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Design and Implementation of a Positioning Learning Support System for Violin Beginners, Using True, **Vague and False Information**

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Abstract: In this paper, we propose a positioning learning support system with false information and vague information teaching functions for violin beginners. A hypothesis is made that the system obscures presented information from the learner or presents erroneous information so that the learner can break away from the learning support information. In an experiment using this system, it was shown that the group learning with vague information and false information tailored to the proficiency level learned more effectively than the group that continued learning with only accurate learning support information. This demonstrates the usefulness of the system. Moreover, we structured the causal relationship between True mode, Vague mode, and False mode objectively and visually in the proposed system using a structured modeling method using the ISM method (Interpretive Structural Modeling). A mutual relationship between various modes can be illustrated as with a multilayer directed graph. From these results, we consider the ideal learning model for the casual relationship between each mode.

Keywords: Human Computer Interaction, liberation from the system support, Musical instrument

1. Introduction

Various skills are needed to play the violin, for example, reading a score, positioning, that is, using only the fingers of the left hand to press strings onto the fingerboard to produce the note indicated, fingering, rhythm sensation, strength of bowing, tempo, and basic stance. Takaya et al. say that violin is a difficult instrument to play, and that it takes a lot of practice to play even rudimentary songs [1]. Acquiring these skills requires a long-term basic training. Beginners have difficulty visualizing the positioning on the fingerboard and performing correct fingering just from looking at the notes and the fingering information indicated on a score. This kind of basic practice, though important, is frustrating to violinists because it is simple.

Our research group has previously constructed a piano learning support system for beginners [2], [3], [4]. It is clear that presenting information directly connected to physical actions such as pressing keys is intuitive for beginners. However, learners tended to excessively depend on this system. As a result, they developed an ineffective practice habit where they repeatedly play the assigned piece from the beginning to the end [5]. It is important to enable learners to be liberated from the system support. As mentioned earlier, the basic practice is simple. According to Tontani et al., continuing simple work has been shown to be very human error prone [6]. Human error means when a failure on the part of a human causes unintended consequences. Even a cautious or skilled person makes mistakes [7]. On the other hand, the case of the kind of situation in which human beings are likely to make a mistake is known as a situation that human errors occur or a pattern of sophistry [8]. Therefore, this study focused on a situation where human errors occur as a method of liberation from auxiliary information. In fact, the information presented by the system contains false information and is presented to the learner as a situation where human errors occur. With regard to the effect of false information, it is known that the false information effect is less likely to occur in situations that intensify vigilance [9], [10]. In addition, if overly obviously false information is contained among multiple pieces of false information, the user becomes cautious of even the false information that seems to be most correct and may become difficult to be deceived [11]. Mori states that users tend to trust the system when the system outputs false information [12]. Therefore, when false information is presented by the proposed system during learning, a mechanism is needed to learn while considering the authenticity of the information presented by the system. We hypothesize that by learning while thinking about authenticity, learning itself will not become monotonous, human error can be prevented, and at the same time, learning can be achieved faster than before. Therefore, the goal of our study is to evaluate the violin learning support system.

The proposed system has functions such as superimposing correct positioning information on the image taken by the camera installed on the fingerboard, presenting the information of the

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musical score currently being played next to the image so as to reduce the movement of the line of sight between the score and the fingerboard, and visualizing the true pitch and actual output sound. Using these functions we are studying methods by which learners can intuitively master correct positioning. In addition, our system has a function to include vague information and false information in the presented positioning information, and supports liberation from auxiliary information. Using the proposed system, we verify that the presentation of auxiliary information containing false information and vague information is more efficient than conventional learning.

2. Related Research

2.1 Presentation of Support Information

Targeting various fields, such as singing, penmanship, instrument-playing, and palpation measurement, learning systems have been proposed which both present exemplary information and current state, and point out mistakes. For example, a lighted keyboard which indicates the next key to be pressed, as well as various kinds of software, are sold by instrument makers for pianists in the early stage of practice [4]. This early stage refers to the stage in which piano beginners first look at a score and practice to remember fingering and keying positions. In addition, learning systems have been proposed which use a projector mounted above a keyboard to display keying position, fingering, rhythm, and score on or around the keyboard [2], [3]. These functions lower the difficulty threshold of learning by providing example information before the user has to perform an action. The system functions are designed to make the user aware of their mistakes so that they can understand the correct execution. Functions include visually emphasizing and contrasting correct keying position and the user's current keying position, in the case of incorrect keying, and imposing penalties, such as withholding the next information to force the user to repeat a section that they played incorrectly.

