



Article

Implementation and Evaluation of a Collaborative Lyric-Writing Support System Using a Lyric Association Map

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Abstract: In many popular songs, lyrics are an important element. The act of collaborative lyric writing by multiple people may produce richer ideas than creative acts by individuals. However, if all members of a songwriting group do not accurately share the elements which are considered to be important in songwriting (i.e., story, character, viewpoint, and line of sight), then it would be difficult for ideas to diverge and converge, which is important in a creative act. In the present paper, we propose a collaborative lyric conception support method, which consists of lyric divergence support using a lyric association map (LAM) based on radial thinking in mind mapping and lyric convergence support using an enumeration of lyric candidate sentences created from the conceived lyric candidates. The visualization of the process of conception in a group facilitates the association, sharing, examination, and consideration of lyrics.

Keywords: CSCW; groupware; lyric writing; mind mapping



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1. Introduction

In popular music, most songs are composed of a melody and lyrics. One person does not always write both the melody and lyrics in a song. In commercial popular music, multiple people often perform composition and lyric writing collaboratively. In consumer-generated media and user-generated content [1], multiple non-specialists on a network also often compose the melody and write the lyrics for a song. Additionally, if it continues to be difficult for individuals to work face to face due to COVID-19, which has been spreading rapidly on a global scale since the beginning of 2020, the demand for online production is expected to increase further.

Our previous research focused on facilitating the composition of songs by allowing multiple people on a network (hereinafter collaborative composition) to share the process of song creation while also allowing members to examine and review it. We previously proposed a support environment for collaborative composition [2]. Furthermore, we proposed a composition support environment for the integrated editing of lyrics and melodies [3]. In this paper, we focus on the creative act of multiple people creating lyrics (hereinafter collaborative lyric writing).

Collaborative lyric writing is a creative act in which words and sentences are conceived based on each member's vocabulary and experience so that richer ideas can be developed compared with individual lyric writing. However, most existing research is related to the automation of lyric writing [4–6] or an environment in which only collaborative composition is possible [7–12], and there are few studies on creation and lyric writing by multiple people.

In this paper, we analyze the creation of lyrics by multiple people as a collaborative act involving the divergence and convergence of ideas and propose a collaborative lyric writing support method using an LAM to support this activity. This study provides the following:

- (1) Proposal of a method to visualize the process of lyric creation in a collaborative group and to expand the lyrical ideas of each group member;

- (2) Proposal of a method to achieve the convergence of the ideas presented in (1) and to determine the most appropriate lyrics;
- (3) Additional implementation and evaluation of the collaborative composition system, which was proposed in our previous paper [2].

The remainder of this paper is organized as follows. In Section 2, we describe previous studies on systems facilitating collaborative composition or lyric writing. In Section 3, we describe lyric writing and its constraints in popular music in general and the lyric-writing method in this study. In Section 4, we describe collaborative lyric writing from the aspects of collaborative and creative acts. In Section 5, we describe the proposed method of lyric conception and convergence using an LAM based on mind maps. In Section 6, we describe an additional collaborative lyric-writing function implemented in our collaborative composition system. In Section 7, we describe an experiment to verify how the use of an LAM affects the conception of lyrics, and in Section 8, we discuss the results of the experiment. Finally, Section 9 presents our summary.

2. Previous Studies

There has been an abundance of research recently on the automatic and semi-automatic generation of lyrics, with the goal of achieving a level comparable to that of human lyric writing. Tra-la-Lyrics 2.0 by Oliveira [4] is a system that integrates a module for generating text with stress that matches the rhythm of a given melody and a module for generating semantic poetry. The generated lyrics had semantic relevance, rhythmic agreement, and rhyme. Settles [5] proposed two natural language processing systems. Titular is a text synthesis algorithm that automatically generates song titles, and LyriCloud is a language browser that suggests lyrics through user interaction. Pudaruth, Amourdon, and Anseline [6] proposed a semi-automatic lyric generation method that generates lyrics based on n-sentence grammar by inputting information about the song, the structure of the song, and the lyrics of the catchy parts. These generated lyrics were grammatically correct but did not make much sense.

There has also been a great deal of research recently on systems that attempt to complete a piece of music by uploading and sharing ideas of music created by participating members of a collaboration. Martin and Torresen [7] proposed RoboJam, a touchscreen-based music application. This system not only generates music in response to user improvisations by using machine learning, but it also allows for human collaboration. Figueiró, Rohde, and Soares [8] proposed ESMERIL, an application for Android OS using Pure Data and openFrameworks. This application creates music by manipulating audio samples. Interaction gestures, called “scenes,” can be scored to enable collaborative remixing. Manesh and Egozy [9] proposed Exquisite Score, a web application that allows collaborative creation of musical pieces using the paradigm of the parlor game “Exquisite Corpse”. Users provide fragmentary ideas, called sections, for a piece of music but can only refer to the section immediately preceding their own. In this way, a collective work can be expected that is free from the limitations of individual production. Men and Bryan-Kinns [10] focused on designing user experiences that support collaboration without negatively impacting the work. LeMo, proposed by Men and Bryan-Kinns, is a virtual reality step sequencer system capable of co-producing music and communicating using 3D annotations. Men and Bryan-Kinns claim that LeMo allows for collaborative composition that makes full use of the auditory sense. Crowd in C[loud], proposed by Lee, Carvalho [11], and Essl, is a music service that focuses on user interaction using cloud computing technology. Participants create short pieces of music as their musical profiles and form a social network based on these pieces of music. The DISSCO, proposed by Tipei, Craig, and Rodriguez [12], is a synchronous and asynchronous system that attempts to execute the cycle of composition, sound design, and performance in an end-to-end, nearly real-time manner. It is also designed for the simultaneous connection of many users.

