methodology originally developed for analyzing Western art music—can be flexibly applied to analyses of instrumental gesture and topography in non-Western music.

[10.3] This project has suggested a number of avenues for further research. First, the potentiality of the *te-utsuri* transformational system could be explored further through an empirical analysis of the core gagaku repertoire in the *Hōshōfu* (鳳笙譜)—a compilation of tablatures for the shō, published by both the Ono Gagaku-kai and the Gagaku Department of Tenrikyō Church. A systematic analysis of the repertoire across all six modes will offer valuable data for exploring issues of syntax in *tōgaku*. An empirical methodology would help confirm whether the Category 1 *aitake* are used most frequently across all modes, how gesturally proximate relationships between *aitake* are consistent across all six modes, and how the syntax of the *aitake* relates to the melodic lines played by the *ryūteki* and *hichiriki*. Lastly, an in-depth examination of the interaction between modal and rhythmic theories of gagaku may reveal how the pitches of the *aitake* interact with those played by the other instruments of the ensemble.

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Appendix

Glossary

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Footnotes

* I am grateful to Ellie M. Hisama, John Roeder, Mariusz Kozak, Nathan Pell, and Michèle Duguay for their insightful comments and suggestions on earlier versions of this article. This work would not have been possible without mentorship from my teachers, Miyata Mayumi and Miura Remi. Special thanks goes to Lan A. Li for her assistance with video production and to the reviewers at *Music Theory Online* for their time and feedback.
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1. A complete list of Japanese terminology appears in the glossary.
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2. Although *tōgaku* originates from Tang China, the style as we understand it today was reorganized between 833–50 by Emperor Saga (嵯峨天皇), who was responsible for standardizing the gagaku ensemble (Malm 2000, 99–100).
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3. A *tōgaku* ensemble is comprised of shō, *hichiriki* (篳篥; double-reed flute), *ryūteki* (龍笛; transverse flute), *biwa* (琵琶; lute), *gakusō* (楽箏; zither), and three percussion instruments: *taiko* (太鼓; big drum), *shōko* (小鼓; small gong) and *kakko* (羯鼓; barrel-shaped drum). The primary melody is always played by the *hichiriki* and embellished by a similar yet not entirely identical melody on the *ryūteki* (see Terauchi 2011). The shō, *gakusō*, and *biwa* provide accompaniment.
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4. Timothy Koozin (2011) follows a similar approach, integrating transformational theory into an analysis of guitar performance to examine how harmonic patterns in pop-rock music are correlated with the layout of the guitar fretboard.
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5. The pitch F♯5, for example, is referred to by shō players as *ge* (下), the name of the pipe, rather than *shimomu* (下無), the name of the pitch in gagaku theory.
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6. The shō is currently used in four genres of gagaku: the instrumental (*kangen*; 管絃) and dance (*samai*; 左舞) genres of *tōgaku* and in the vocal genres of *rōei* (朗詠) and *saibara* (催馬楽).
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7. Crucially, performers must keep their instruments heated to prevent the reeds from trapping moisture. Using a charcoal or electric heater, shō players heat their instruments not only before and after performances, but also during any pauses or breaks between individual pieces.
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8. According to Shigeo Kishibe and Leo Mario Traynor (1952) and Hayashi (1954), the pipes *ya* and *mō* were assigned the pitches G and D♯, respectively, when the shō was imported from Tang China in the eighth century. Once the number of modes was reduced to six, instrument makers muted the two pipes since their pitches were no longer necessary for performance. The shō stored at the Shōsō-in (正倉院), the treasure house of Tōdaiji temple in Nara, can generate sound from the *ya* and *mō* pipes.
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9. While an overview of the rhythmic and metrical principles of gagaku lies beyond the scope of this article, interested readers should consult Endō 2013, 147–52; Garfias 1975, 81–113; Kapuscinski and Rose 2013a; Masumoto 2010, 218–33; and Terauchi 1996.
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10. Alexander R. Jensenius et al. (2010, 23–24) propose four frequently used categories of gesture in music: sound-producing, communicative, sound-facilitating, and sound-accompanying.
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11. See also Berry (2009, [2]), who proposes the term "practical bodily gesture" to refer to "movements of the body that are concerned with producing sound from one's instrument."
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12. The minimization of the individual in gagaku is also reflected in the fact that names of composers for many classical pieces are seldom known or recorded.
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13. I thank Steven G. Nelson for bringing this point to my attention. Drawing upon James Gibson's (1986) theory of affordances, previous work in music perception and empirical musicology has explored the correlation between instrument design and musical idiomaticity (Huron and Berec 2009; Windsor and de Bézenac 2012).
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14. The practice of translating gagaku into Western notation is also common outside the realm of scholarly discourse. For example, Shiba Sukehiro (1969, 1971), former head of the Music Department of the Imperial Household Agency, transcribed a number of Gagaku works into Western notation. For a brief introduction to the theory of the gagaku tone system, see Garfias 1975, 57–71.
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15. Andrew Mead also suggests the possibility of "different patterns of nearness for production versus perception" (1999, 8).
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16. The finger holes for the *otsu*, *ge*, and *hi* pipes are located on the inside rather than on the outside. Moreover, given its physical location on the instrument, the *hi* pipe is pressed using the backside of the ring finger.
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17. Whereas Lewin's Generalized Interval System (GIS) is based on a Cartesian perspective, which positions the listener as an external observer to model distances between two musical objects, the STRANS system adopts a transformational perspective, which encapsulates both the idea of the interval as distance and as motion (Satyendra 2004, 100). The STRANS perspective rephrases the logic of measuring the "intervallic distance from *s* to *t*" into the following statement: "Ti is the unique transposition operation on this space that maps *s* into *t*" (Lewin 1987, 157).
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18. The reader will notice that the pipes *ya* and *mō*, respectively numbered 9 and 16 in Example 2a, are left out of the formula, as neither is used in playing *aitake*.
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19. The following formula is modeled after Joti Rockwell's Definition 1 (2009a, 140).
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20. The alignment of the fingers on the shō from right to left correlates with the order of the letter designations in the formula.
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21. Whereas the finger hole for *jū* is located on the side of the pipe facing the performer, the hole for *ge* is located on the side of the pipe facing away from the performer.
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22. The performer's experience of a movement in clockwise or counterclockwise motion, however, depends on which finger they are moving. While a movement in clockwise motion requires extending the right-hand thumb or left-hand ring finger, a movement in the same direction requires the performer to contract their right-hand index finger or left-hand thumb.
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23. Dmitri Tymoczko asks a somewhat similar question in the context of voice-leading size in Western common-practice music theory: "is the smaller voice leading the one that minimizes the total amount of motion or the largest distance moved by any voice?" (2011, 49). For Tymoczko, having more voices moving by smaller distances constitutes a "smaller" voice leading as compared to fewer voices that move by larger distances.
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24. The approach of categorizing *aitake* based on the gestural proximity of *te-utsuri* is similar to that of Richard Cohn's voice-leading zones, which categorize major and minor triads based on the distance (in voice-leading units) from the C augmented triad (2012, 102–6).
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25. The only exception is *aitake kotsu*, which shares four out of the five pitches (A5, B5, E6, F♯6) in *aitake gyō*.
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26. The *aitake gyō* as well as *jū* in *Sōjō* mode pose interesting questions about issues of cardinality and present a promising direction for future research. The issue of cardinality has been a recurring theoretical issue in considering parsimonious voice leading: see Cheung 2018, Childs 1998, Rockwell 2009b, Straus 2003, and Tymoczko 2011.
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27. *Otsu,* in fact, is the only member of Category 1 that can be reached via minimally parsimonious *te-utsuri* from *jū*: moving from *jū* to *ge* and *bō* each requires a total of three finger hole traversals, and motion from *jū* to *ichi* and *kotsu* requires a total of four finger holes (Appendix). Moving from *jū* to *aitake* in Categories 2 and 3 requires more laborious *te-utsuri*. Similarly, the closest *aitake* to *ge* are *ichi* and *otsu* in Category 1, *jū* in Category 2, and *bi* in Category 3, each requiring a traversal of three finger holes in total, with *bō* and *kotsu* (both Category 1) requiring transformations of four and five finger holes, respectively.
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28. According to the rules established in Example 13, the *te-utsuri* from *jū* (Category 2) to *otsu* (Category 1) [*TU*(-1, +1, 0, 0)] is more proximate than that from *kotsu* to *otsu* [*TU*(0, 0, 0, -2)], both of which are in Category 1. This exception does not suggest that *jū* should also be considered a Category 1 *aitake*. Category 1 constitutes a network of *aitake* that are connected to one another through minimally parsimonious *te-utsuri*. Since there is only one *aitake* from which *jū* can be reached by minimally parsimonious *te-utsuri*, *jū* cannot belong in Category 1. While the reason for this will be explored in further detail later in the article, for now it is sufficient to note that *jū*

cannot be categorized as a Category 1 *aitake* due to a lack of consistency in the *te-utsuri* proximity between *jū* and the other Category 1 *aitake*.
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29. In principle, shō players must first memorize *shōga* (唱歌), a system of mnemonics used for learning repertoire, before learning *te-utsuri*. To this day, all musical knowledge is transmitted orally from teacher to student through the recitation of *shōga* (Shono 1987, 25). In the Music Department of the Imperial Household Agency, for example, students are only permitted to lay their hands on an actual instrument after demonstrating mastery of *shōga*. In university courses and amateur ensembles, however, *te-utsuri* is taught in tandem with *shōga*.
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30. Ōno's discussion of *shōga* for shō follows the format of "Te-utsuri Kudensho" (「手移口伝書」), a set of notes on *te-utsuri* compiled by his colleague Yamanoi Motokiyo (山井基清; 1885–1970). Yamanoi's notes are considered by many to be the authoritative source on te-utsuri. The notes (published in Ōno 1996, 369–88) were originally passed down to Yamanoi from Imperial Household Agency musician Ōno Tadayori (多忠保; 1873–1941).
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31. *Goshōraku-no-kyū*, the third section of a three-part work, represents five moral principles: benevolence, social responsibility, respect, wisdom, and trustworthiness.
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32. Each *hyōshi*—which loosely translates to "metrical phrase"—in *Goshōraku-no-kyū* is comprised of four "measures" consisting of eight beats for a total of 32 beats. Each measure contains either one or two *aitake*. If a single measure contains two *aitake*, their durations are equal and thus each *aitake* lasts for two beats.
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33. In his analysis of Sofia Gubaidulina's *Pantomime*, Berry makes a similar case from the perspective of the audience, noting that audience members are able to "experience the piece through their bodies as it unfolds, recognizing periods of tension and relaxation as a kind of musical form" (2009, [14]).
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34. The definition of *chōshi* has no equivalent in Western music and thus requires an unpacking of Japanese aesthetics and the tone system of gagaku to fully appreciate its inner workings, which is beyond the scope of this study. Broadly speaking, the concept is construed as a pattern of melodic movement according to the mode in which the piece is set. For a more detailed discussion of *chōshi*, see Endō 2013, 137–45 and 153–62, Marett 2001b, and Masumoto 2010, 203–7.
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35. Hayashi has also noted that the pitch-class content for any given *aitake* falls within the range of seven consecutive fifths (Hayashi 1954, 22).
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36. Ogyū Sorai, *Kingaku Dai-ishō* (琴学大意抄)(1722); Tayasu Munetake, *Gakkyokukō Furoku* (楽曲考付録)(1768) (Hayashi 1954, 18).
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37. The procedures for tuning gagaku instruments—especially the shō and the *gakusō*—and the problems caused by these tuning systems are outlined in Tōgi 1989, Akedo 2011, and Service 2012.
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38. The shō is only capable of playing nine of the twelve pitch classes in the tone system. János Kárpáti has echoed this claim, noting that "there is no mention in the sources of actual musical material being transposed into all twelve degrees" (1983, 175).
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39. For a detailed theoretical discussion of the *ryo* and *ritsu* modes, see Garfias 1975 (59–63), Service 2012 (187–94), and Endō 2013 (134–46).
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40. More detailed comparisons of the Japanese and Chinese tone systems are offered in Hayashi 1954 and Garfias 1975, whereas historical analyses of the differences between the Japanese and Chinese traditions can be found in Marett 1985, Watanabe 2009, and Ono 2016.
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41. Tuning techniques used in gagaku (e.g., Method of Subtracting and Adding Thirds, Method of Advancing Six and Retreating Eight, and Method of Advancing Eight and Retreating Six; terms translated into English in Service 2012, 187–91) are outlined in Akedo 2011 and Service 2012, 187–92.
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42. This finding is consistent with Malm's observation which designates D as "the basic pitch of the Japanese tonal system" (2000, 114).
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43. As with the *aitake gyō*, jū (*Sōjō*) is categorized as a Category 2 *aitake* due to differences in cardinality.
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44. Cusick's vision towards an embodied music theory has been pursued by a growing number of music theorists in recent years (Abrahams 2019; Cox 2011; De Souza 2017, 2018; Doğantan-Dack 2011; Easley 2015; Koozin 2011; Kozak 2019; Montague 2012; Rockwell 2009a; Sterbenz 2017). The relationship between instrumental gesture and musical sound has also been explored by ethnomusicologists (Baily 1977, 2006; Baily and Driver 1992; Yung 1984).
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Prepared by Michael McClimon, Senior Editorial Assistant

