CREATE YOUR WORLD
SCRATCH AT MIT 2012

Making Music with Scratch

a workshop presented at

Scratch@MIT 2012

Friday, July 27, 2012

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www.performamatics.org

Scratch is developed by the Lifelong Kindergarten Group at the MIT Media Lab. See http://scratch.mit.edu.
Performamatics is an NSF-funded interdisciplinary project at UMass Lowell. See http://performamatics.org.

Copyright Notice

A full color version of this handout in PDF format may be downloaded from:

http://bit.ly/scratch2012music

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Contents

Workshop Description 5
- Workshop Topics 8
- Additional Workshop Information and URLs 9
- About the Workshop Leaders 10
- Important Note on Turbo Speed 11
- Acknowledgements 11

Performamatics
- Project Website 13
- Workshop Information 14

Playing and Synchronizing MIDI Files 17
- MP3 Player Scripts 18
- Control Script 19

Example 1 - Frère Jacques
- Version 1: Playing Notes 21
- Version 2: Using Loops 22
- Version 3: Separating Phrases 23
- Version 4: Playing a Round 25

Example 2 - Row, Row, Row Your Boat
- Version 1: Playing Notes 29

continued on next page

Contents (cont'd)

Version 2: Playing Notes Using Variables 30
Version 3: Separating Initialization 31
Version 4: Separating Phrases 33
Version 5: Looping and Fading 36
Version 6: Playing a Round with One Instrument 38
Version 7: Playing a Round with Two Instruments 40
Version 8: Storing Notes and Rhythms in Lists 43
Version 9: Playing a Round Using Lists 45
Version 10: Synchronizing Play from Lists 47

Extending the Examples 51

The IchiBoard 55

The PicoBoard 57
Serial to USB Setup 54
USB to USB Setup 59

Computing and Music:
What Do They Have in Common? 61

Computer Science, Math, and Music:
Concepts Covered in Scratch 65

Additional Readings 67

Related Websites 71

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Workshop Description

> "There is nothing like making music and messing with sound to inspire people to learn how to program."
>
> — Prof. Dan Trueman, co-founder of the Princeton Laptop Orchestra

We couldn't agree more. However, the cost of "getting into the digital music game" can be prohibitive on many fronts. Our work strives to make the excitement of music technology accessible to students of all levels.

This workshop presents a subset of the techniques we've developed to allow students to explore the intersection of computing and music using the sound capabilities built into Scratch. In addition, it gives participants the opportunity to create music-generating programs themselves using a variety of Scratch constructs. The workshop will conclude with a mini concert in which some participants will play the music they created using these techniques.

One of the distinctive characteristics of the workshop is that it is presented in true interdisciplinary fashion: by a CS and a Music professor working together. This is a hallmark of our work. Participants will be exposed to a

Workshop Description (cont'd)

fresh approach to teaching that they may be able to implement to a greater or lesser degree in their own schools and institutions.

Background

Music applications are incredibly powerful and engaging tools for getting students interested in learning about technology. They can range from music cataloging applications such as the popular musicbrainz.org site, to music playing applications such as the ubiquitous Apple and Adobe products, to music transcribing and composing applications such as Finale, Sibelius, and Noteflight.

We are interested in harnessing the engaging power of music to stimulate student interest in computing in general and computational thinking in particular. Toward that end we have designed an interdisciplinary, general education course that teaches computing *and* music to undergraduates in novel ways and that is open to all students in all majors. Our project is called "Performamatics," and it has been funded by two grants from the National Science

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Workshop Description (cont'd)

Foundation. (Please see www.performamatics.org for further information on this project.)

The centerpiece of Performamatics is "Sound Thinking," an interdisciplinary course taught with a music and a computer science professor in the room for all class meetings. (Please see soundthinking.uml.edu for the course website.) This approach models the interdisciplinary environments that students will encounter when they graduate and provides valuable lessons for life in the world of work.

The computational thinking component of our approach not only helps arts majors learn to think analytically, but also helps technical majors understand computing concepts at a deeper level through applications that employ the engaging power of music. We take advantage of the "low floor and high ceiling" of Scratch to appeal to students at both ends of the curricular spectrum. We believe that this is one of the real powers of this media-rich visual programming system. We have seen that harnessing its music capabilities is a tremendous "hook" for making programming appealing to a wide range of students, from those in middle school to those in undergraduate programs.