2.2 Liberation from Support Information

In the early stages of playing, the learner practices while using auxiliary information. Since it is necessary finally to be able to play music without using auxiliary information, liberation from auxiliary information is important. Takegawa proposed a system that has the function of providing the learner with visual feedback showing whether auxiliary information was used, to promote departure from assistance. There are also proposals for systems that allow learners to gradually reduce auxiliary information according to their degree of skill acquisition [13].

In Oike et al.'s research on learning basic nursing skills, anticipating that learners would actively participate, become interested and enhance their interest, they created video teaching materials with the theme of searching for mistakes, and made a proposal to verify the effect on learning [14]. In these conventional studies, it is clear that searching for mistakes itself is efficient for learning, so it can be inferred that in our research searching for mistakes, contained within vague information, can be used for learning. However, while the works of research previously described are similar to our research in that they use mistake searching problems for learning, they do not show whether they can be applied to learning instruments, as an example of another field, as well.

Regarding research into systems that provide false information, there has been a study in which subjects taking exercise were supplied with false pulse rate information, to verify whether this would have an influence on their general life sign information [15], [16], [17]. This study is similar to the presentation of positioning information in our research, in that there is an indicator of correct information, like the doctor in the placebo experiment, and false information, like the placebo. This type of research is similar to our research, but the approaches are different in that our research considers how the subjects that have been lied to change their attitude towards learning.

Another study asserts that the manner in which people react to lies varies depending on the individual personality and the content of the lie [18]. Similarly to our research, this study answers the question of how people react when told a lie, but it does not show with what kind of attitude a person who has been lied to applies him or herself to learning. Also, being presented with false or vague information forces learners to begin considering the reliability of the support information during the early stages of learning, and we hypothesize that this will render them able to understand more deeply the correspondence between notes on a score and the actual positioning on the violin.

As a system that provides false information and enables efficient learning, Yokoyama et al. designed a system that artificially generates mistakes in piano playing [19]. Yokoyama et al. propose post-processing to include false information in the output sound, but do not mention preliminary processing because false information is not included in musical score information and the like presented beforehand.

3. Design

The Positioning learning support system proposed by our research group is targeted at beginners of the violin. While utilizing staff notations and auxiliary information generated by the system, the learner practices from a state of being unable to play any assigned pieces, and wanting to improve as soon as possible, to finally being able to play with correct positioning without mistakes, without using the system support. Therefore, the following two points are required for the system design.

3.1 Presentation of Positioning Information

In conventional positioning learning, stickers corresponding to each note are stuck on the fingerboard to present positioning, and gradually peeled off according to the level of proficiency of the learner. However, since various positioning information are presented, it is difficult for a beginner to find the position corresponding to the note currently to be played. Therefore, in the system proposed by our research, only the positioning information corresponding to the musical note currently to be played is presented. By presenting only one piece of positioning information, the system shows the positioning to be pressed in a way that is easy for the learner to understand.



Fig. 1 Learning mode.

3.2 Liberation from Learning Support Information

As mentioned earlier, as a practice method with a low learning threshold for beginners, the proposed system presents only the correct information corresponding to the musical note to be played. Although this seems to be very effective for learning, the learner receiving this presentation continues a monotonous work, learning by vaguely placing their fingers at the presented position without thinking [5]. Monotonous work is a factor that easily causes a human error. Also, in actual positioning learning, it is desirable to master skills so that the learner is finally able to play without referring to stickers.

Therefore, we propose presentation methods showing not only correct information but also including vague and false information. The proposed method is shown in **Fig. 1**. The presentation of vague information imitates the conventional method of learning using stickers, and presents multiple pieces of positioning information. The presentation of false information presents false positioning and learners can learn while considering the authenticity of the information. Ideally, the system will be used in such a way that when using correct information the learner's proficiency level is the lowest, and as learning level increases the learner alters the presented information, transitioning from vague to false information.