3. Lyric Writing in Popular Music

3.1. Current Situation of Lyric Writing in Popular Music

Generally, in commercial popular music, independent lyricists with advanced skills and experiences write lyrics to take advantage of the division of labor. However, with the decline in the cost of music production, mainly due to the digitization [13,14], it has become possible for small independent labels, independent individuals and groups, and even completely unknown amateurs to easily publish their music. As a result, there are more and more opportunities for lyricists with less specialized skills and experience to write lyrics.

Additionally, many songs have multiple people credited with writing the lyrics. For example, in the Oricon Music (Japan's most well-known music chart published by Oricon Inc.) 1st Half of 2019 Total Single Ranking [15], 5 of the top 20 songs were written by more than one person. There are also many examples outside Japan of multiple lyricists being credited for their collaboration on songs, including those by famous artists such as The Beatles.

The research on collaborative music composition support introduced in Section 2 addresses the post-digital music production system described above. In existing products, for example, there is Pro Tools' Cloud Collaboration (<https://www.avid.com/ja/pro-tools/cloud-collaboration> (accessed on 24 March 2022)), which was incorporated later as a feature of the product, or products that have enabled collaborative music production from the start, such as OHM Studio (<https://ohmpeace.band/ohm-studio/> (accessed on 24 March 2022)).

However, lyric writing in popular music is the process of constructing phrases, sentences, and stanzas by writing a series of words. This process is an act of creativity in which the words and sentences are conceived based on the lyricist's knowledge of vocabulary, grammar, and other linguistic knowledge and experience. The success or failure of a song depends on the ability of the lyricists to create good ideas. However, in the act of collaborative lyric writing, simply combining the lyrics conceived by each lyric writer does not necessarily result in good lyrics.

From the above, we think it is important to devise both a methodology and a support system to facilitate the entire act of creating one thing with all lyric writers. We discuss the methodologies in Sections 4 and 5 and the support systems in Section 6.

3.2. Constraints on Lyric Writing in Popular Music

In lyric writing for popular music, it is thought that lyrics are produced from words conceived under certain constraints. In addition to the following constraints, ethical constraints exist, but they are beyond the scope of the present study.

1. Structural Constraints

It is necessary to consider the rhythm and number of notes of a song when writing the words and sentences of its lyrics. When comparing English and Japanese lyrics, English lyrics usually correspond to one syllable per note, while Japanese lyrics usually correspond to one mora per note [16]. Therefore, the number of words that make up a lyric is smaller for Japanese songs, and the choice of words becomes more important.

Additionally, when lyrics are added to the melody of a previously composed piece of music, the temporal changes in the pitch of the melody tend to be important when selecting words that can be sung naturally and comfortably in Japanese. This is because Japanese is classified as a pitch-accented language, in which words are distinguished by their pitch [17].

In summary, in Japanese lyric writing, it is important to pay particular attention to the following two points when selecting words and phrases:

- i. The relationship between the number of notes in the melody and number of morae of the words to be used;
- ii. The harmony between the pitch accent of the word and the pitch of the melody.

For these reasons, knowledge of synonyms is also important in the selection of Japanese lyrics.

2. Content Constraints

To create lyrics that many listeners can relate to, it is necessary to use content and expressions that are based on their experience and knowledge. The lyricist thus also should have a deep understanding of these concepts.

3.3. Lyric Writing Method in the Present Study

In popular music, many lyric-writing methods have been published and explained. Currently, there is no formulaic method for lyric writing. However, in a collaborative effort, all members must share a common lyric-writing method. In this study, we decided to provide lyric writing support based on a lyric-writing method [18] that allows members to easily share and discuss structure and considers elements such as story, character, viewpoint, and line of sight. This method clarifies the above-mentioned elements and considers the lyric text based on the relationship between them, but it does not provide a specific procedure for writing lyrics. However, we decided to use this method because the meanings of the elements are clear, and the visualization of the relationships makes sharing among members easy. In this study, we define the above elements as follows:

- Character involves a character whose existence is described in the lyrics. In the case of lyrics narrated by the singer, the names of the characters are not always explicitly described. The central character is called the protagonist.
- Lyric story involves a world composed of words and phrases conceived by the characters. It is also the world that constitutes the message that the lyricist is trying to convey. The lyrics are made up of important words extracted from the words that make up the lyric story.
- Viewpoint is the position of the characters in the lyric story's world.
- Line of sight is a line (vector) that indicates that the protagonist is paying attention to a character in a specific viewpoint.

4. Collaborative Lyric Writing

4.1. Aspects of Collaborative Action

The act of collaborative lyric writing can be regarded as a creative act in which each member conceives words and sentences based on his or her linguistic knowledge and experience, such as vocabulary and grammar. Additionally, when collaborative lyric writing is viewed as a collaborative problem-solving act, it corresponds to the planning and performance task and the creative and decision-making task in Mcgrath's task cycle model [19]. In the execution of these tasks, the externalization [20] and sharing of thought processes facilitated in the collaborative state is important. Based on the above, such a joint creative act by multiple people may produce richer ideas than an individual creative act. In other words, the following two points can be expected in response to the constraints mentioned in Section 3.2:

- (1) With respect to structural constraints, to compose lyrics with a small amount of information, trial and error methods, such as the examination and selection of appropriate words, are necessary. In collaborative lyric writing, the vocabulary of each member is used to expand the range of choices, and the collaborative examination and consideration of words among members facilitates the writing of lyrics.
- (2) Concerning content constraints, members can discuss and examine whether the lyrics they produce are understandable, satisfactory, and relatable to listeners based on the experience and knowledge of each member.