Workshop Topics

1. Demonstration of Scratch music capabilities
2. Playing MP3 files from Scratch
   - Synching music to animations
   - Manipulation of MP3 files using Audacity
3. Playing MIDI notes from Scratch
   - Creating and playing simple melodies
   - Using loops and broadcasts to structure music
4. Playing MIDI notes using lists
   - Creating and populating lists
   - Working with rhythm and note lists
5. Synchronizing multiple parts
   - Techniques that do not work, and those that do
6. Introduction to external sensor devices
   - The Scratch Board and PicoBoard
   - The IchiBoard
7. Sharing what you've created
   - Live performances by participants ☺

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Additional Workshop Info and URLs

Participants should download and install:

- **Scratch 1.4**
  scratch.mit.edu/download
- **Audacity 2.0.1**
  audacity.sourceforge.net/download

Participants should also download and install the appropriate sensor board drivers for their systems.

- for **PicoBoards**
  www.picocricket.com/whichpicoboard.html
- for **IchiBoards**
  www.cs.uml.edu/ecg/index.php/IchiBoard

Important Note: Scratch does not have access to a MIDI synthesizer on systems running Linux, Ubuntu, etc. Scratch **does** synthesize notes on these systems, but you only get one instrument.

About the Workshop Leaders

Jesse Heines is a Professor of Computer Science at UMass Lowell. He has a keen interest in CS education and computer applications in the arts, particularly those in music. He teaches courses in object-oriented and graphical user interface programming. Jesse grew up in a musical household and currently enjoys singing in a barbershop chorus.

Gena Greher spent 20 years as a music producer/director in advertising before moving to UMass Lowell. She has published on the influence of multimedia technology in the general music classroom, middle school music curricula, and music teacher education curricula. Gena teaches courses in music methods, world music for the classroom, technology in music ed., and socio-cultural impacts on teaching music.

Jesse's and Gena's work has been supported by two **National Science Foundation** awards: "Performamatics: Connecting Computer Science to the Performing, Fine, and Design Arts" and "Computational Thinking through Computing and Music." Please see www.performamatics.org for more information on these projects and the opportunity to attend one of our two-day, NSF-sponsored interdisciplinary workshops.

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Important Note on Turbo Speed

The timing of virtually all music scripts can be improved by setting Turbo Speed. To do this, select:

Edit ➔ Set Single Stepping... ➔ Turbo Speed

Acknowledgements

Additional contributors to this work include UMass Lowell Profs. Gena Greher, S. Alex Ruthmann, and Fred Martin, graduate student Mark Sherman, recent undergraduates Paul Laidler and Charles Saulters, and current undergraduates Brendan Reilly, Angelo Gamarra, Matt Vaughan, and Nathan Goss.

The materials presented in this workshop are based on work supported by the National Science Foundation under Award Nos. 0722161 and 1118435. Any opinions, findings, and conclusions or recommendations expressed or implied in these materials or the workshop discussion are those of the authors alone and do not necessarily reflect the views of the National Science Foundation.

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Performamatics Project Website

UMass Lowell TUES Performamatics Project : Home - Mozilla Firefox

File Edit View History Bookmarks Tools Help

UMass Lowell TUES Performamatics Proj...

teaching.cs.uml.edu/~heines/TUES/ProjectHome.jsp

Google

University of Masschusetts Lowell
Depts. of Music and Computer Science

UMASS LOWELL

Computational Thinking through Computing and Music

an interdisciplinary NSF TUES project

Home | Workshop | About Our Project | About Us | Resources | Publications

Our second **two-day interdisciplinary workshop** will take place on:
Thursday and Friday, January 17-18, 2013, at UMass Lowell

Our third **two-day interdisciplinary workshop** will ***tentatively*** take place on:
Thursday and Friday, June 20-21, 2013, at UMass Lowell

To attend the workshop, please fill out the **workshop application** form.