4. Implementation

Figure 2 presents the structure of the proposed system. The system consists of a MIDI-support enabled violin made by Cantini Electric Violins, a Roland GR-55 guitar synthesizer (effector), and a two million pixel BSW20KM11BK web camera with a built-in microphone.

In addition, the performance data generated by the MIDIsupport enabled violin is sent to the PC in MIDI data format via the MIDI sound source. A web camera is fixed with an acrylic plate to the adjusting screw corresponding to the E string on the scroll of the MIDI-support enabled violin, and always shoots the finger board from directly above. Based on the camera image and MIDI data generated by the web camera, the PC outputs contents such as musical score information and positioning information to the display.

The content to be presented is implemented in Unity, and the language used is C#. MIDI data input from the MIDI violin is read by Processing's RWMidi library. In addition, in order to implement this system, it was necessary to read a pitch deviation smaller than the note number that can be read with the RWMidi





Fig. 3 Presented contents by system.

library. Therefore, we used the MidiBus library to detect a slight pitch deviation. The data received in Processing is transmitted in real time to Unity by UDP using OSC protocol ^{*1}.

4.1 Information Presented to Learners

The System presents the contents to the learner, as shown in **Fig.3**. The numbers in the figure correspond to the following numbered items.

(1) Presentation of Positioning Information

As shown in **Fig. 4**, the blue light is presented in real time at the position of the positioning that corresponds to the musical notes of the musical score. Specifically, the position of the positioning corresponding to the musical score is superimposed on the video generated by the web camera fixed to the scroll portion of the violin. Also, in the upper left of the image generated by the Web camera, a rectangle of colors visualizing the deviation of the pitch is presented in real time. The color changes at the time of Note On, a fine pitch change during playing, and Note Off. We propose presentation methods showing not only the correct information but also presentation methods including vague and false information in the proposed system of blue light. The proposed method assumed is shown in Fig. 1. The presentation of vague information imitates conventional learning using stickers, and presents multiple pieces of positioning information. The

^{*1} Abbreviation for Open Sound Control communication, by which data can be transmitted and received between different applications in real time.



Fig. 4 Positioning information superimposed on the camera image.



Fig. 5 Part of score

presentation of false information presents false positioning and learners can learn while considering the authenticity of the information.

(2) Presentation of the Score

The score is displayed on the right side of the presented content. A pink downward triangle is presented above the note from which the learner starts playing. A white downward triangle is presented above the next note to be played. If the note number on the score and the performance data match within a semitone, the white triangle will advance to the next note and the learner can play the next note. If the performance data is off by more than a semitone, the white triangle does not advance to the next note. In addition, as shown in Fig. 5, under the notes already played the deviation of the pitch at note-on is presented as history. With this history, the system can be used for reviewing learning. We prepared a musical score by which, for practice of scales, learners can repeat the notes from musical note A4 to A5 eight times. The reason for choosing this assigned piece is that in violin textbooks, before playing the set pieces, beginners are made to practice scales and establish positioning first [20].

(3) Visualization of Pitch Deviation

It is difficult for learners to judge by their own ears whether correct pitch is being played. Especially in the case of the violin, which has a narrow fingerboard meaning that a slight shift in finger position, finger inclination, or the like, can alter the pitch. In the case of a lesson, learners can always receive feedback on the notes they play from the teacher after playing. However, in the case of beginners, it is difficult to follow the positioning corresponding to the musical notes while playing the violin, and it is







Fig. 7 Color example.

impossible to immediately record any deviations of the pitch that they play by themselves. Accordingly, it is difficult to look back after playing the violin. Therefore, this system visualizes the deviation of the pitch, records it in the history of the task record, and provides feedback on which parts of playing need improvement. Although this system does not explicitly point out errors, it was created with reference to a system that makes learners spontaneously notice errors by presenting the current situation. Nakano et al. proposed MiruSinger which is a learning support system for singing [21]. MiruSinger presents both the correct pitch and the pitch currently being sung on the display in real time, so that the learner can spontaneously notice any errors and correct the pitch. In our research, by visualizing the difference between the pitch currently being played and the accurate pitch, users can understand at a glance how much the pitch deviates. Therefore, the system tends to serve as an index of the degree of mastery of assigned pieces of music. Colorization is another way of making pitch deviation visible, as shown in Fig. 6. As shown on the left of the figure on the left, when the pitch is totally off colors such as red, blue and green are shown sparsely. However, if the pitch is not entirely off the colors shown are limited to shades of green, as shown on the right. In this manner, it is possible to visualize the deviation of the pitch, feedback the pitch and present it to the learner as history, to make the degree of learning progress comprehensible at a glance. The visualization of the pitch will be described in detail in the next section.