4.2. Aspects of Creative Action

Although there is no unified model for the creative process, Zeng, Proctor, and Salvendy proposed a model with generality based on many studies on the creative process [21],

and in this sense, it is appropriate as a basic model for the discussion of the creative process in this paper.

In this model, the creative act consists of four processes: analysis, ideation, evaluation, and implementation. These processes are recursive, dynamic, and evolutionary, rather than linear; that is, they are not simply executed in a fixed order. Applying this model to lyric writing, we obtained the following steps:

- Analysis: Think about and decide on the theme, characters, and other elements needed to write the lyrics;
- Ideation: Find potential words for lyrics by association;
- Evaluation: Review the candidate lyrics to determine whether they should be adopted;
- Implementation: Determine the lyrics based on the adopted candidate lyrics.

It is thought that by having members collaborate in each of these steps, it is possible to create lyrics smoothly and without getting stuck in thought [22]. The purpose of this research is to support collaborative lyric writing by proposing a support method that seamlessly connects analysis and ideation as divergence and evaluation and implementation as convergence.

5. Collaborative Lyric Writing Support Using the LAM

In this section, we investigate a conception support method for music lyrics. In conception support, it is important to facilitate both divergence and convergence of ideas [23]. For this reason, the proposed method also includes both divergence and convergence. The divergence support method is explained in Section 5.2. The convergence support method is described in Section 5.3.

Collaborative lyric writing is not necessarily a synchronous process involving multiple members. Asynchronous work procedures, such as when one member writes a lyric and another member makes changes to this lyric later, are also possible. Therefore, this method should apply to both individual and collaborative work.

In this paper, the terms lyrics and lyric candidates will be used separately. A lyric candidate refers to all sequences of one or more words, whether or not a sentence is formed by them, that are conceived using the proposed method. A lyric refers to a lyric candidate that is determined to be associated with the melody of the music.

5.1. Investigation of Methods to Support Word Divergence

Support methods for individual and collaborative divergent thinking include mind mapping by Buzan and Buzan [24], the KJ method by Kawakita [25], and the NM method by Nakayama [26]. Mind mapping is a visual drawing method based on radial thinking. The structure of a mind map mimics the synaptic connections of the human brain, and by branching out from a central image on the map, ideas can be expanded, and associations can be facilitated. It is believed that these characteristics make mind maps that are ideal for use in the act of associating words and phrases that are first examined and discussed in lyric writing. In this study, we propose an LAM, which is an extension of mind maps, as a divergence support method.

5.2. Supporting Word Divergence Using the LAM

As mentioned in Section 3.3, it is important to create a lyric story that clarifies characters, viewpoints, and lines of sight to create lyrics. In this paper, a lyric story is defined as a set of words and phrases that express various concepts that make up the world that the lyrics are trying to convey, such as relationships among characters, thoughts, situations, and dialogues. The individual words in such a phrase set are referred to as lyric keywords.

The structure that shows the relationships between the lyric keywords that compose the lyric story is considered to have a high affinity with the structure of the keywords conceived by the radial thinking of mind mapping. This is because of the following reasons:

- (1) Radial expression from the center and diffusion of word conception.

The radial representation of keywords from the central image in mind mapping can correspond to the diffusion of ideas of lyric keywords conceived from a central image on the protagonist or a character other than the protagonist. However, since there is only one central image in a mind map in principle, we refer to the latter as a sub-image and distinguish it from the central image.

- (2) Chain of keyword conception.

By adding sub-branches under a branch, it is possible to associatively extend the world shown by the lyric story.

- (3) Conversion from lyric story into lyrics.

Since the relationship can be found among the lyric keywords of the branches that make up the lyric story, the lyric sentences can be easily composed using the lyric keywords.

- (4) Easy understanding of relationships between characters.

The joining of branches with arrows in a mind map is the joining of viewpoints, which makes it easier to understand the relationships among characters.

We define an LAM as a mind map that introduces sub-images and constructs a lyric story composed of lyric keywords. The advantages of using the LAM for collaborative lyric writing are as follows:

- (1) Easy understanding and sharing of the lyric story through the LAM's radial representation.

The map allows members to easily identify and share the lyric story behind the lyrics.

- (2) Adding, editing, or deleting lyric keywords without affecting the overall structure.

When lyrics are presented in text only, the overall structure of the lyrics varies greatly depending on how they are edited.

- (3) Bottom-up creation of lyrics through associations between lyric keywords.

Particularly for beginners in lyric writing, it is expected that it is difficult to create from a large framework of lyrics (whole lyrics, stanzas, and sentences). By using an LAM, it is possible to create lyrics in a bottom-up manner by associating and connecting new words.

5.3. Supporting Lyric Convergence by Enumerating Lyric Candidates

Sentences in lyrics can be regarded as a story-type, non-multi-attribute knowledge format [27]. Since the lyric story we defined in Section 3.3 must eventually take the form of lyrics, the goal is to transform this lyric story into a narrative text.

In other words, in the divergence stage using the LAM, word-level association focused on relationships adds lyric candidates. In the next stage, when the candidate lyrics are examined and converge to form lyrics, they are recognized as a story-type, non-multi-attribute knowledge format. It is said that if such recognition can be achieved in a group, further structuring of knowledge into a story type will be promoted within the group [27].