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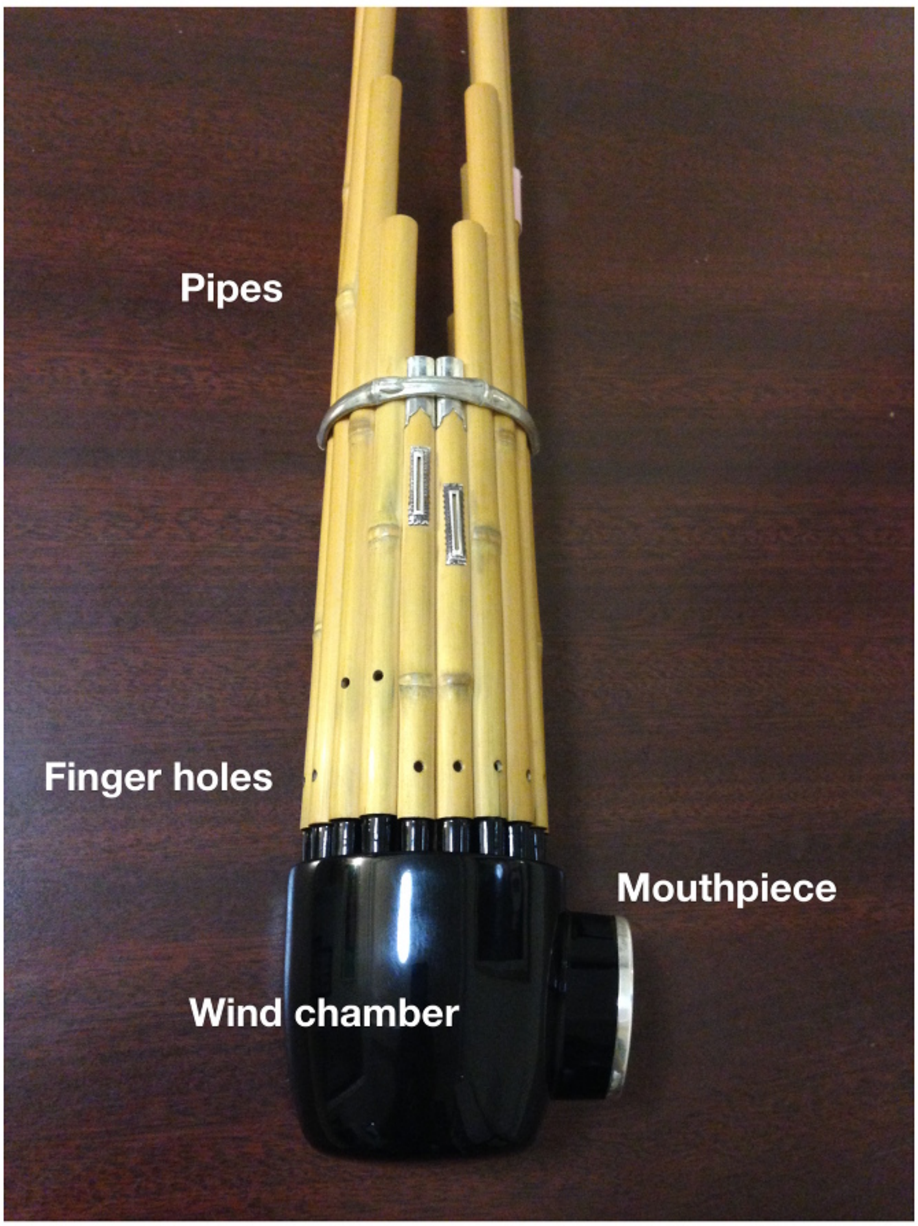
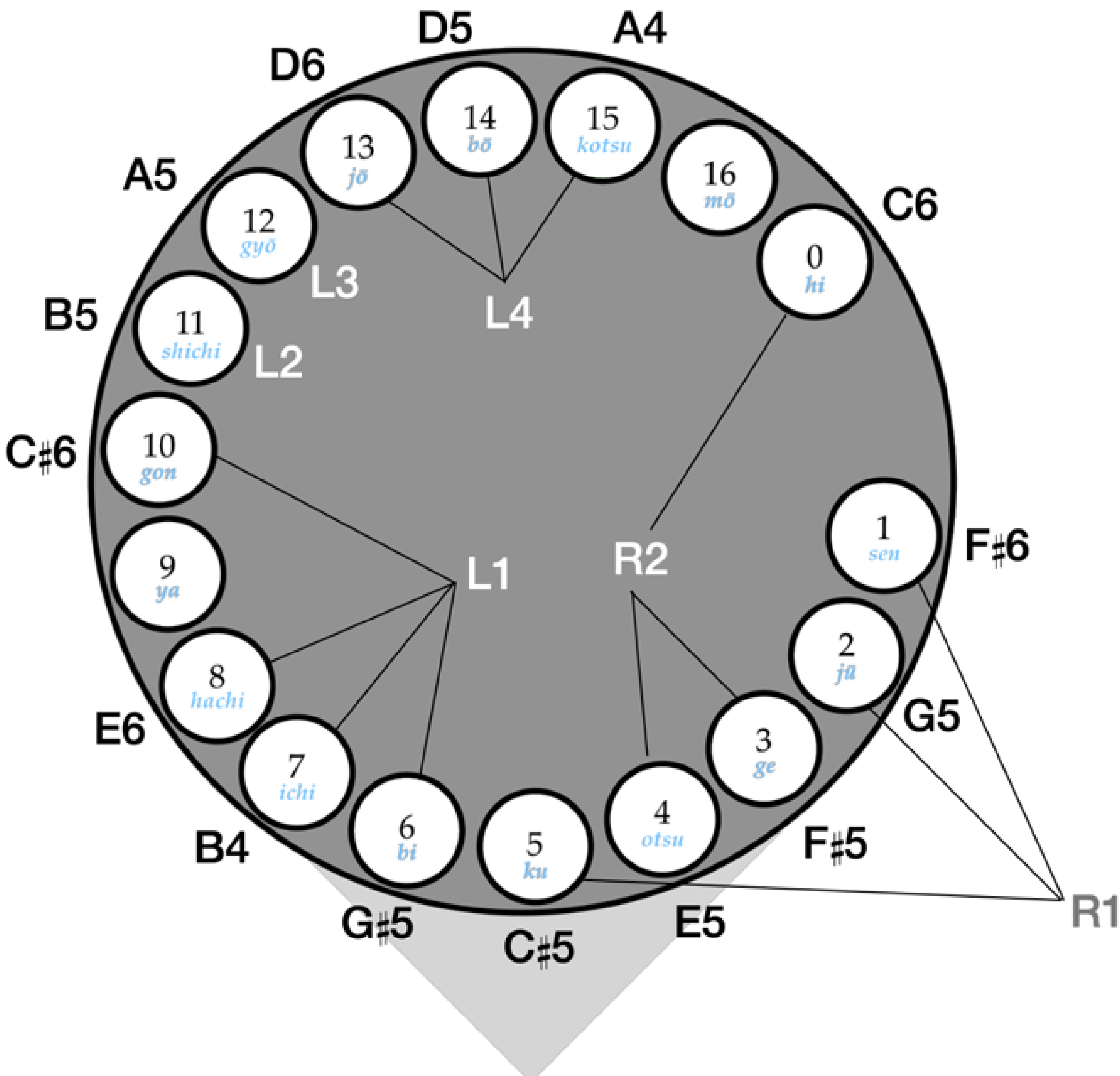
MTO 26.4 Examples: Momii, A Transformational Approach to Gesture in Shō Performance

(Note: audio, video, and other interactive examples are only available online)
https://mtosmt.org/issues/mto.20.26.4/mto.20.26.4.hannaford.html

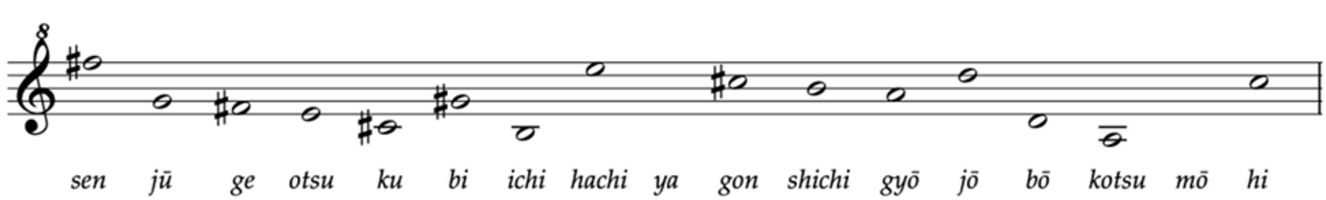
Example 1. Parts of the shō



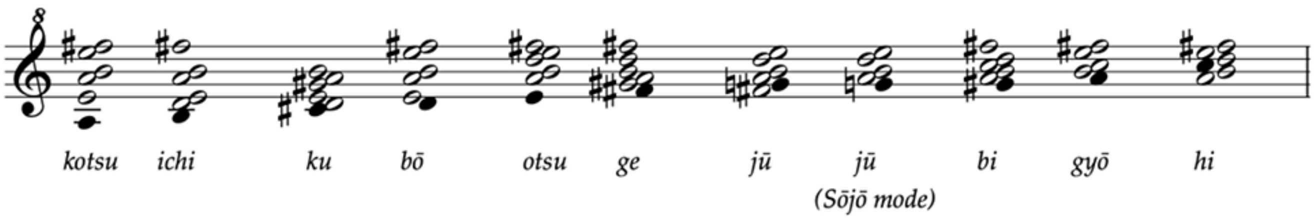
Example 2a. Pipe holes and fingerings of the shō