Our goal is to develop and disseminate ways to enhance students' grasps of computational thinking by engaging them in fundamental concepts that unite computing and music. Our approach leverages students' near universal interest in music as a context and springboard for engaging in rich computational thinking experiences. Prior work in an NSF CPATH project showed this approach to be effective at creating value in both discipline-specific courses for Computer Science and Music majors, as well as General Education courses for all majors. This project will develop additional activities to deepen students' experiences in computing and music, and explore additional techniques for evaluating learning through those activities. The project will also disseminate our work through workshops for pairs of interdisciplinary faculty at 4- and 2-year colleges.

Our materials teach concepts such as modularization by breaking songs down into their components, looping and subroutines by noting where musical phrases are repeated intact and with small variations (requiring parameters), logic flow by creating musical flowcharts, and algorithms by writing programs that generate music. New materials will explore ways to teach more advanced computing concepts such as threads and synchronization by writing programs that play multiple parts simultaneously and use various Application Programmer Interfaces (APIs), allowing us to combine software platforms into systems that to do more than is possible by one alone.

A major component of this project is the sharing of our techniques and materials through sponsored workshops at conferences and on-site at universities where participants attend as a pair: at least one from Computer Science (or another science or engineering department) and one from Music (or another arts department). This will ensure that collaborations begun in the workshops have a foothold on sustainability when the participants return to their own institutions.

This project is supported by Award No. 1118435 from the National Science Foundation (NSF) Division of Undergraduate Education (DUE). It falls under the TUES program: Transforming Undergraduate Education in STEM (Science, Technology, Engineering, and Mathematics). Any opinions, findings, conclusions, or recommendations expressed in our materials are solely those of the authors and do not necessarily reflect the views of the National Science Foundation.

NSF

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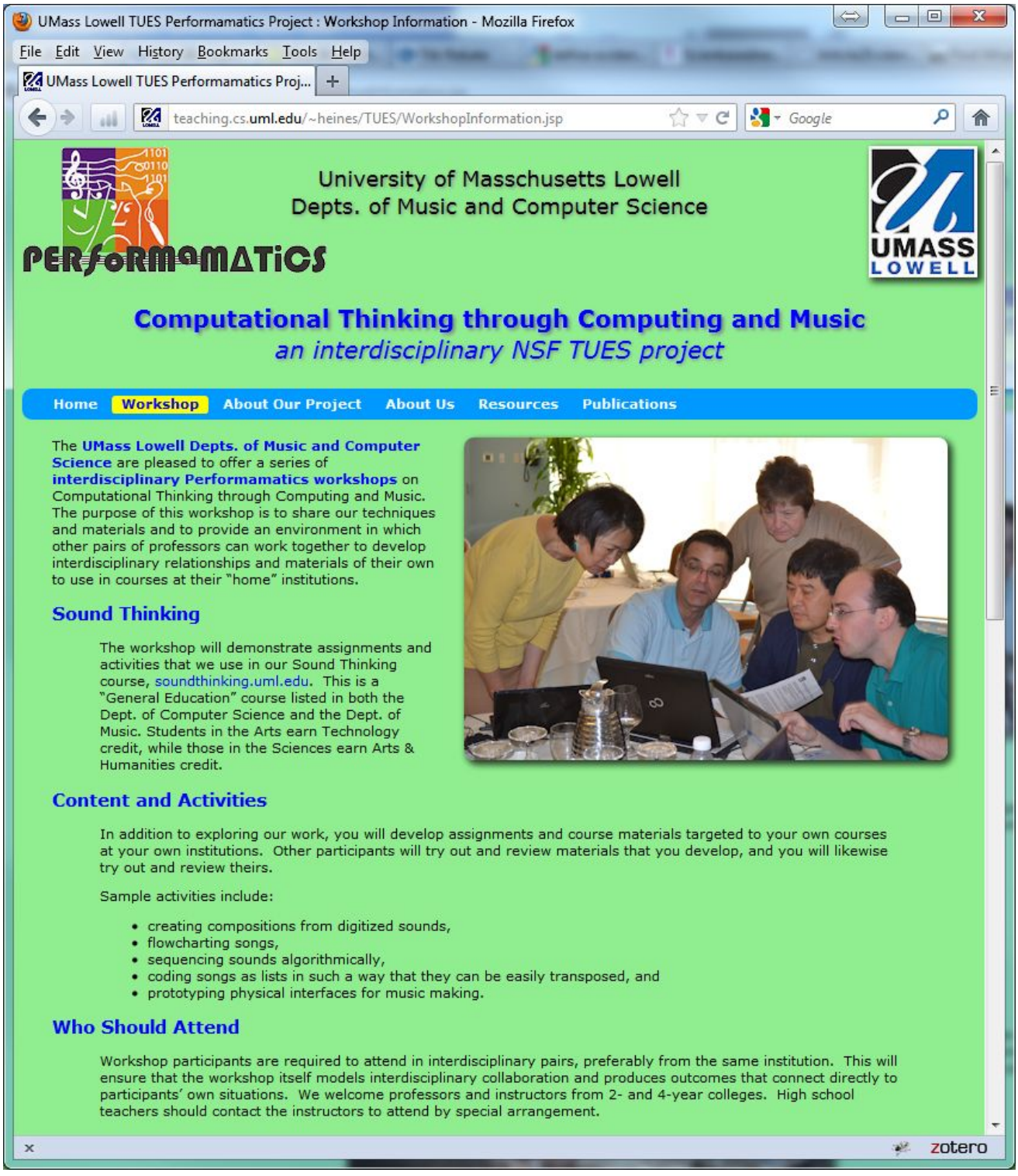
Performamatics Workshop Info