The above convergence from lyric candidates to lyrics requires the process of (1) discarding and selecting words displayed in the LAM and (2) combining these words to form sentences. The problem here is that it is difficult to build narrative lyrics directly from the LAM by looking at it, because the knowledge formats of the two are different.

Therefore, we adopted a method that converted the whole set of lyric candidates into a list of lyric candidate sentences and selected from these candidate sentences. A lyric candidate sentence is an arrangement of lyric candidates of neighboring branches according to one of the following three rules. This is because, as described in (4) of Section 5.2, there is a high possibility that the connected branches can be composed as lyric sentences, because they are related to the terms of their ideas:

- (1) All lyric keywords from the terminal branch to the central image;
- (2) All lyric keywords from the terminal branch to the sub-image;

- (3) All lyric keywords from the sub-image to the central image.

Such an enumeration method has an additional advantage in that it can prevent the situation in which a lyric candidate is not recognized at all because it is not explicitly mentioned [28]. To make an optimal decision as to which lyric candidate to adopt, all lyric candidate sentences should be enumerated and reviewed by the user.

However, since grammatical rules such as case changes, prepositions, and particles are not taken into account in the LAM, it is unlikely that the selection of words displayed in the LAM alone will result in grammatically correct lyrics. For this reason, as described in (1) in Section 3.2, it is desirable to be able to immediately check what the pitch accent will be when the lyrics are sung.

6. Implementation of the Proposed Method in the Cooperative Composition System

In this section, we first describe the requirements for lyric conception support in collaborative lyric writing using our system in Section 6.1. Then, in Section 6.2, we outline the lyric-writing part of the collaborative composition system we implemented in our previous study [2]. Next, we describe the additional LAM window implemented to support the divergence in Section 6.3, as well as the additional lyric editing window implemented to support convergence in Section 6.4.

6.1. Requirements for the Lyric Ideation Support Function

Based on the discussion in Section 3.2, Section 3.3, Section 4 and Section 5, we defined the following four requirements for lyric ideation support in collaborative lyric writing using our system:

1. All lyric candidates expressed on the LAM should be displayed such that members can easily grasp them;
2. The operations to add, edit, and delete viewpoints and branches should be easy;
3. All lyric candidate sentences created from the lyric candidates on the LAM should be listed, and the members should be able to see the candidates at any time;
4. The members should be able to discuss and exchange opinions with other members regarding the decisions for lyrics.

Requirements 1 and 2 for divergence support were implemented in the LAM window, as described in Section 6.3. Additionally, requirements 3 and 4 for convergence support were implemented in the lyric editing window, as described in Section 6.4.

In the LAM window and the lyric editing window, the results of adding words by adding branches and editing and deleting words are immediately reflected in the other window. In this way, the divergence of words promotes convergence, and the convergence of words also promotes divergence. This mutual promotion of divergence and convergence facilitates the execution of the recursive, dynamic, and evolutionary steps of the creative process model in the work of Zeng, Proctor, and Salvendy, as described in Section 4.2. The correspondence between the steps of the model and the functions of the system are as follows: analysis corresponds to function (1) in Section 6.3, ideation corresponds to function (2) in Section 6.3, evaluation corresponds to functions (1) and (3) in Section 6.4, and implementation corresponds to functions (1) and (2) in Section 6.4.

6.2. Overview of the Collaborative Composition System

This system is asynchronous groupware based on the client–server method. By operating the client application of this system on a web browser, multiple users can write lyrics and compose music. In this section, we describe only the part related to the lyric-writing function in the outline of our system. For other outlines, please refer to our previous study [2].

When the server receives the Japanese text of the lyrics input by a member, the server decomposes the text into parts of speech using the morphological analysis system MeCab, adds data such as the type of part of speech and pronunciation, and returns this information to the client in JSON format. The client side uses the received pronunciation

data to determine the vocalization of the melody. We used the Renoid voice file “Nagone Mako” (<http://kenchan22.web.fc2.com/i/nagonemakovoice.html> (accessed on 24 March 2022)) as the sound source for the singing part of the music. This voice file contains vocal data in Japanese phoneme units without pitch change. Therefore, Waves Tune Real-Time was used to correct the pitch of the melody as the voice was voiced.

The LAM module maintained and visualized the tree structure of the nodes that contained words with the protagonist’s viewpoint as the root. The lyric addition and editing module traced the words from the terminal nodes of the LAM, visualized the generated lyric candidate sentences, and enabled editing and assignment of the sentences to melodies.

6.3. LAM Window

In the LAM window shown in Figure 1, unique icons represent viewpoints, and name labels are displayed below the icons. The lyric keywords of the branch are displayed parallel to the straight line representing the branch.