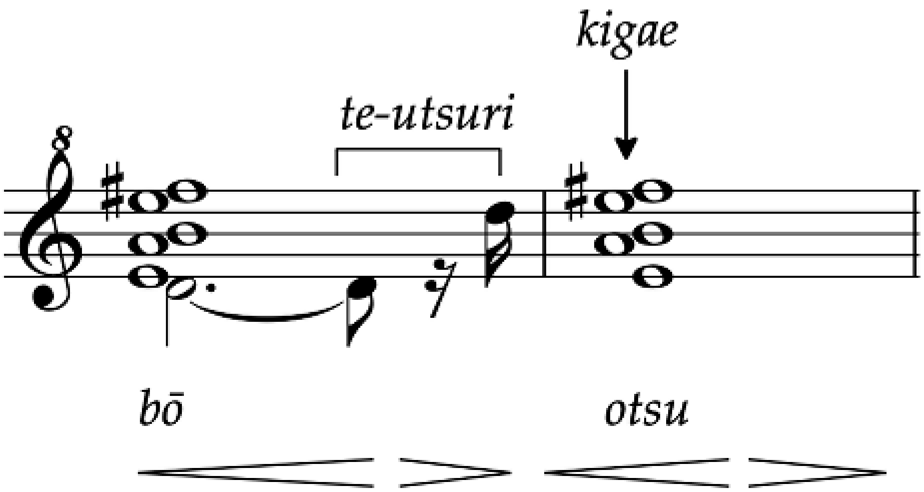
Example 2b. Pitches of each shō pipe shown in Western notation



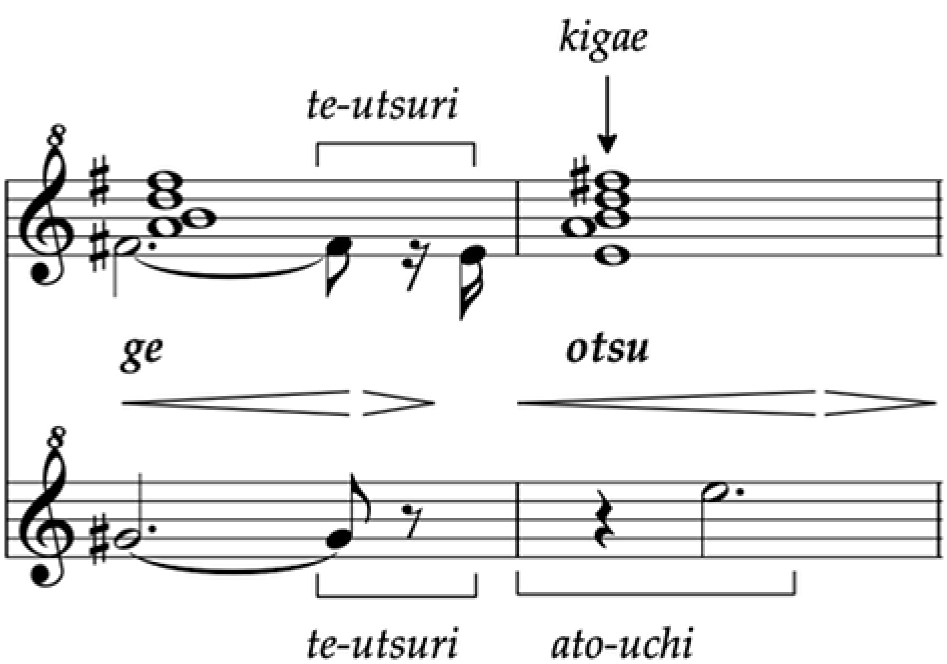
Example 3. List of *aitake*



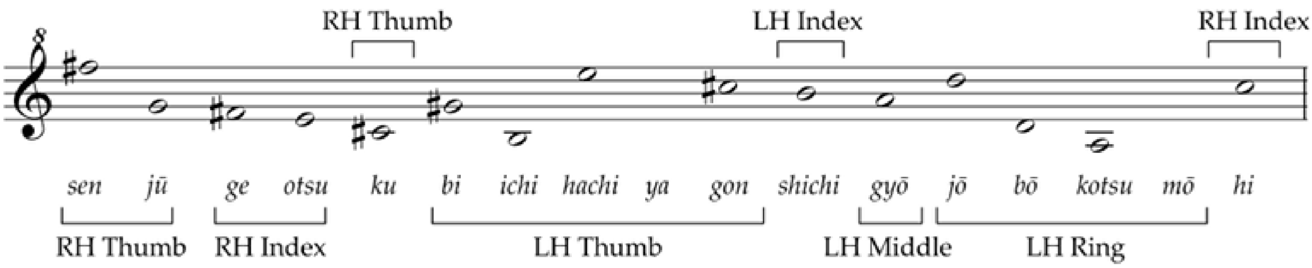
Example 4. *Te-utsuri* and kigae in Western notation

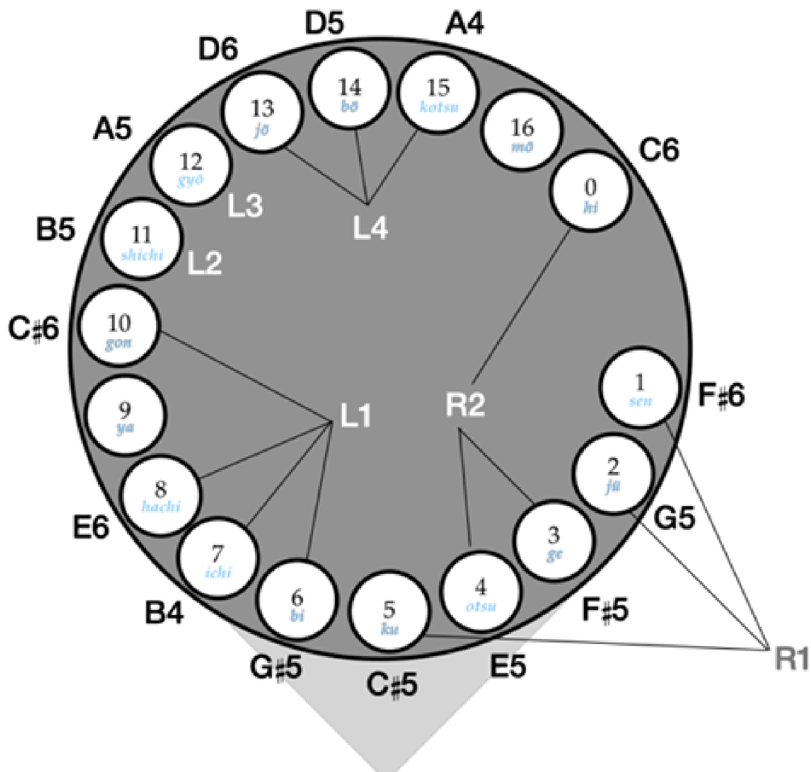


Example 5. The *ato-uchi* technique in Western notation

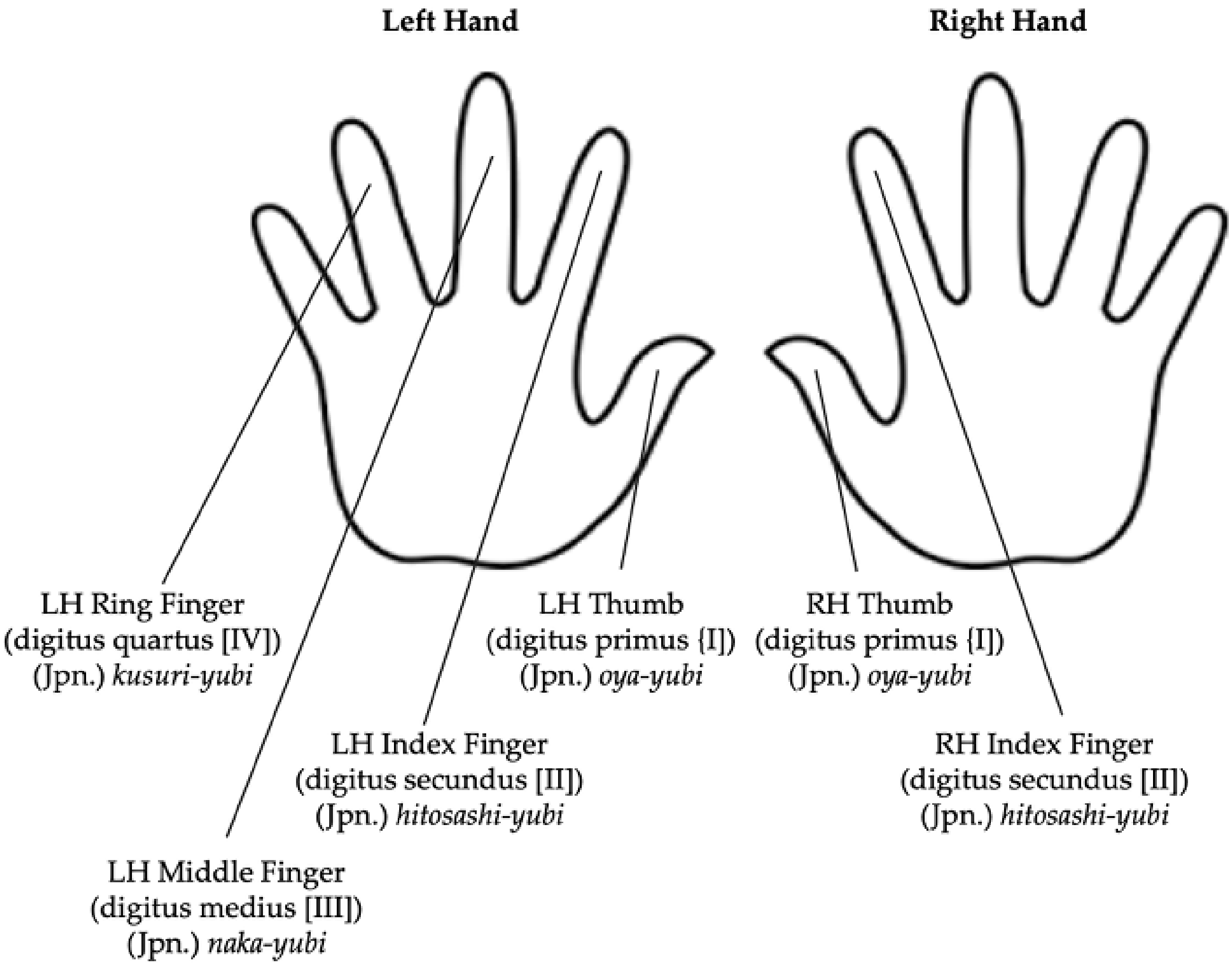


Example 6. Distribution of finger holes across the left hand (LH) and right hand (RH)