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Performamatics Workshop Info (cont'd)

UMass Lowell TUES Performamatics Project : Workshop Information - Mozilla Firefox

File Edit View History Bookmarks Tools Help

UMass Lowell TUES Performamatics Proj...

teaching.cs.uml.edu/~heines/TUES/WorkshopInformation.jsp

Venue

Univ. of Massachusetts Lowell
Inn & Conference Center
50 Warren Street
Lowell, MA 01852
1-978-934-6920

Upcoming Dates

Thursday-Friday, January 17-18, 2013
full two-day workshop
9:00 AM to 5:00 PM both days

Thursday-Friday, June 20-21, 2013
*full two-day workshop — **dates tentative***
9:00 AM to 5:00 PM both days

Cost

Thanks to support for the National Science Foundation, there is no charge to participants to attend the workshop. In addition, our project funds cover two nights' lodging and meals on both days of the workshop. Limited funds are also available to help support participant travel to and from the workshop. Prospective participants requiring travel support should contact the instructors for further information.

How to Apply

Please fill out our **Workshop Application** form.

Instructors



Jesse Heines is a Professor of Computer Science with a strong interest in the power of music to engage students and help them learn computing concepts as they explore music applications. He teaches courses on graphical user interfaces, web programming, and C++.

Gena Greher is a Professor of Music Education. Her research focuses on creativity and listening skill development in children and examining the influence of integrating multimedia technology into urban music classrooms and in the music teacher education curriculum.

S. Alex Ruthmann is an Assistant Professor of Music Education. His research explores social/digital media musicianship and creativity and the development of technologies for music learning, teaching, and engagement in schools and community-based arts+computing programs.

Further Information

Please contact:

- Jesse Heines — Jesse_Heines@uml.edu — 978-934-3634
- Gena Greher — Gena_Greher@uml.edu — 978-934-3893
- Alex Ruthmann — Alex_Ruthmann@uml.edu — 978-934-3879