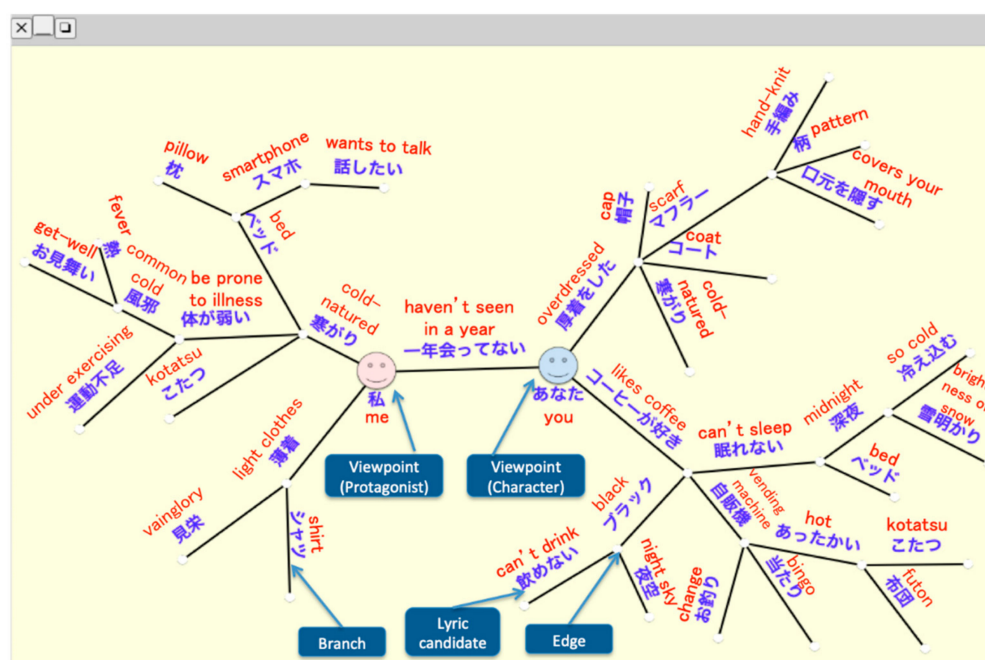


Figure 1. LAM window. (The blue texts next to the branches are the Japanese lyric keywords entered by the authors. The authors added the names of each element in white on dark blue, the arrows, and the English translations of the lyric keywords in red).

The LAM window has the following three functions:

1. Viewpoint editing function.

The viewpoint editing function sets or unsets the center of an arbitrary edge as the viewpoint. This function satisfies requirement (2) in Section 6.1. When setting the viewpoint, the name of the character is entered as text. When the input is complete, an icon and a name label appear on the screen.

2. Branch editing function.

The branch editing function adds or inserts a branch or sub-branch under any image or branch and sets the lyric keyword. This function satisfies requirement (2) in Section 6.1. The text data can be changed at any time. It is also possible to register the pronunciation of the lyric keyword in the dictionary data, which are valid only for the current project. The added or inserted branches can be deleted arbitrarily.

3. Branch coordinate modification function.

The branch coordinate modification function moves a branch to an arbitrary position in the window by dragging the sub-image or edge with the mouse. This feature satisfies requirement (1) in Section 6.1. The sub-branches under the branch to be moved are also moved at the same time. Currently, changing the coordinates of a branch only affects the visibility of the LAM.

6.4. Lyric Editing Window

In the lyric editing window shown in Figure 2, the members examine the lyric candidate sentences automatically listed from the LAM and decide the lyrics. It is also possible to directly edit the words of the lyric candidate sentences. The following is a description of each part of the window.



Figure 2. Lyric editing window. (The black texts in the lyrics display area and the blue texts in the lyric candidate label display area and the lyric candidate label display area are the Japanese lyric keywords entered by participants C and D in Table 1. The black texts in the phonogram display area are the phonograms of the texts in the lyrics display area, which are automatically generated. The authors added the names of each area in white on dark blue and the English translations of the Japanese texts in red).

The theme name display area shows the theme number and the theme name. “Theme” is an element that divides the music by its development (i.e., verse, chorus, and bridge). The lyrics display area shows the current lyrics, and the various operation buttons are displayed to the right of the lyrics. In the phonogram display area, the sound pattern of the lyrics in the lyrics display area is displayed using hiragana (Japanese phonogram characters). In Japanese, there is more than one sound pattern for a word written in kanji (Japanese ideogram characters). Since the number of morae will change when changing the sound pattern, it is necessary to check which sound pattern is used. If one wants to use an uncommon sound type, one can specify it at the time of word registration to the dictionary using the lyric editing function described below. This feature can also be used to handle euphonic changes in other languages. The notation switch button is used to switch all the kanji displayed in the window to hiragana notation or back to kanji notation. In the lyric candidate label display area, the labels of the lyric candidate registered in the theme are displayed. In the lyric candidate sentence display area, all the lyric candidate sentences

are displayed word by word in a tabular format. To the right of it, the theme buttons for registering lyric candidate sentences are displayed.

Our system is specialized for Japanese lyric writing; as described in (1) in Section 3.2, the relationship between the number of notes in a melody and the number of morae in a word must always be considered in Japanese lyric writing. For this reason, the number of "Unentered" in the notes display area shows the number of notes in the melody for which the morae have not been determined.

The lyric editing window has the following three functions:

1. Lyric selection function.

The lyric selection function sets arbitrary lyric candidates as the lyrics of a particular theme. This function satisfies requirement (3) of Section 6.1. First, the lyric candidate sentence can be registered to the theme of the corresponding theme number by pressing the theme button on the same line as the lyric candidate sentence to register. By clicking on the lyric candidate label registered in the lyric candidate label display area, the corresponding lyric candidate is confirmed as a lyric. Manipulating the cursor in the lyrics display area specifies the position where the lyric is determined. At this time, the lyric is immediately reflected in the melody of the corresponding theme. To confirm by listening to the computer-generated singing of the lyrics, the play button and stop button can be used. The reset button is used to delete all lyrics of the corresponding theme.

A scat (pronounced "la" by default) is assigned to the melody for which lyrics have not yet been determined. If the number of morae in the lyrics exceeds the number of notes in the melody, then the number of unentered notes becomes negative, and the remaining extra morae are ignored.