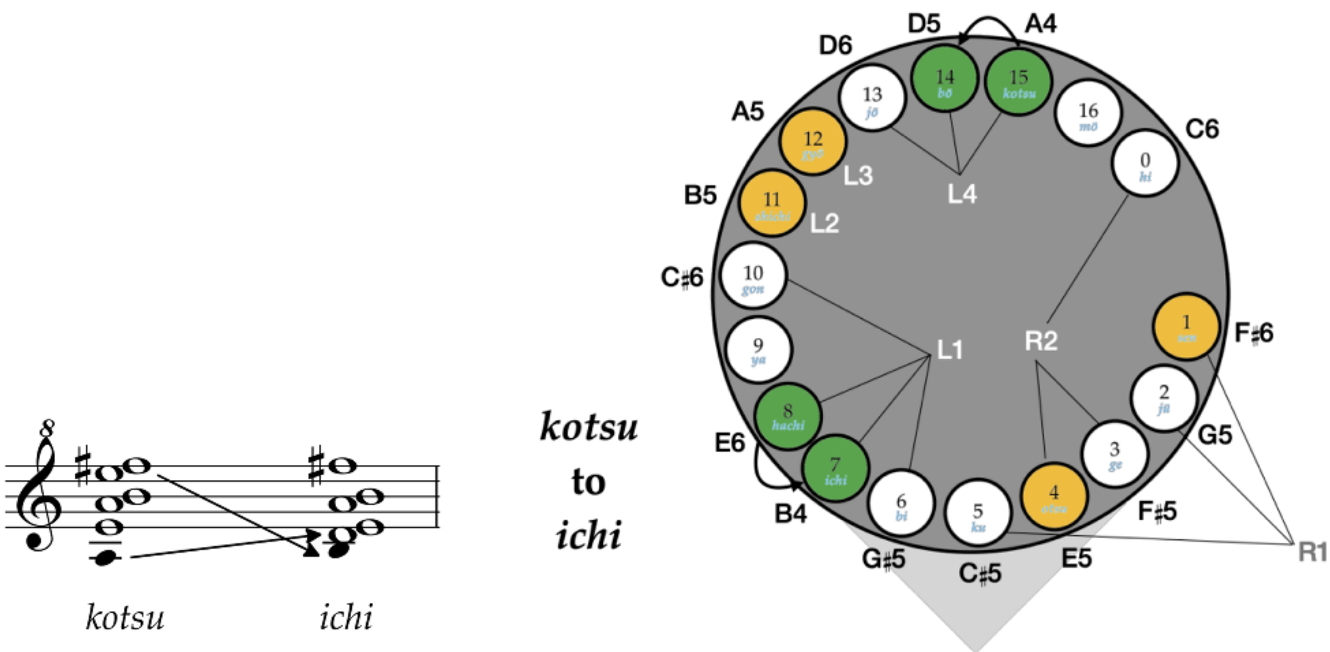




Example 7. Diagram of fingers used in shō performance



Example 8. *Te-utsuri* from *aitake kotsu* to *aitake ichi*



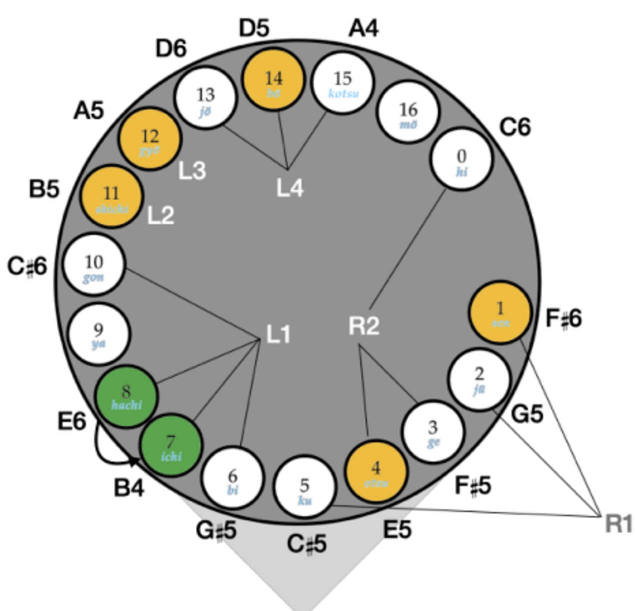
Example 9. List of *aitake* expressed in the form of (R1, R2, L1, L4)

Aitake	**Expressed as (R1, R2, L1, L4)**
kotsu (乞)	(1, 4, 8, 15)
ichi (一)	(1, 4, 7, 14)
ku (工)	(5, 4, 6, 14)
bō (凢)	(1, 4, 8, 14)
otsu (乙)	(1, 4, 8, 13)
ge (下)	(1, 3, 6, 13)
jū (十)	(2, 3, 8, 13)
jū (*Sōjō*)(十[双調])	(2, –, 8, 13)
bi (美)	(1, 0, 6, 13)
gyō (行)	(1, –, 8, 13)
hi (比)	(1, 0, 8, 13)

Example 10. Summary of *te-utsuri* between six-note *aitake*

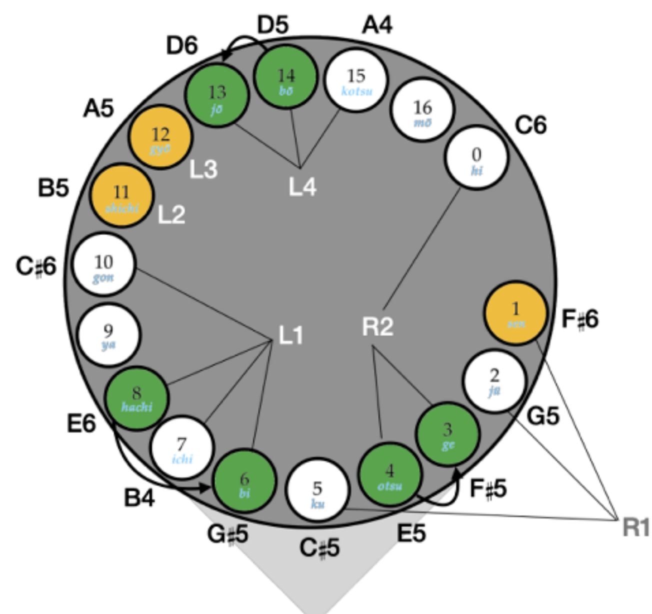
		To								
		Kotsu (A)	Ichi (B)	Hi (C)	Ku (C♯)	Bo (D)	Otsu (E)	Ge (F♯)	Ju (G)	Bi (G♯)
From	Kotsu (A)		(0, 0, -1, -1)	(0, -4, 0, -2)	(+4, 0, -2, -1)	(0, 0, 0, -1)	(0, 0, 0, -2)	(0, -1, -2, -2)	(+1, -1, 0, -2)	(0, -4, -2, -2)
	Ichi (B)	(0, 0, +1, +1)		(0, -4, +1, -1)	(+4, 0, -1, 0)	(0, 0, +1, 0)	(0, 0, +1, -1)	(0, -1, -1, -1)	(+1, -1, +1, -1)	(0, -4, -1, -1)
	Hi (C)	(0, +4, 0, +2)	(0, +4, -1, +1)		(+4, +4, -2, +1)	(0, +4, 0, +1)	(0, +4, 0, 0)	(0, +3, -2, 0)	(+1, +3, 0, 0)	(0, 0, -2, 0)
	Ku (C♯)	(-4, 0, +2, +1)	(-4, 0, +1, 0)	(-4, -4, +2, -1)		(-4, 0, +2, 0)	(-4, 0, +2, -1)	(-4, -1, 0, -1)	(-3, -1, +2, -1)	(-4, -4, 0, -1)
	Bo (D)	(0, 0, 0, +1)	(0, 0, -1, 0)	(0, -4, 0, -1)	(+4, 0, -2, 0)		(0, 0, 0, -1)	(0, -1, -2, -1)	(+1, -1, 0, -1)	(0, -4, -2, -1)
	Otsu (E)	(0, 0, 0, +2)	(0, 0, -1, +1)	(0, -4, 0, 0)	(+4, 0, -2, +1)	(0, 0, 0, +1)		(0, -1, -2, 0)	(+1, -1, 0, 0)	(0, -4, -2, 0)
	Ge (F♯)	(0, +1, +2, +2)	(0, +1, +1, +1)	(0, -3, +2, 0)	(+4, +1, 0, +1)	(0, +1, +2, +1)	(0, +1, +2, 0)		(+1, 0, +2, 0)	(0, -3, 0, 0)
	Ju (G)	(-1, +1, 0, +2)	(-1, +1, -1, +1)	(-1, -3, 0, 0)	(+3, +1, -2, +1)	(-1, +1, 0, +1)	(-1, +1, 0, 0)	(-1, 0, -2, 0)		(-1, -3, -2, 0)
	Bi (G♯)	(0, +4, +2, +2)	(0, +4, +1, +1)	(0, 0, +2, 0)	(+4, +4, 0, +1)	(0, +4, +2, +1)	(0, +4, +2, 0)	(0, +3, 0, 0)	(+1, +3, +2, 0)	

Example 11. Comparing gestural proximity between two te-utsuri operations



te-utsuri from *bō* to *ichi*: $TU_{(0, 0, -1, 0)}$

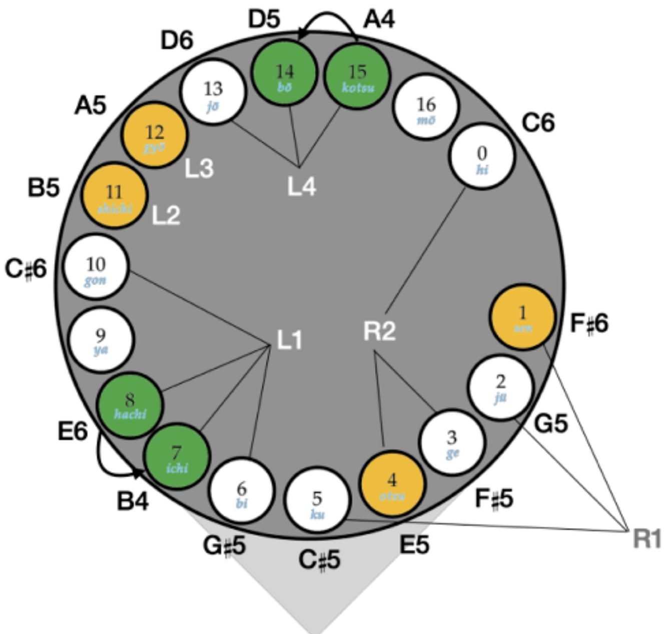
(gesturally proximate)



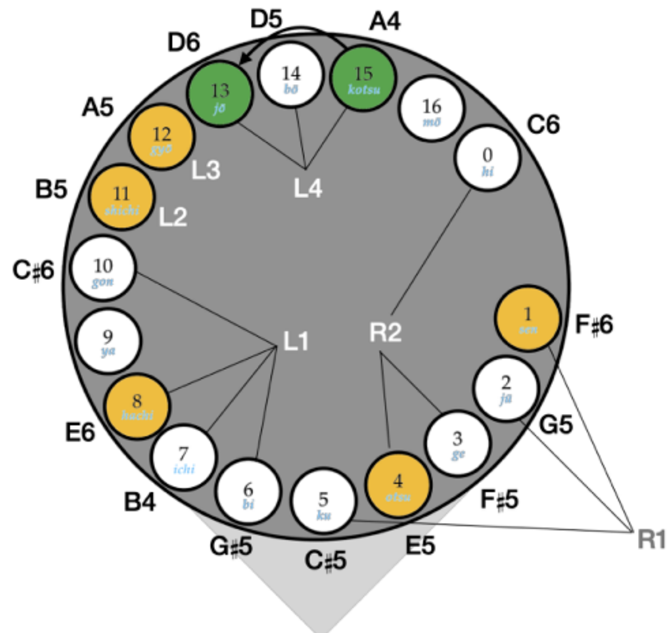
te-utsuri from *bō* to *ge*: $TU_{(0, -1, -2, -1)}$

(gesturally distant)

Example 12. Comparing gestural proximity between two *te-utsuri* operations with the same number of finger hole traversals



te-utsuri from *kotsu* to *ichi*: $TU_{(0, 0, -1, -1)}$
(gesturally proximate)



te-utsuri from *kotsu* to *otsu*: $TU_{(0, 0, 0, -2)}$
(gesturally distant)

Example 13. Rules for comparing the gestural proximity of multiple *te-utsuri* operations

STEP 1: Count the total number of finger hole shifts.