We propose a color-based indicator, as shown in **Fig. 7**, in order to show the difference between the correct sound of the note(s) at the performance place presented in the score information and the sound currently being played by the learner. A green color represents an accurate sound. Changing to a red color means that the sound being played is higher than the correct sound, while changing to a blue color means that the sound being played is



Fig. 8 Determining the position of vague and false mode.

lower than the correct sound. The extremes of blue and red indicate that the sound is different by more than a semitone. Every two colors are separated by a distance of 10 cents.

(4) Learning Mode Selection Button

When using this system, it is possible to select from three learning modes. The correct mode which presents only the correct positioning, the Vague mode which presents the positioning including vague information, and the false mode which presents the positioning including a piece of false information for one in every four notes. The timing of when to select each mode is optional.

Switching modes can be done by clicking with the mouse. The learner himself/herself considers which learning mode is effective with respect to his/her current proficiency level, and switches the mode and learns, making the learning efficiency higher than that of the conventional learning. In this way self-reliant learning can be carried out smoothly.

4.2 Generation of Information

4.2.1 Generation Position of Vague or False Information

As shown in **Fig. 8**, in the vague and false mode we presented positioning at a position 15 px either side of the correct position. The presentation range of positioning is 40 px, and it is generated at a random position. A range 15 px either way is a distance of about 1 cm on the finger board, which is just a semitone difference.

Positions separated from the position to be played by low semitones (-100 cents) and high semitones (+100 cents) are taken as basic positions, and the range between each of those positions to a whole tone (200 cents each) is made to correspond to each pattern and presented at a random position.

In Vague mode, since the index finger is easy to remember, there are only two candidate positions. The middle finger is complicated, as the positions to be pressed for C4 and G5 vary, therefore there are three candidate positions. The ring finger is also a hard finger to press with, thus there are three candidate positions. When presenting two positions, the true position and one additional position, either lower or higher than the true position, are presented to make a total of two positions. There are two patterns for presenting three positions. In the first pattern, one position higher than the true position and one position lower than the true position is added to the true position to make a total of three positions. In the second pattern, the true position and two lower positions are presented. We present three positions for the middle finger and ring finger. If we present two high positions there is a possibility of presenting positions included in the second position, which is clearly out of the range of the first position, making the incorrect positioning easy to notice. The Vague mode is ap-



Fig. 9 Correspondence between each note and positioning.

plied to all musical notes except A4 and E5. Musical notes A4 and E5 are open strings, and are the same as in the True mode.

In the False mode, the Positions separated from the position to be played by a low semitone (-100 cents) and at high semitone (+100 cents) are taken as the basic positions, and false information is randomly presented in the range from those positions to either a high or a low whole tone. False information occurs with a probability of 25% and the remaining 75% is the true information. In this experiment, we set a limit on the number of musical scale exercises, and, in order to randomly generate false information, manually determine the timing of false information.

4.2.2 Appearance Patterns of Vague and False Information

As shown in **Fig.9**, we included vague information and false information beforehand in the places where violin beginners are apt to mistakes. Regarding the field painted black, we present the same positioning as in the correct answer mode. The red dashed line is the position of the positioning which should originally have been pressed.

Regarding the practice score

There are 8 phrases in all, and each phrase repeats the same notes from musical note A4 to A5.

True mode

All eight phrases adopt the same presentation model.

Vague mode

The learning mode is the same for odd phrases and even phrases respectively. As described above, when presenting two positions, the true position and an additional position either higher or lower than the true position is presented to make a total of two positions. There are also two patterns of three positions. In the first pattern, there is the true position with one higher position and one lower position added to make a total of three positions. In the second pattern, there is the true position with two lower positions added. How to use these learning modes can be confirmed in the Figure. Musical notes A4 and E5 are open strings, making the positioning very easily understandable for learners. Therefore, the vague information is not applied to these strings. **False mode**

In the first phrase the false information is applied to B4 and A5. In the second phrase the false information is applied to D5 and G5. In the third phrase the false information is applied to C5 and A5. In the fourth phrase, the false information is applied to B4 and G5. The fifth phrase is the same as the first phrase, the sixth phrase is the same as the second phrase, the seventh phrase is the same as the third phrase. In the eighth phrase the same learning mode is applied as in the fourth phrase.