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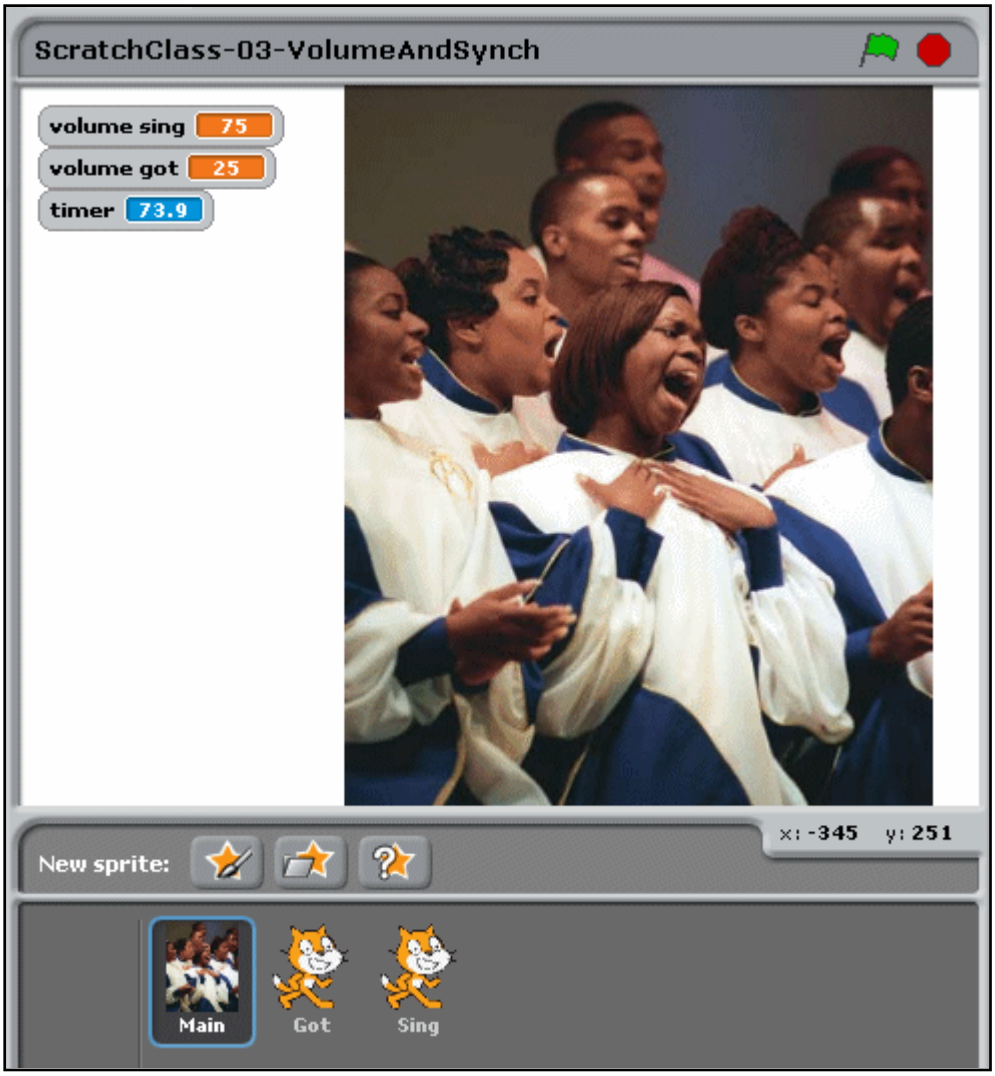
Playing and Synchronizing MIDI Files



Volume and Synchronization Concepts

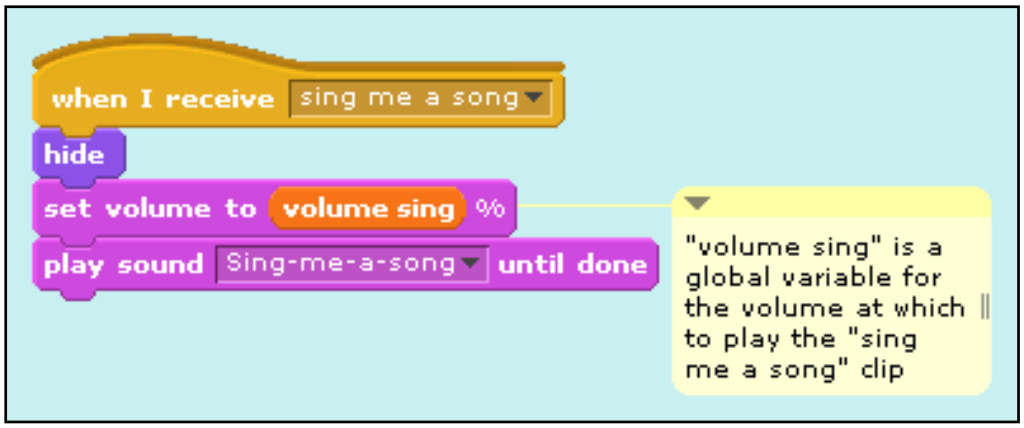
- use of variables when setting the volume
- local vs. global attributes, specifically volume
- use of a control script and broadcasts
- use of the Scratch timer for synchronization

Playing and Synching MIDI Files (cont'd)

MP3 Player Scripts

Script in Sprite "Got"

Script in Sprite "Sing"



Each script must be in its own sprite to allow volume to be controlled independently.