Example: Because the *te-utsuri* between *ichi* and *bō* requires a fewer total number of finger hole traversals (1) than the *te-utsuri* from *ichi* to *jū* (4), the former is deemed more gesturally proximate than the latter.

STEP 2: If STEP 1 yields the same number of finger hole traversals, then count the number of fingers involved in the *te-utsuri*. The *te-utsuri* with a larger number of fingers moving by smaller distances is more gesturally proximate than that with a small number of fingers moving by larger distances.

Example: Both the *te-utsuri* from *ge* to *otsu* [$TU_{(0, +1, +2, 0)}$] and from *ge* to *ichi* [$TU_{(0, +1, +1, +1)}$] require the same number of finger hole traversals (3). The *te-utsuri* from *ge* to *ichi* is more gesturally proximate, because the operation involves a larger number of fingers moving by smaller distances.

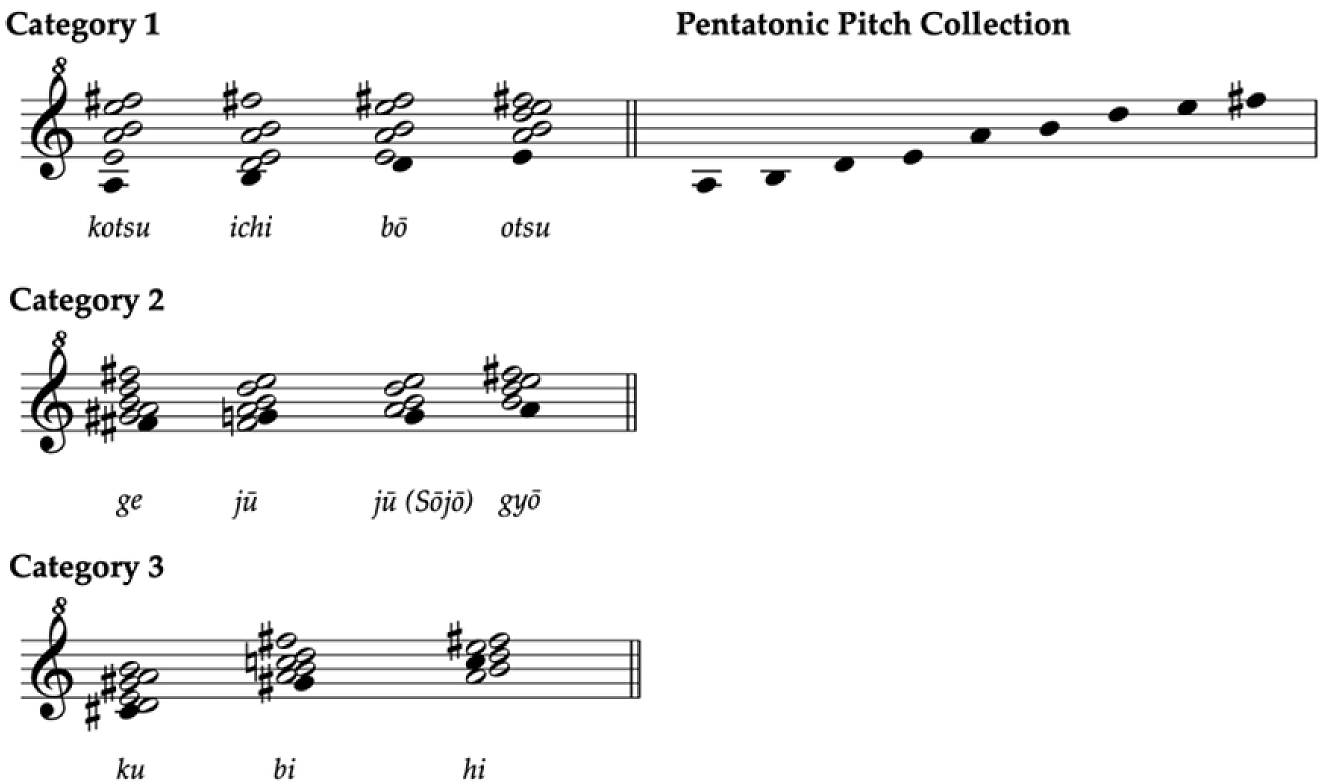
Example 14. *Te-utsuri* operations from *aitake jū* to *aitake ichi*, *kotsu*, and *hi*, listed in order of gestural proximity

	Te-utsuri	***TU*** **(a, b, c, d) operation**	**Number of Finger Holes Traversed (*a* + *b* + *c* + *d*)**	**Number of Shifting Fingers**	**Shifting Fingers (R1, R2, L1, L4)**			
Most Proximate	*jū to ichi*	(-1, +1, -1, +1)	4	4	R1	R2	L1	L4
	jū to kotsu	(-1, +1, 0, +2)	4	3	R1	R2		L4
Least Proximate	*jū to hi*	(-1, -3, 0, 0)	4	2	R1	R2		

Example 15. *Te-utsuri* operations from *aitake ichi*, listed in order of gestural proximity

	Te-utsuri	***TU*** **(a, b, c, d) operation**	**Number of Finger Holes Traversed (*a* + *b* + *c* + *d*)**	**Number of Shifting Fingers**	**Shifting Fingers (R1, R2, L1, L4)**				
Most Proximate	*ichi to bō*	(0, 0, +1, 0)	1	1			L1		**Minimally Parsimonious**
	ichi to otsu	(0, 0, +1, -1)	2	2			L1	L4	
	ichi to kotsu	(0, 0, +1, +1)	2	2			L1	L4	
	ichi to ge	(0, -1, -1, -1)	3	3		R2	L1	L4	
	ichi to jū	(+1, -1, +1, -1)	4	4	R1	R2	L1	L4	
	ichi to ku	(+4, 0, -1, 0)	5	2	R1		L1		
	ichi to bi	(0, -4, -1, -1)	6	3		R2	L1	L4	
Least Proximate	*ichi to hi*	(0, -4, +1, -1)	6	3		R2	L1	L4	

Example 16. Categorization of *aitake*



Example 17. *Te-utsuri* from *aitake ichi* to *aitake gyō*

Example 18. List of all minimally parsimonious *te-utsuri*

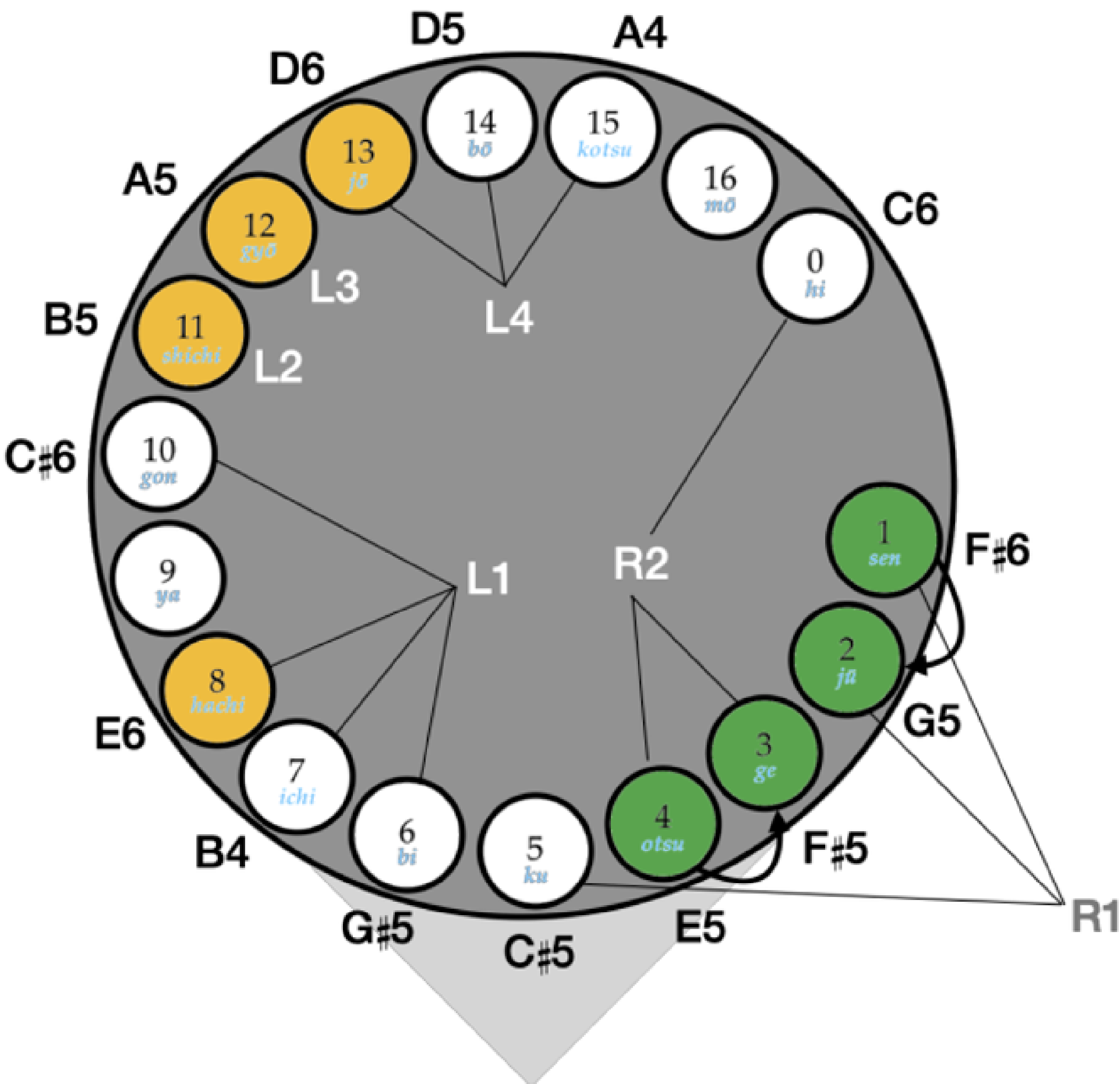
Category 1 ⇆ Category 1

Te-utsuri	$TU_{(a, b, c, d)}$ operation	Fingering Shifts			
		LH Ring Finger	LH Thumb	RH Thumb	RH Index Finger
bō to kotsu	(0, 0, 0, +1)	*Bō* (D5) to *Kotsu* (A4)			
bō to otsu	(0, 0, 0, -1)	*Bō* (D5) to *Jō* (D6)			
bō to ichi	(0, 0, -1, 0)		*Hachi* (E6) to *Ichi* (B4)		
ichi to bō	(0, 0, +1, 0)		*Ichi* (B4) to *Hachi* (E6)		
ichi to otsu	(0, 0, +1, -1)	*Bō* (D5) to *Jō* (D6)	*Ichi* (B4) to *Hachi* (E6)		
ichi to kotsu	(0, 0, +1, +1)	*Bō* (D5) to *Kotsu* (A4)	*Ichi* (B4) to *Hachi* (E6)		
kotsu to bō	(0, 0, 0, -1)	*Kotsu* (A4) to Bō (D5)			
kotsu to ichi	(0, 0, -1, -1)	*Bō* (D5) to *Kotsu* (A4)	*Hachi* (E6) to *Ichi* (B4)		
kotsu to otsu	(0, 0, 0, -2)	*Kotsu* (A4) to *Jō* (D6)			
otsu to bō	(0, 0, 0, +1)	*Jō* (D6) to *Bō* (D5)			
otsu to ichi	(0, 0, -1, +1)	*Jō* (D6) to *Bō* (D5)	*Hachi* (E6) to *Ichi* (B4)		
otsu to kotsu	(0, 0, 0, +2)	*Jō* (D6) to *Kotsu* (A4)			