For the purpose of clarity, in the Vague mode and the False mode, which have the same presentation method as the True mode, the background is colored in black.

In general, in learning the violin, open strings can be learned without placing the fingers, so the learner does not have to learn thinking about positioning. Therefore, in the Vague mode and the False mode, the A4 sound and the E5 sound of the open string, which have relatively low difficulty, are presented in the same manner as in the correct answer mode. Regarding the first finger, which the next note to press with the index finger, it is difficult for beginners to determine the position [22]. Therefore, the B4 sound and the F5 sound are presented at only two points in the Vague mode. With regard to the middle finger, when playing line A, it comes close to the ring finger, but in the case of line E, it comes close to the index finger. Since the positioning position for each string is different, it is judged to be positioning that is difficult to learn, and in the Vague mode three points are presented. The ring finger is a finger into which it is hard to focus strength compared to other fingers, so it tends to be difficult to play with. Therefore we present three points, as with the middle finger [2], [23].

The learner can change the mode with arbitrary timing when using the system. However, since the Vague mode always contains correct answer information, it is expected to be easier for beginners to use than the false mode and to have a low degree of difficulty. Therefore, learning in the order of the correct answer mode, then the Vague mode, and finally the False mode is the ideal usage of the proposed modes.

5. Experiment

An evaluation experiment was conducted to show that learning with the effectiveness of selecting from the true, vague and false information suggested by this research (All Group), is more useful than learning using only the true information (True Group). Also, in order to analyze to what extent the vague and the false information contribute to learning efficiency, we decided to compare a Vague Group (VG) using the true information and the vague information, and a False Group (FG) using the true information and the false information.

5.1 Pretreatment of Experiment

In the experiment, 28 subjects were classified into 4 groups of 7 subjects each. There were 15 males and 13 females. The average age of the subjects is 21.9 for the males and 21.3 for the females. The subjects' major music experience (overlapping in the case of some subjects) is as follows. 14 subjects have experience (6.5 years on average) of piano, 3 subjects have experience (7.0 years on average) of guitar, 3 subjects of drums (5.3 years on average), 3 subjects of bass (4.0 years on average), 2 subjects of Electone (5.0 years on average), and 2 subjects of trombone (2 years on average). There were 5 subjects with no music experience. There was no significant difference between gender, age and music experience between modes.

The 4 groups were the True Group (TG) who could use only the true information, the Vague Group (VG) who could switch between the true information and the vague information, the False Group (FG) who could switch between the true information and the false information, and the All Group (AG) who could switch between true, vague and false information.

Prior to the experiment it was confirmed that all the subjects were able to read a score and had little experience of the violin. In the experiment, so that the experimental result could be approximated to an accurate value, the bow was not used and subjects performed with the rendition style called pizzicato, which is less fatiguing. Pizzicato is a style of playing by plucking strings. Subjects were given approximately 15 minutes to touch the violins and practice using the system and playing pizzicato.

In the experiment, we recorded a log of the display of the system screen, the MIDI data (the note number of the current note to be played and the pitch bend input by the subject) and what mode subjects used.

5.2 Experimental Procedure

Subjects performed a scale practice and the musical piece Twinkle Twinkle Little Star, referred to as the test piece, as one set, and they repeated three sets with breaks of approximately 5 minutes in between each set. In the scale practice, the musical scale from the A4 sound to A5 sound was repeated eight times, making a total of 64 sounds played. The purpose of scale practice is to memorize the positioning of the violin. Subjects practiced scales using the modes assigned to their groups. The screen display during the scale practice is the same as the content screen shown in Fig. 3. After the scale practice, as a test of achievement level, subjects played the test score called Twinkle Twinkle Little Star, which uses a scale from the A4 tone to the F5 tone. Unlike in the scale practice, during the achievement level test only the test score was presented.



Fig. 10 Score of test average for each group.