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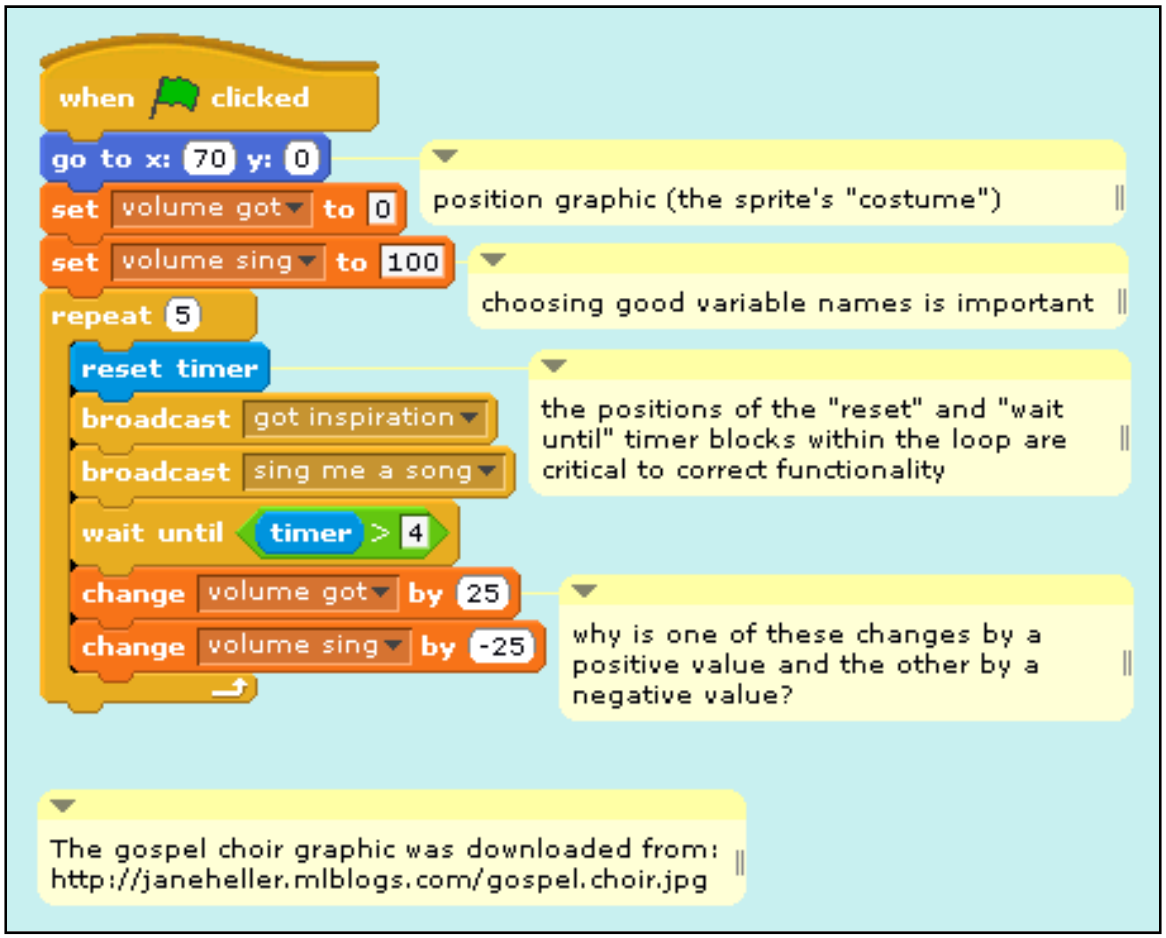
Playing and Synching MIDI Files (cont'd)

Control Script

Script in Sprite "Main"



Note the order of the blocks and the critical position of the **change** blocks. Changing the volume parameter before the **wait until** block will cause the volume to be changed while the MP3 is playing. Such behavior may be desirable in other programs, but not this one.