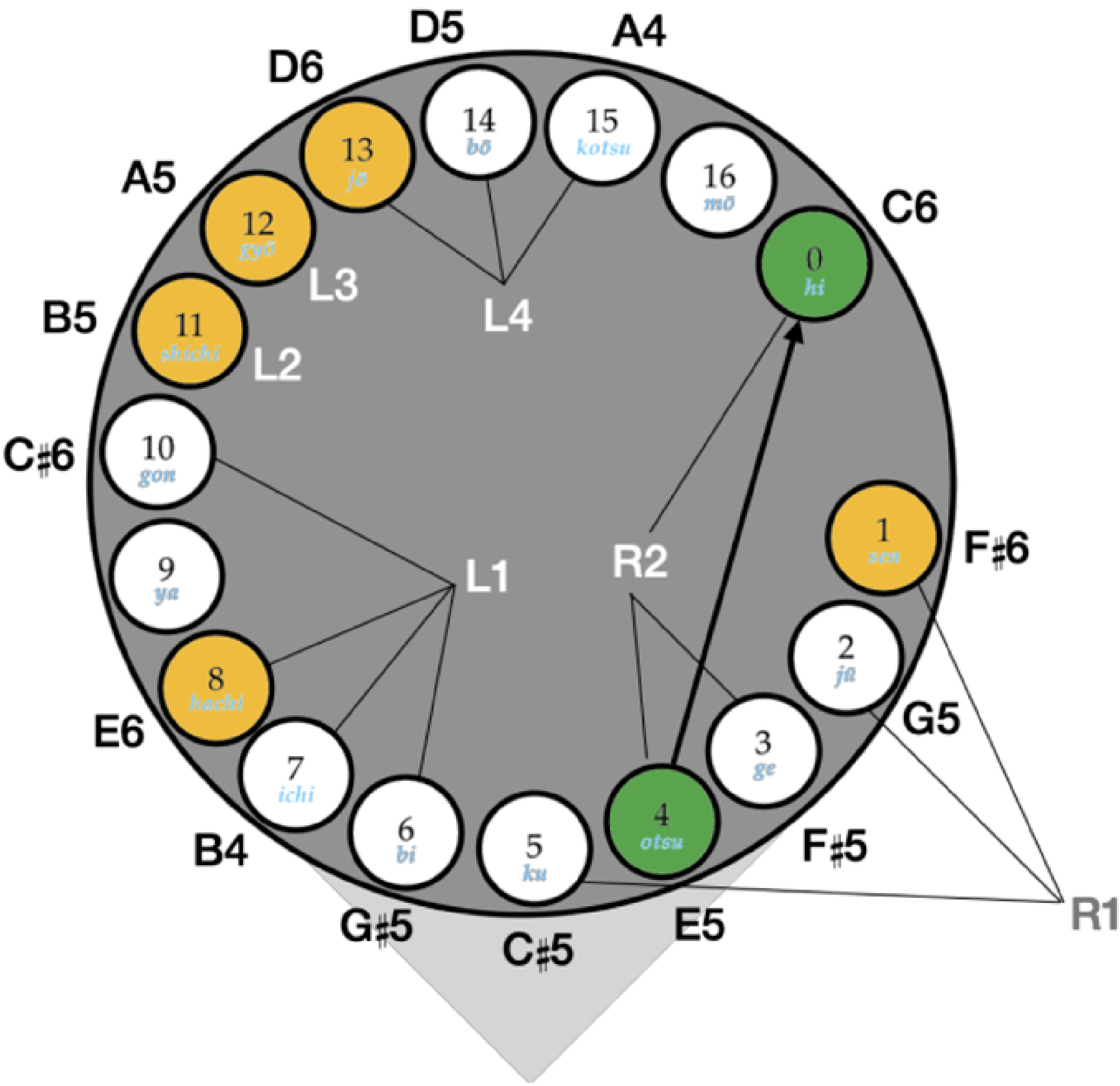
Category 2 ⇆ Category 1

otsu to jū	(+1, -1, 0, 0)			*Sen* (F#6) to *Jū* (G5)	*Otsu* (E5) to *Ge* (F#5)
jū to otsu	(-1, +1, 0, 0)			*Jū* (G5) to *Sen* (F#6)	*Ge* (F#5) to *Otsu* (E5)

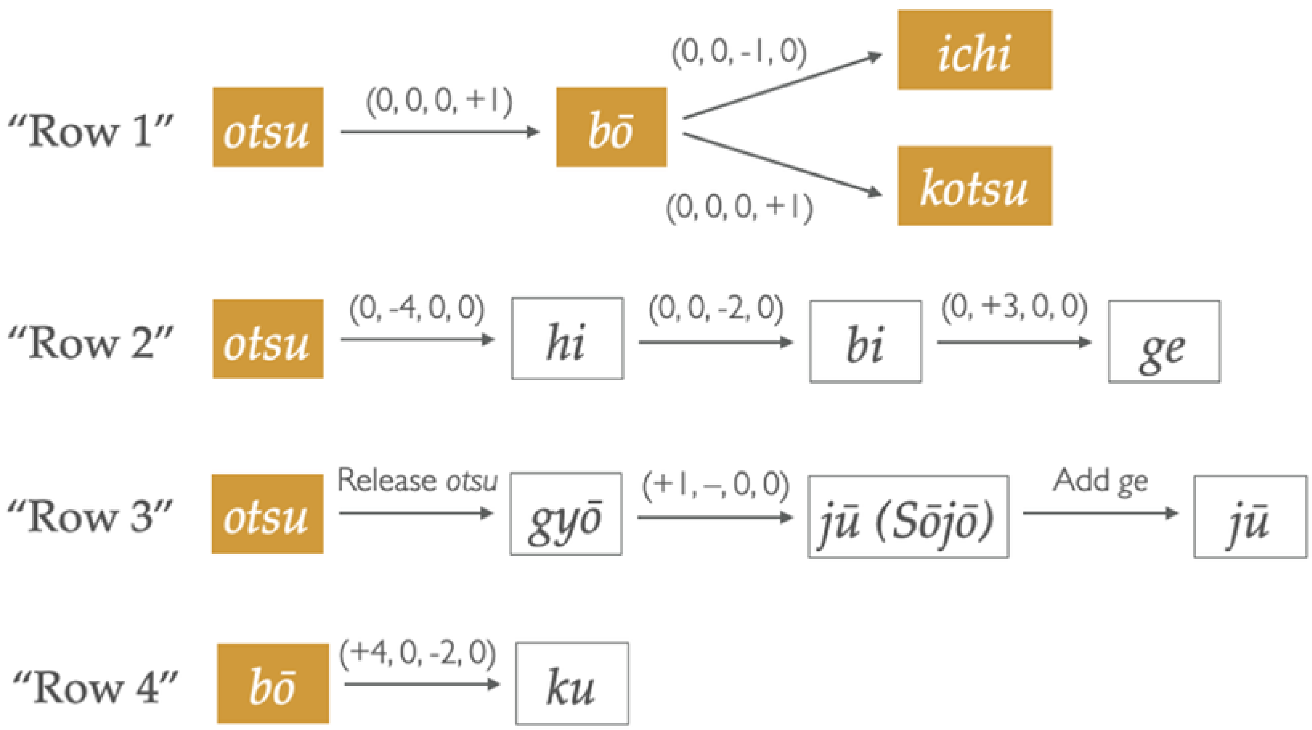
Example 19a. *Te-utsuri* from *aitake otsu* to *aitake jū*. The left-hand placement for *jū* is identical to that of *otsu*, and the right thumb and right index finger each shift by one finger hole



Example 19b. *Te-utsuri* from *aitake otsu* to *aitake hi*. The left-hand placement for *hi* is identical to that of *otsu*, and the right index finger requires each of its fingers to shift by one finger hole



Example 20. Method of organizing *aitake* as proposed by Yamanoi Motokiyo's "Te-utsuri Kudensho"



Example 21. Summary of *te-utsuri* and *aitake* in *Goshōraku-no-kyū*

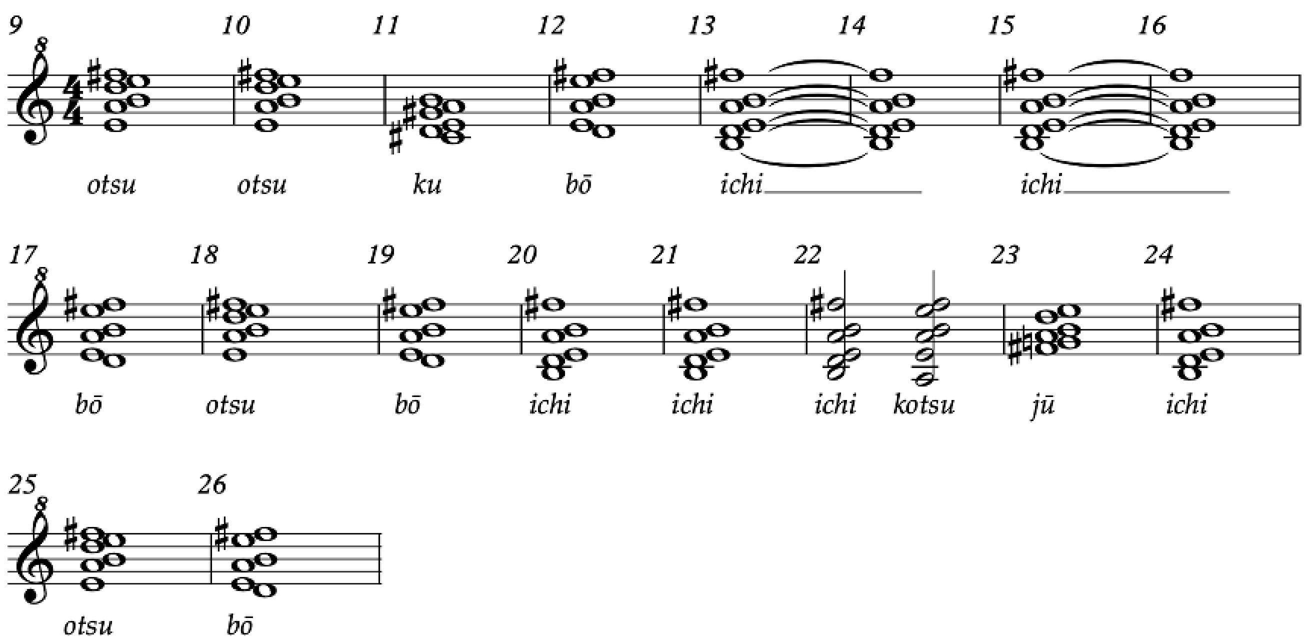
(a)Summary of *aitake* and *te-utsuri* in *Goshōraku-no-kyū*

Measure	9	10	11	12	13	14	15	16	17
Category	1	1	3	1	1	1	1	1	1
pitch classes	(02479)	(02479)	(013568)	(02479)	(02479)	(02479)	(02479)	(02479)	(02479)
aitake	*otsu*	*otsu*	*ku*	*bō*	*ichi*	*ichi*	*ichi*	*ichi*	*bō*
Te(e,f,g,h)		(+4,0,-2,+1)	(-4,0,+2,0)	(0,0,-1,0) Parsimonious				(0,0,+1,0) Parsimonious	