5.3 Result of Experiment

The experimental results are shown below. The score of the test piece contained 42 notes in all, making 42 the maximum score, so this was converted to 100% and the results were summarized. First, the scores of each test were compared for each group, as shown in **Fig. 10**.

A two-way ANOVA was conducted using a mode (True Group, Vague Group, False Group, All Group) and the test (test 1 to 3) as factors. The main effect of the mode was not obtained (F (3, 24) = 1.80, p > .05), but the main effect of the test was obtained (F (2, 48) = 6.36, p < .005). The result of a multiple comparison using Ryan's method showed a significant difference was found between the first and the third tests (t (48) = 3.564, p < .05).

5.3.1 Comparison of the Third Test Average

Next, the score of the third test was compared for each group, as the final mastery level. We conducted a one-way ANOVA with Mode as the factor, only for the Third Test. The result showed that the main effect of the mode was obtained (F (3.24) = 3.12, p < .05). The result of multiple comparison using Ryan's method showed a significant difference between True Group and All Group (t (24) = 2.91, p < .05).

5.3.2 Mode Transition of All Groups

From the results, it was revealed that All Group had the highest score among the 4 groups, and the score increased each time the subjects played the test piece. Compared with learning using only true information, or true information with only one of either false information or vague information added, learning with the possibility of choosing for oneself from all the kinds of information, like All Group, is more useful. Therefore, as detailed below, the structure analysis was performed on the mode transition usage of the subjects in All Group. We structured the causal relationship between modes objectively and visually in the proposed system using a structured modeling method using the ISM method (Interpretive Structural Modeling). The ISM method is one of the methods proposed by Warfield as an application of the graph theory [24]. A mutual relationship between various items can be illustrated as a multilayer directed graph. The generated model is used as an interpretation and examination tool for objectively solving problems, such as a problem solving method of the system usability and the analysis of causality of design specifications. Regarding the application procedure of the ISM method, there are three steps: (1) extraction of elements and creation of adjacency matrix A, (2) creation of reachable matrix T, and (3) structuring by multilayer directed graph. Regarding the extrac-



Fig. 11 Each directed digraph by the ISM method.

 Table 1
 Percentage of mode transition of all time.

item	F_1 (True)	F_2 (Vague)	F_3 (False)
F_1 (True)	0.0	33.3	26.7
F_2 (Vague)	0.0	0.0	26.7
F_3 (False)	10.0	3.3	0.0

tion of elements, the threshold of the number of times of mode transition is set to 2 or more. Below, the result of applying (1) and (2) to each and every scale practice is shown, and each directed graph is summarized as in **Fig. 11**. F_1 corresponds to the correct answer mode, F_2 corresponds to the Vague mode, and F_3 corresponds to the False mode. Also, the rate of mode transitions for all times is shown in the **Table 1**. If there is a transition from any mode to another mode, 1 is entered, and if there is no transition 0 is entered. In the adjacency matrix A, the transition from any mode to the same mode is defined as not transitioning, and it is entered as 0.

All time refers to Accumulated practice, which is a summary of all of First practice (First time), Second practice (Second time), and Third practice (Third time). The threshold values of First time, Second time, and Third time are determined to be 2 or more, and transitions less than 2 are not shown in the directed graph. However, All time is the sum of all practice, and the threshold value of this transition is also set to 2 or more. For this reason, for example, one transition in First time and Second time is not shown in each of the corresponding directed graphs, but, since there is a total of 2 transitions in All time, it is shown in the directed graph of All time.

From the results of each test and all tests, shown in the directed graph of Fig. 11, it was possible to observe a trend in which the hierarchical level rises in the order of F_1 (True mode), F_2 (Vague mode), F_3 (False mode). Therefore, it became clear that, as mode transition, F_1 (True mode) strongly exerted an influence on F_2 (Vague mode) and F_3 (False mode). This is also supported by the fact that the transition ratio of F_1 (True mode) to F_2 (Vague mode) in the Table 1 is 33.3% and the transition ratio of F_1 (True mode) to F_3 (False mode) is 26.7%.

From the results of all tests, it is evident that F_2 and F_3 influence each other. The transition ratio of F_2 (Vague mode) to F_3 in the Table 1 is 26.7%, indicating that F_3 (False mode) is more influenced by F_2 (Vague mode).