2. Lyric editing function.

The lyric editing function fine tunes the lyrics as shown below:

- Change the order of the words in lyrics;
- Edit lyrics line by line;
- Delete lyrics line by line;
- Modify text data (same as function (2) in Section 6.2);
- Register word(s) to the dictionary (same as function (2) in Section 6.2);

3. Commenting function.

Clicking the comment button activates the commenting function. This function is equivalent to the commenting function that we already implemented in our system [2]. The commenting function is used to comment on each theme of the lyrics and to share them among the members. This function satisfies requirement (4) in Section 6.1. It is also possible to comment on existing comments. This function makes it possible to discuss and examine whether the lyrics are relatable and meaningful, as described in the content constraint subsection in Section 3.2.

7. Experiment

7.1. Evaluation Index

Since there are no similar examples of collaborative lyric-writing tasks with divergence and convergence of lyrics using the LAM window and the lyric editing window implemented in our system in previous studies, the result of the task using them is unclear. Therefore, in this study, we conducted a preliminary evaluation experiment with few participants to understand the tendency of the collaborative lyric-writing process and the validity of the experimental methodology before conducting the main experiment. In this study, to understand the tendency of the work, we used the operation history-saving function implemented in our system, and both the work results and the operation history were used for evaluation.

First, we examined whether there was a difference in the number of word ideas and the number of specific operations in the lyric-writing process between the groups that used

the LAM and those that did not. We also examined whether there was a difference in the number of word ideas and the number of specific operations in the lyric-writing process between the groups of collaboration and non-collaboration.

The following evaluation indices were used: (1) the number of lyric keywords entered by the participant in the task (called the number of input words), (2) the number of possible lyric candidates among the input words (called the number of conceptions), and (3) the ratio of the number of ideas to the number of input words (called the ratio of the number of conceptions), where (1) was for quantitatively measuring the participants' works, (2) was for quantitatively measuring the participants' ideas, and (3) was to measure the efficiency of the conceptions in the participants' work. In this study, we decided to only discuss the created lyrics (Section 8.4) and excluded the quality of the created lyrics from the evaluation.

The number of word ideas was calculated from the operation history of the system using "add branch", "insert branch", and "edit association word" from the system operation history. The target words were classified into seven types: words that fully agreed with already existing words, words contained in already existing words, particles and auxiliary verbs only, words with minor changes from already existing words, combinations of already existing words, meaningless, and other. Only the words classified as "other" would be treated as words representing new ideas.

7.2. Experimental Overview

7.2.1. Participants

A total of eight undergraduate students and faculty members of the university (seven males and one female) participated in the experiment. Six of the participants had experience in linguistic creation, including the writing of tankas, haikus, novels, and tabletop role-playing game scenarios.

7.2.2. Grouping of Experimental Tasks

We set two conditions for comparison: collaboration or non-collaboration and LAM-use or LAM non-use. The participants were grouped into four groups based on the combination of the two conditions described above as follows: collaboration with LAM use, non-collaboration with LAM use, collaboration with LAM non-use, and non-collaboration with LAM non-use. Two participants were assigned to each group, and two units (unit of task execution) were formed from those two participants. Table 1 shows all groupings of participants. Each of the two units in each group was given a different piece of music for writing lyrics. Each participant performed the task asynchronously and individually. The task was performed for about 1 h each time, and the task of the same person was performed about 1 week apart.

Table 1. Grouping of eight participants (A–H).

Group	First Round		Improvement Round		Second Round	
	Task ID	Participant	Task ID	Participant	Task ID	Participant
Non-collab. LAM use	1	A	-	-	2	A
	3	B	-	-	4	B
Collab. LAM use	5	C	6	D	7	C
	8	D	9	C	10	D
Non-collab. LAM non-use	11	E	-	-	12	E
	13	F	-	-	14	F
Collab. LAM non-use	15	G	16	H	17	G
	18	H	19	G	20	H

The following are the details for each group.

1. Collaboration group and non-collaboration group.

The non-collaboration group consisted of four units, with one person per unit. Simply put, each person conducting the work completed the task twice (hereafter, the first task is referred to as the “first round”, and the second task is referred to as the “second round”). The collaboration group consisted of four units, with one main lyric writer and one co-lyric writer per unit. Because of the small number of participants in this experiment, assigning two participants to each other as the main lyric writer and co-lyric writer created two units. The work procedure was as follows. First, the main lyric-writer performed the first round. Next, the co-lyric writer added words and lyric candidates that he or she associated with the result of this work (hereafter the “improvement round”). This round existed only for the collaboration group. Finally, the main lyric writer performed the second round using the additional result and completed the lyrics. The responsibility for accomplishing the task rested with the main lyric writer, who decided whether or not to incorporate the added associative words and lyric candidates into the final lyrics. Although the co-lyric writer only added and developed the associated words and lyric candidates in his or her task of the improvement round, this task was treated in the same way as the tasks of the first and second rounds.

2. LAM use group and LAM non-use group.

Half of the collaboration group and half of the non-collaboration group were classified into the LAM use group and the rest into the LAM non-use group. The LAM use group used the LAM window described in Section 6.3 and the lyric editing window described in Section 6.4 to write lyrics. For the LAM non-use group, the LAM window was not presented while working. Instead, only the lyric editing window with a text input area (Figure 3), which was created for this experiment, was presented. Therefore, the participants in the LAM non-use group registered lyric candidates directly by typing.