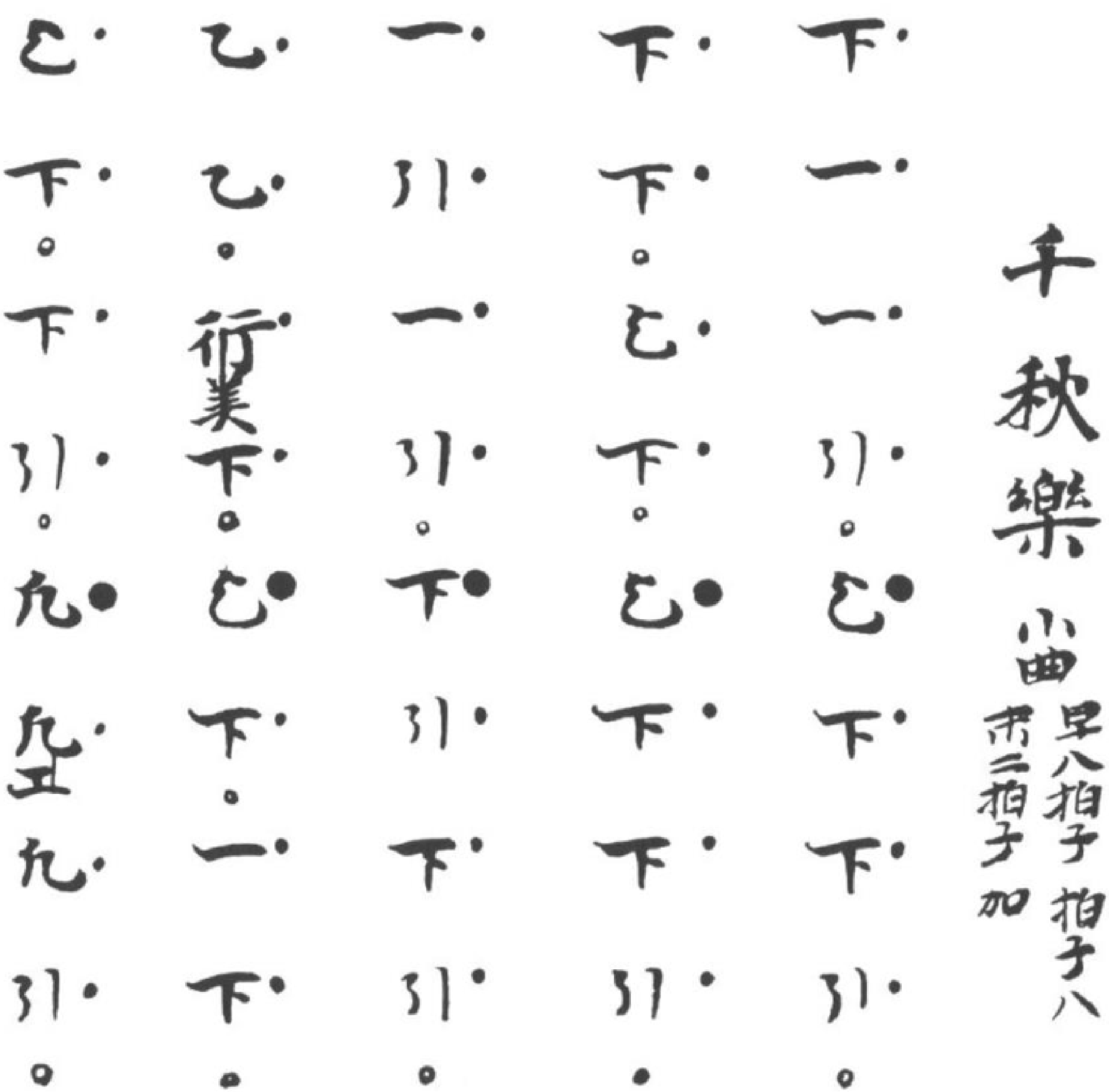
Measure	17	18	19	20	21	22	22	23	24	25
Category	1	1	1	1	1	1	1	2	1	1
pitch classes	(02479)	(02479)	(02479)	(02479)	(02479)	(02479)	(0257)	(024579)	(02479)	(02479)
aitake	*bō*	*otsu*	*bō*	*ichi*	*ichi*	*ichi*	*kotsu*	*jū*	*ichi*	*otsu*
Te(e,f,g,h)	(0,0,0,-1) Parsimonious	(0,0,0,+1) Parsimonious	(0,0,-1,0) Parsimonious			(0,0,+1,+1) Parsimonious	(+1,-1,0,-2)	(-1,+1,-1,+1)	(0,0,+1,-1) Parsimonious	

Measure	25	26	27	27	28	29	30	31	32
Category	1	1	2	2	1	1	1	1	1
pitch classes	(02479)	(02479)	(024579)	(02358)	(02479)	(02479)	(02479)	(02479)	(02479)
aitake	*otsu*	*bō*	*jū*	*ge*	*otsu*	*otsu*	*otsu*	*otsu*	*otsu*
Te(e,f,g,h)	(0,0,0,+1) Parsimonious	(+1,-1,0,-1)	(-1,0,-2,0)	(0,+1,+2,0)					

(b)Western transcription of *Goshōraku-no-kyū*, mm. 9–26



Example 22. Notation of *aitake* for the piece *Senshūraku* in *Banshiki-chō* mode (notation is read from top to bottom and right to left. Each of the characters represents an aitake)



Example 23. Frequency of *te-utsuri* and duration of *aitake* in *Goshōraku-no-kyū*

	Motion	Count	Category		Duration (beats)		Duration	Percentage
	jū to ge	4	C2 to C2	*otsu*	44	Consonance	92	71.9%
	ge to jū	4	C2 to C2	*ichi*	30	Non-consonance	36	28.1%
	jū to otsu	4	C2 to C1	*jū*	22			
	bō to ichi	4	C1 to C1	*bō*	16		**No. of occurences**	**Percentage**
	kotsu to bō	3	C1 to C1	*ge*	10	C1 to C1	15	37.5%
	bō to otsu	2	C1 to C1	*ku*	4	C1 to C2	7	17.5%
	otsu to ge	2	C1 to C2	*kotsu*	2	C2 to C1	6	15.0%
	otsu to ku	2	C1 to C3			C2 to C2	8	20.0%
	ku to bō	2	C3 to C1			C1 to C3	2	5.0%
	ichi to kotsu	2	C1 to C1			C3 to C1	2	5.0%
***Goshōraku-no-kyū* (五常楽急)**	*kotsu to jū*	2	C1 to C2			C2 to C3	0	0.0%
	jū to ichi	2	C2 to C1			C3 to C2	0	0.0%
	bō to jū	2	C1 to C2			C3 to C3	0	0.0%
	ichi to otsu	2	C1 to C1					**100.0%**
	ichi to bō	1	C1 to C1					
	ichi to jū	1	C1 to C2				**Percentage**	
	otsu to bō	1	C1 to C1			Cons. to Cons.	37.5%	
						Cons. to Diss.	22.5%	
						Diss. to Cons.	20.0%	
						Diss. to Diss.	20.0%	
							100.0%	

Example 24. Pitch-class and intervallic structures of Category 1 aitake

Aitake	Category	Pitch-classes (Normal Order)	Set-class	Interval Class Vector
kotsu (乞)	Category 1	E, F♯, A, B	(0257)	<021030>
ichi (一)		A, B, D, E, F♯	(02479)	<032140>
otsu (乙)		A, B, D, E, F♯	(02479)	<032140>
bō (几)		A, B, D, E, F♯	(02479)	<032140>

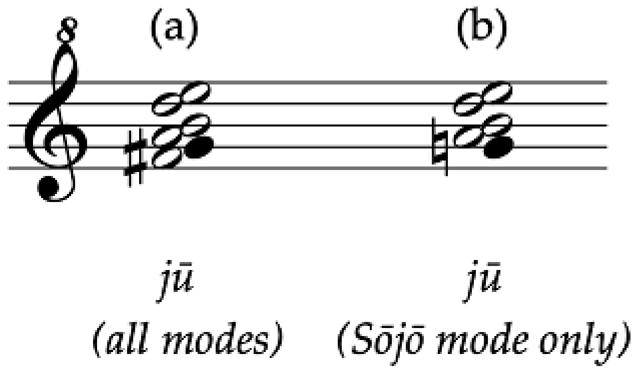
Example 25. *Aitake* organized into stacked consecutive fifths

Category	Aitake	Fundamental Tone	Consecutive Chain of Fifths (Pitch classes)								
1	*kotsu* (乞)	A4				A	E	B	F♯		
	ichi (一)	B4			D	A	E	B	F♯		
	bō (几)	D5			D	A	E	B	F♯		
	otsu (乙)	E5			D	A	E	B	F♯		
2	*ge* (下)	F♯5			D	A		B	F♯		G♯
	jū (十)	G5		G	D	A	E	B	F♯		
	jū (*Sōjō*)(十[双調])*	G5		G	D	A	E	B			
	gyō (行)*	A5			D	A	E	B	F♯		
3	*ku* (工)	C♯5			D	A	E	B		C♯	G♯
	bi (美)	G♯5	C		D	A		B	F♯		G♯
	hi (比)	C6	C		D	A	E	B	F♯		

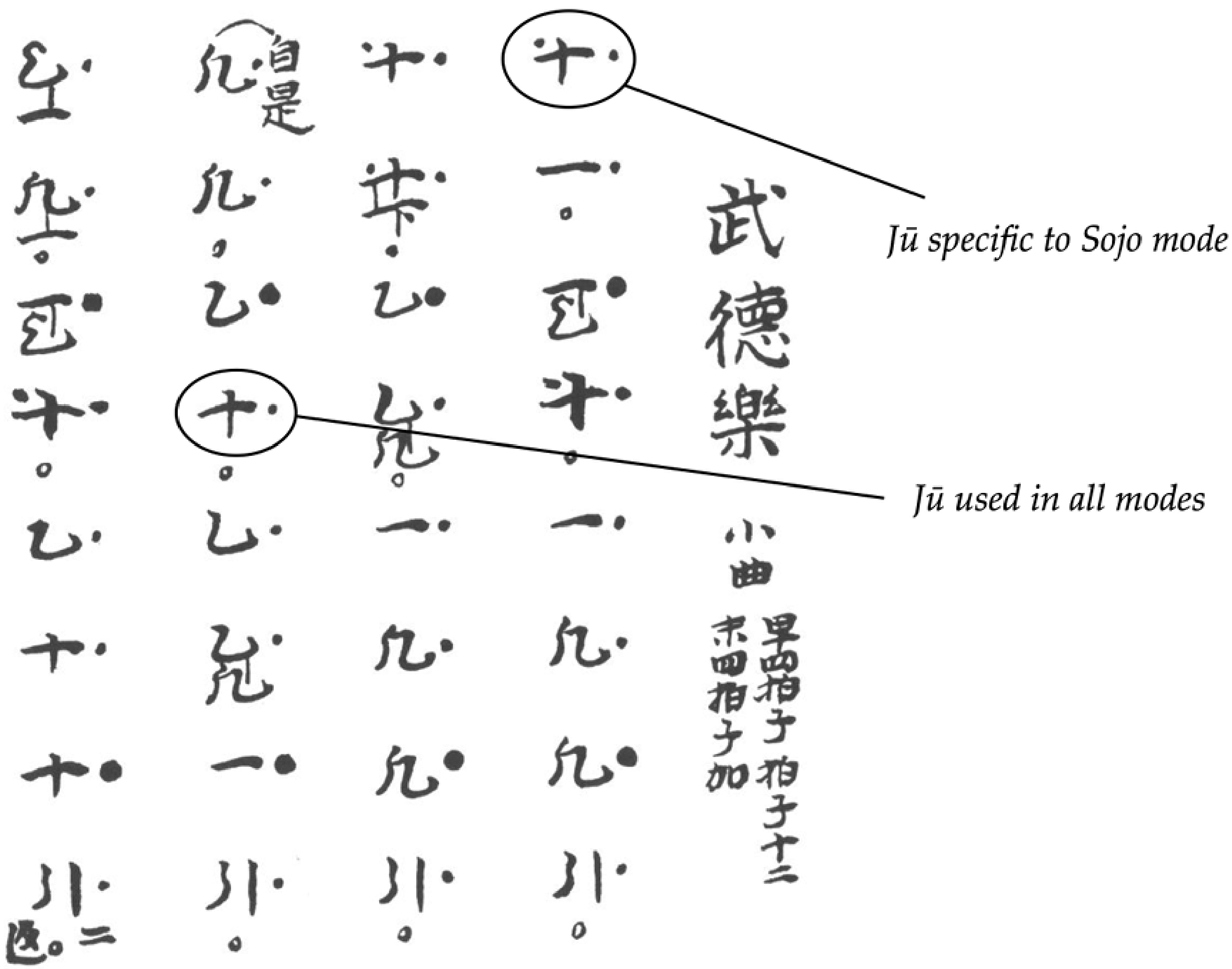
* Five-note *aitake*

Example 26. Six modes of *gagaku*

Example 27. Two forms of the *aitake jū*



Example 28. Two types of the *aitake jū* in *Butokuraku* (武徳楽) (*Sōjō* mode)