5.4 Consideration on Experimental Result

According to the experiment results, the proposed method that uses All Group comprising the True, Vague and False modes has a better learning efficiency than the comparison methods of True Group, Vague Group and False Group. Of the three modes, False mode in particular was effective for learning. Also, by using the evaluation method using the ISM method, it could be seen that, regarding the usage transition of modes, F_1 (True mode) more strongly influenced F_2 (Vague mode) and F_3 (False mode), as in Fig. 11, and that F_2 (Vague mode) and F_3 (False mode) influenced each other. From the directional graph described above, it can be deduced that basic training in F_1 (True mode) is the initial learning method, while the ideal learning model is using F_2 (Vague mode) and F_3 (False mode) and F_2 (Vague mode) and F_2 (Vague mode) and F_3 (False mode).

The subject who scored the highest among All Group explained that "The reason for switching modes was that in True mode the practice is simple and monotonous, making it hard to learn, and also I wanted to prevent over dependence on the system. I could look at the notes on the score and remember the corresponding distance between fingers, when I used False mode." From this comment it can be understood that the subject carried out basic practice by looking at the notes and fingering on the score, visualizing the position on the fingerboard from the notes, and playing with the designated fingering, and learned without support information and while switching between modes, which is the intended use of our system. Another subject in All Group said "I learned the approximate positions in True mode then switched to False mode to see if I really remembered in False mode." In this way, it became clear that there is also a usage method whereby False mode is not considered as a part of the learning modes and is approached with the same kind of motivation as if taking a test. This is considered to be because the mode named False mode is prepared in advance and the selection of this mode is made possible with the learner knowing what sort of function the False mode is. A learning method of switching modes suddenly, such as in the case of a learner who trusts the system switching to False mode, can also be cited, but when such a learning method is used, the problem arises that the learner becomes unable to trust the information presented by the system. It is necessary to reexamine the explanation of system functions, and whether switching of modes should be optional.

5.4.1 System UI

Regarding the UI of the system, all the subjects were able to use each function. Regarding the function of visualizing the deviation of pitch, various approaches are conceivable, such as a method of visualization by color, a method of presentation by numerical value, and a method of presentation with a scale such as a tachometer. Some subjects were puzzled in the initial stage of the experiment because they had trouble understanding the relationship between the presentation of a color and the position of the fingers on the fingerboard, thus reexamination is necessary. As for the method of superimposing positioning information on the fingerboard of the violin like AR, it is necessary to compare this with the method of actually embedding in the fingerboard LED lights that shine to indicate the positions to be pressed in real time.

5.4.2 Regarding Generation of Vague Information and False Information

In this system, the timing of the presentation of vague information and false information is determined manually, and the positions generated are random within certain rules. However, these rules are not based on the estimation of what notes subjects are likely to play incorrectly, obtained from the analysis of subjects' data, but instead are based on the consideration of the difficulty of playing with each finger in a previous research. Therefore, it is necessary to analyze the data of the subject and to include vague information and false information focusing on the notes most likely to be mistaken. In actual experiments, some subjects pressed the incorrect positioning presented in the vague information and mistook the false information for the true information, which suggests that from the viewpoints of hooking and error searching problems the system is useful. However, since the false information was presented for one in every four notes, during the experiment the subjects had a tendency to play with confidence that most notes are true. Therefore, it is necessary to compare the increase and the decrease of the generation of the false information, such as including the false information for one in every three notes rather than four. In addition, it is expected that an approach that analyzes what notes each learner is likely to make a mistake on and recommends the mode suited to the learner's proficiency level using machine learning etc. can also be effective.

6. Conclusion

In this research, we made a new proposal to present true, vague, and false information to learners according to the mastery level by making it possible to choose what type of information is presented. This is a method of departure from supplementary information for positioning on the violin. In this proposed method, the verification was carried out under the hypothesis that the learning efficiency is better with our system than the conventional method of presenting the true information. Experiment results show that the approach of this research, such as presenting true, vague and false information to learners by the proficiency degree, is useful. We also analyzed the mode transitions and ratios of subjects in All Group using the ISM method. Analysis results revealed that the True mode strongly influences the Vague mode and the False mode, and that the Vague mode and the False mode affect each other. Future work will involve conducting an experiment on the evaluation for various generations. Additionally, we propose a function that recommends the mode suitable for the degree of proficiency of the learner.

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