50	違う	be different	世間体	public image				1	2	3	4
51	憧れ	adoration	恋人	lover	立場	position		1	2	3	4
52	そんな	such	を	wo (particle)	も	mo (particle)	は	ha (particle)	1	2	3
53	過ぎてく	goes by	日々	days	日常生活	daily life			1	2	3
54	消えていく	fades	日々	days	日常生活	daily life			1	2	3
55	見ているだけの	just be watching	スマホの画面	smartphone screen					1	2	3
56	私のこと	about me	見てほしい	want to see					1	2	3
エフエム 過ぎ去った 日常 今では なつかしい passed usual now nostalgic by day											

Regist

Figure 3. A text input area at the bottom of the lyric editing window. (The blue texts in the lyric candidate sentence display area are the Japanese lyric keywords entered by participants C and D in Table 1. The black texts in the text input area are the Japanese lyric keywords entered by the authors. The authors added English translations of the Japanese texts in red.)

7.2.3. Experimental Task

The experimental task was to create lyrics for an original piece of music (four parts: melody, piano, bass, and drums; 33 bars), for which everything except the lyrics had already been composed by an experimenter. We prepared two songs with the same basic structure but different chord progressions, melodies, and rhythmic patterns to avoid duplication among the units of the same group. The experimenter verbally explained the general theme of the song and that it could be changed if requested by the participants. The experimental explanation and the lyrics were written entirely in Japanese.

TaskID	1	2	3	4	5	6	7	8	9	10
Participant	A	A	B	B	C	D	C	D	C	D
Number	38	21	20	11	64	7	7	7	32	2
Average	20.9									

Table 3. Number of conceptions in the LAM non-use group.

TaskID	11	12	13	14	15	16	17	18	19	20
Participant	E	E	F	F	G	H	G	H	G	H
Number	23	7	23	5	19	22	9	24	12	14
Average	15.8									

Table 4. Number of conceptions in the collaboration group.

TaskID	5	6	7	8	9	10	15	16	17	18	19	20
Participant	C	D	C	D	C	D	G	H	G	H	G	H
Number	64	7	7	7	32	2	19	22	9	24	12	14
Average	18.3											

Table 5. Number of conceptions in the non-collaboration group.

TaskID	1	2	3	4	11	12	13	14
Participant	A	A	B	B	E	E	F	F
Number	38	21	20	11	23	7	23	5
Average	18.5							

Table 6. Results of the subjective evaluation of lyric-writing functions.

Evaluation Target	Evaluation Item	Average
LAM window (evaluated only by those who used it)	Visibility of the LAM	3.6
	Usability	3.7
	Whether or not it was useful for conceiving lyrics	4.4
Lyric editing window (evaluated by all participants)	Visibility of the table	3.75
	Ease of checking lyrics	4.25
	Usability	3.45
	Whether or not it was useful for deciding lyrics	4.3

(A)	(B)
スマホの画面見ているだけなの I'm just watching my smartphone screen. 微笑むあなた私の王子様 You, on the screen, are my dream. あなたと私立場が違う The position of you and me is different. あなたは高嶺の花 You are out of my league. 見てほしい私のこと I want you to see me. あなたと私 そんな妄想 You and me, such a fantasy. ささいなことも憧れ I long for the little things. そんな日々が過ぎてく 消えていく These days are passing and disappearing.	新しいページが増えた季節 It is the season of new pages. 今年はどうな春描こう What kind of spring shall I paint this year? あなたと景色見る Looking at the scenery with you, 色がうまれてく colors are born. このノートあふれても Even if this notebook overflows, 君とずっとそばにいる I'll always be there with you. そんなこと考えて That's what I was thinking 君の横顔見ていた 隣で as I looked at your profile, right next to you.

Figure 4. (A) Lyrics created by participants C and D (collaboration and LAM use group). (B) Lyrics created by participants G and H (collaboration and LAM non-use group). The black texts are the Japanese lyrics created by participants. The authors added the English translations of the Japanese lyrics in red.

7.3.1. Comparison between the Use and Non-Use of the LAM

The number of input words was almost the same for both the LAM use and LAM non-use groups. In contrast, the ratio of the number of conceptions to the total number of input words was 0.672 for the LAM use group and 0.516 for the LAM non-use group. The average number of conceptions per task was 1.32 times higher in the LAM use group than in the LAM non-use group. A *t*-test was conducted on the mean number of conceptions in these two groups, and no significant difference was found ($p = 0.442$). The number of times a word was deleted was significantly higher in the LAM use group ($p = 0.09$).

In the subjective evaluation of the lyric-writing function, both the LAM window and the lyric editing window received a score of 3.45 or higher, indicating a generally high evaluation. The high scores for “Is it useful for ideas?” and “Is it useful for deciding lyrics?” indicate that there were high expectations for these functions.

7.3.2. Comparison between Collaboration and Non-Collaboration

The ratio of the number of conceptions to the total number of input words was 0.605 for the collaboration group and 0.58 for the non-collaboration group, and the average number of conceptions per task of the collaboration group was 0.99 times that of the non-collaboration group. The *t*-tests were conducted on the average number of words and phrases per task, and no significant difference was found between the two groups ($p = 0.968$).

8. Discussion

8.1. Use of the LAM

Although the ratio of the number of conceptions to the total number of input words and the average number of conceptions were both higher in the LAM use group, the difference was not significant. One possible reason for not finding significant differences was the large variation in the number of input words among the participants. The reason for the large variation is thought to be the difference in the individual qualities of the ideas and the difference in proficiency within a short work period. In particular, it is assumed that the LAM use group was not able to concentrate on the task as much as the LAM non-use group because the group members had to look at two windows to examine divergence and convergence.

However, the number of conceptions in the LAM use group was higher than that in the LAM non-use group. Therefore, it is possible that the performance of the LAM use group will be significantly improved if the experiment is conducted with more detailed procedures, such as distinguishing the time for the divergence phase and the convergence phase and improving the visibility of the window.