Example 29. Pitch-class and intervallic structures of Category 1 *aitake* and *jū*

Aitake	Category	Pitch-classes (Normal Order)	Set-class	Interval Class Vector
kotsu (乞)	Category 1	E, F♯, A, B	(0257)	<021030>
ichi (一)		A, B, D, E, F♯	(02479)	<032140>
otsu (乙)		A, B, D, E, F♯	(02479)	<032140>
bō (几)		A, B, D, E, F♯	(02479)	<032140>
jū (*Sōjō*)(十[双調])	Category 2	G, A, B, D, E	(02479)	<032140>
jū (十)		D, E, F♯, G, A, B	(024579)	<143250>

Appendix. List of all *te-utsuri* between six-note *aitake* used in *tōgaku* performance

	Te-utsuri	$TU_{(a, b, c, d)}$ operation	Number of Finger Holes Traversed $(a + b + c + d)$	Number of Shifting Fingers	Shifting Fingers (R1, R2, L1, L4)				
Most Proximate	*ichi to bō*	(0, 0, +1, 0)	1	1			L1		**Minimally Parsimonious**
	ichi to otsu	(0, 0, +1, -1)	2	2			L1	L4	
	ichi to kotsu	(0, 0, +1, +1)	2	2			L1	L4	
	ichi to ge	(0, -1, -1, -1)	3	3		R2	L1	L4	
	ichi to jū	(+1, -1, +1, -1)	4	4	R1	R2	L1	L4	
	ichi to ku	(+4, 0, -1, 0)	5	2	R1		L1		
	ichi to bi	(0, -4, -1, -1)	6	3		R2	L1	L4	
Least Proximate	*ichi to hi*	(0, -4, +1, -1)	6	3		R2	L1	L4	
Most Proximate	*kotsu to bō*	(0, 0, 0, -1)	1	1				L4	**Minimally Parsimonious**
	kotsu to ichi	(0, 0, -1, -1)	2	2			L1	L4	
	kotsu to otsu	(0, 0, 0, -2)	2	1				L4	
	kotsu to jū	(+1, -1, 0, -2)	4	3	R1	R2		L4	
	kotsu to ge	(0, -1, -2, -2)	5	3		R2	L1	L4	
	kotsu to hi	(0, -4, 0, -2)	6	2		R2		L4	
	kotsu to ku	(+4, 0, -2, -1)	7	3	R1		L1	L4	
Least Proximate	*kotsu to bi*	(0, -4, -2, -2)	8	3		R2	L1	L4	
Most Proximate	*otsu to bō*	(0, 0, 0, +1)	1	1				L4	**Minimally Parsimonious**
	otsu to ichi	(0, 0, -1, +1)	2	2			L1	L4	
	otsu to jū	(+1, -1, 0, 0)	2	2	R1	R2			
	otsu to kotsu	(0, 0, 0, +2)	2	1				L4	
	otsu to ge	(0, -1, -2, 0)	3	2		R2	L1		
	otsu to hi	(0, -4, 0, 0)	4	1		R2			
	otsu to bi	(0, -4, -2, 0)	6	2		R2	L1		
Least Proximate	*otsu to ku*	(+4, 0, -2, +1)	7	3	R1		L1	L4	
Most Proximate	*bō to kotsu*	(0, 0, 0, +1)	1	1				L4	**Minimally Parsimonious**
	bō to otsu	(0, 0, 0, -1)	1	1				L4	
	bō to ichi	(0, 0, -1, 0)	1	1			L1		
	bō to jū	(+1, -1, 0, -1)	3	3	R1	R2		L4	
	bō to ge	(0, -1, -2, -1)	4	3		R2	L1	L4	
	bō to hi	(0, -4, 0, -1)	5	2		R2		L4	
	bō to ku	(+4, 0, -2, 0)	6	2	R1		L1		
Least Proximate	*bō to bi*	(0, -4, -2, -1)	7	3		R2	L1	L4	
Most Proximate	*jū to otsu*	(-1, +1, 0, 0)	2	2	R1	R2			**Min. Parsimonious**
	jū to bō	(-1, +1, 0, +1)	3	3	R1	R2		L4	
	jū to ge	(-1, 0, -2, 0)	3	2	R1		L1		
	jū to ichi	(-1, +1, -1, +1)	4	4	R1	R2	L1	L4	
	jū to kotsu	(-1, +1, 0, +2)	4	3	R1	R2		L4	
	jū to hi	(-1, -3, 0, 0)	4	2	R1	R2			
	jū to bi	(-1, -3, -2, 0)	6	3	R1	R2	L1		
Least Proximate	*jū to ku*	(+3, +1, -2, +1)	7	4	R1	R2	L1	L4	

	Te-utsuri	$TU_{(a, b, c, d)}$ operation	Number of Finger Holes Traversed $(a + b + c + d)$	Number of Shifting Fingers	Shifting Fingers (R1, R2, L1, L4)				
Most Proximate	*ge to ichi*	(0, +1, +1, +1)	3	3		R2	L1	L4	
	ge to otsu	(0, +1, +2, 0)	3	2		R2	L1		
	ge to jū	(+1, 0, +2, 0)	3	2	R1		L1		
	ge to bi	(0, -3, 0, 0)	3	1		R2			
	ge to bō	(0, +1, +2, +1)	4	3		R2	L1	L4	
	ge to kotsu	(0, +1, +2, +2)	5	3		R2	L1	L4	
	ge to hi	(0, -3, +2, 0)	5	2		R2	L1		
Least Proximate	*ge to ku*	(+4, +1, 0, +1)	6	3	R1	R2		L4	
Most Proximate	*ku to ichi*	(-4, 0, +1, 0)	5	2	R1		L1		
	ku to ge	(-4, -1, 0, -1)	6	3	R1	R2		L4	
	ku to bō	(-4, 0, +2, 0)	6	2	R1		L1		
	ku to jū	(-3, -1, +2, -1)	7	4	R1	R2	L1	L4	
	ku to kotsu	(-4, 0, +2, +1)	7	3	R1		L1	L4	
	ku to otsu	(-4, 0, +2, -1)	7	3	R1		L1	L4	
	ku to bi	(-4, -4, 0, -1)	9	3	R1	R2		L4	
Least Proximate	*ku to hi*	(-4, -4, +2, -1)	11	4	R1	R2	L1	L4	
Most Proximate	*bi to hi*	(0, 0, +2, 0)	2	1			L1		**Min. Parsimonious**
	bi to ge	(0, +3, 0, 0)	3	1		R2			
	bi to jū	(+1, +3, +2, 0)	6	3	R1	R2	L1		
	bi to ichi	(0, +4, +1, +1)	6	3		R2	L1	L4	
	bi to otsu	(0, +4, +2, 0)	6	2		R2	L1		
	bi to bō	(0, +4, +2, +1)	7	3		R2	L1	L4	
	bi to kotsu	(0, +4, +2, +2)	8	3		R2	L1	L4	
Least Proximate	*bi to ku*	(+4, +4, 0, +1)	9	3	R1	R2		L4	
Most Proximate	*hi to bi*	(0, 0, -2, 0)	2	1			L1		**Min. Parsimonious**
	hi to jū	(+1, +3, 0, 0)	4	2	R1	R2			
	hi to otsu	(0, +4, 0, 0)	4	1		R2			
	hi to ge	(0, +3, -2, 0)	5	2		R2	L1		
	hi to bō	(0, +4, 0, +1)	5	2		R2		L4	
	hi to ichi	(0, +4, -1, +1)	6	3		R2	L1	L4	
	hi to kotsu	(0, +4, 0, +2)	6	2		R2		L4	
Least Proximate	*hi to ku*	(+4, +4, -2, +1)	11	4	R1	R2	L1	L4	

GLOSSARY OF JAPANESE TERMS

Aitake: Five- to six-note clusters played by the shō in tōgaku repertoire. Aitake accompany the melodic lines played by the hichirki and ryūteki. Each aitake contains a fundamental tone, which is usually the lowest pitch of the cluster.

Chōshi: The term for mode in gagaku. There are currently six chōshi in use: Ichikotsu-chō (modal center D), Hyōjō (E), Sōjō (G), Ōshiki-chō (A), Banshiki-chō (B), and Taishiki-chō (E). Each mode is categorized as a ryō (Ichikotsu-chō, Sōjō, Taishiki-chō) or ritsu (Hyōjō, Ōshiki-chō, Banshiki-chō) mode based on its intervallic structure. Each mode is associated with a specific season, color, direction, element, and affect.

Gagaku: Japanese traditional court music tradition originating in the eighth century. In its current form, gagaku consists of indigenous vocal genres and instrumental and vocal genres originating from China and Korea. Currently performed by the Music Department of the Imperial Household Agency, professional ensembles such as Reigakusha and Tokyo Gakuso, community groups, and at Shintō ceremonies.

Hichiriki: A double-reed flute that serves as one of the main melodic instruments in gagaku. One of the three primary wind instruments of gagaku.

Ryūteki: A transverse flute that serves as the one of the main melodic instruments in gagaku. One of the three primary wind instruments of gagaku.

Shō: A free-reed mouth organ comprised of seventeen bamboo pipes, two of which are muted today. Serves an accompanimental role to the primary melodic instruments (hichiriki, ryūteki). One of the three primary wind instruments of gagaku. Originally imported into Japan from Tang China during or prior to the Nara Period (710–94). Sound can be produced either by inhaling or exhaling into the mouthpiece. The instrument must be heated prior to and after performance to prevent the metal reeds from collecting moisture. In contemporary performances of gagaku, the shō is used in both instrumental (tōgaku) and vocal (rōei; saibara) genres.

Shōga: Mnemonic system for learning repertoire. For shō, the syllables of shōga consist of the names of aitake, which are set to a melody resembling the melody played by the hichiriki.

Te-utsuri: Standardized ordering in which the fingers must shift between holes to move from one aitake to another.

Tōgaku: A genre of gagaku that was imported into Japan from Tang China in the seventh and eighth centuries. The literal meaning of the term is "music of the Tang dynasty." *Tōgaku* is further categorized into instrumental (*kangen*) and dance (*samai*) music, both of which feature three primary wind instruments: hichiriki, ryūteki, and shō. In tōgaku repertoire, the shō primarily plays aitake to accompany the melodic lines played by the hichiriki and ryūteki.