For the LAM use group, the number of times a word was deleted was significantly higher. In an interview with a participant in the collaboration and LAM non-use group, the participant commented that he left the lyric candidates input by other members without deleting them out of concern for the other members. These results indicate that the LAM facilitated the editing of words without affecting the overall structure of the map, as described in Section 5.2 and advantage (2) of the LAM and demonstrated the superiority of the LAM in the editing process.

8.2. Collaborative Lyric-Writing

In this experiment, there was no significant difference between the collaboration group and non-collaboration group in the ratio of the number of conceptions to the total number of input words or in the average number of conceptions per task. Furthermore, there was no significant difference between these two groups in terms of the mean number of conceptions. In other words, the number of conceptions did not indicate which group was superior in terms of collaborative lyric writing. Therefore, it is necessary to examine other indices to investigate what aspects of collaborative lyric writing can be superior to independent lyric writing.

8.3. Lyrics Created by Participants

In this experiment, seven units out of eight completed the final lyrics. Figure 4 shows two of the examples. Even in the other cases, the expressions were natural and maintained the appearance of the lyrics. In the authors' subjective opinion, there were differences in the taste of lyrics. Those differences were largely due to the difference in the original lyrical ability and sense of the participants.

Analyzing the interview logs shows that the participants in the collaboration and LAM use group stated "it is easier to derive ideas now with LAM than with nothing" and "with LAM, it is easier to intervene in lyric-writing when there is a team to cooperate with" (participant D). A participant in the non-collaboration and LAM use group commented that "I could find words smoothly because it was a method for associating from the front using a map" (participant C). From these comments, it is thought that the LAM was effective for the conception of lyrics.

A participant in the collaboration and LAM non-use group had the opinion that "I didn't change the words made by the cooperative participant because I thought it was better not to change them" (participant H), and they considered the previous results to be important after round 1. Some of the participants in the LAM non-use group had more time to do nothing as time went by, and they also commented that "it was very difficult to develop ideas" (participant F). In addition, once an idea was solidified, it was sometimes difficult to develop it from there.

8.4. Limitations of the Study and Future Challenges

In Section 3, we discussed the constraints of lyric writing in Japanese, the authors' native language. The proposed system described in Section 6 is specifically designed for lyric writing in Japanese. For lyric writing in other languages, such as English, Italian, and Chinese, it is necessary to discuss the language-specific characteristics and the relationship between words and melodies in the same way. Therefore, it is unclear at this point how effectively this method will work for each language, and clarifying that is a future task.

In the evaluation of the system by questionnaires and interviews with the participants, negative opinions were noticeable in the visibility and availability of our system. Regarding visibility, the participants were divided into two groups: those who found the screen easy to see and those who found it difficult to see. As for availability, there were many comments that processing particles in Japanese was troublesome or that a dedicated function was needed (participants A, C, D, and H). To solve these problems, the specifications and functions of the system need to be re-examined and refined, which is also a future task.

In this preliminary experiment, there was a large individual variation in the number of ideas in each group, and no significant differences were found. There are two possible major reasons for the large variation in the data. The first was the small number of participants, and the second was the lack of concentration on the task because the divergent and convergent tasks were performed at once in one task. Based on the creative process model of Zehn et al. described in Section 4, the task essentially should be divided into a divergence phase corresponding to ideation and a convergence phase corresponding to evaluation. Therefore, it was found to be desirable to increase the number of participants and to give the participants a task that clearly divided the divergence phase and the convergence phase in the main experiment.

9. Conclusions

In this paper, we considered the creation of lyrics by multiple people as a collaborative act involving the divergence and convergence of ideas and proposed a method for supporting collaborative lyric writing using an LAM implemented as asynchronous groupware to support this process over a network. The proposed method visualizes the process of lyric writing in a group and makes it easier for members of a lyric-writing group to both expand their ideas for lyrics and to decide on the most appropriate lyrics.

We conducted an experiment with the purpose of verifying the effectiveness of the above functions. In a comparison between the groups that wrote lyrics (LAM use and LAM non-use), the number of times a word was deleted was significantly higher in the LAM use group. This result indicates that the LAM can be used to easily edit words without affecting the overall composition, and we concluded that this functionality was effective. Although the average number of conceptions was larger in the group that used the map, there was no significant difference in the number of conceptions. One possible reason for this was the large variation in the number of input words among individuals. In the future, we think we should conduct experiments that clearly distinguish the divergence phase from the convergence phase.

Additionally, there was almost no difference in the number of conceptions between the group that wrote lyrics in collaboration and the group that wrote lyrics alone. Therefore, it was found that an evaluation index other than the number of conceptions may be necessary. In the future, we would like to reexamine the evaluation indices and conduct further experiments using different evaluation indices or a greater number of participants.

We are also considering conducting experiments with various variations, such as verifying the differences in the effects of our system on experienced lyricists, inexperienced lyricists, or mixed groups of both, as well as having multiple people work at the same time to simulate synchronous work and verify the differences from asynchronous work.

At present, the proposed system only supports Japanese lyric writing. Although there are many difficulties in realizing lyrics in multiple languages with a single system, it is a challenging research theme. We are planning to continue our research with the support of multiple languages in the future.

The data consisting of words, lyric candidates, and lyrics obtained through the lyric-writing process using our system were also considered useful for analyzing the lyric writing trends in both individual and collaborative lyric writing. This kind of analysis can be applied to the evaluation of lyrics conceived by users and may be an interesting subject for future study.

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