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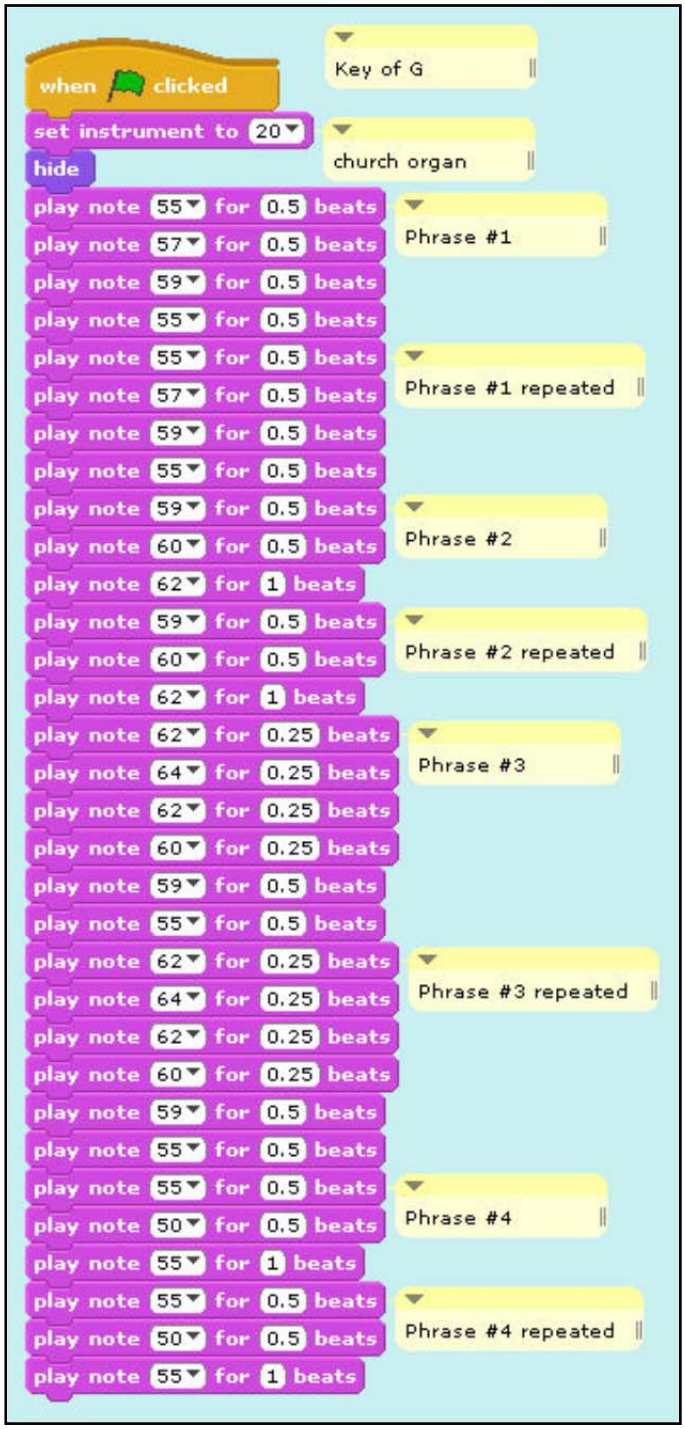
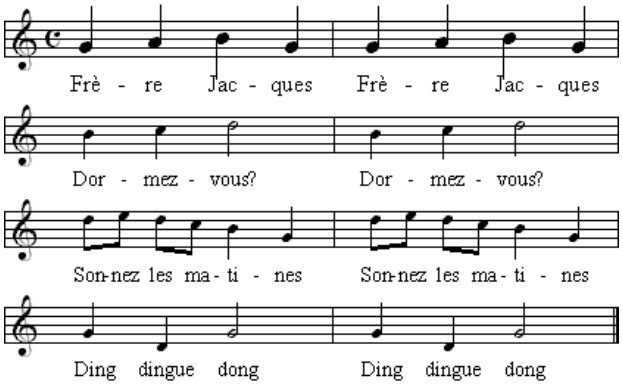
Frère Jacques

Version 1: Playing Notes

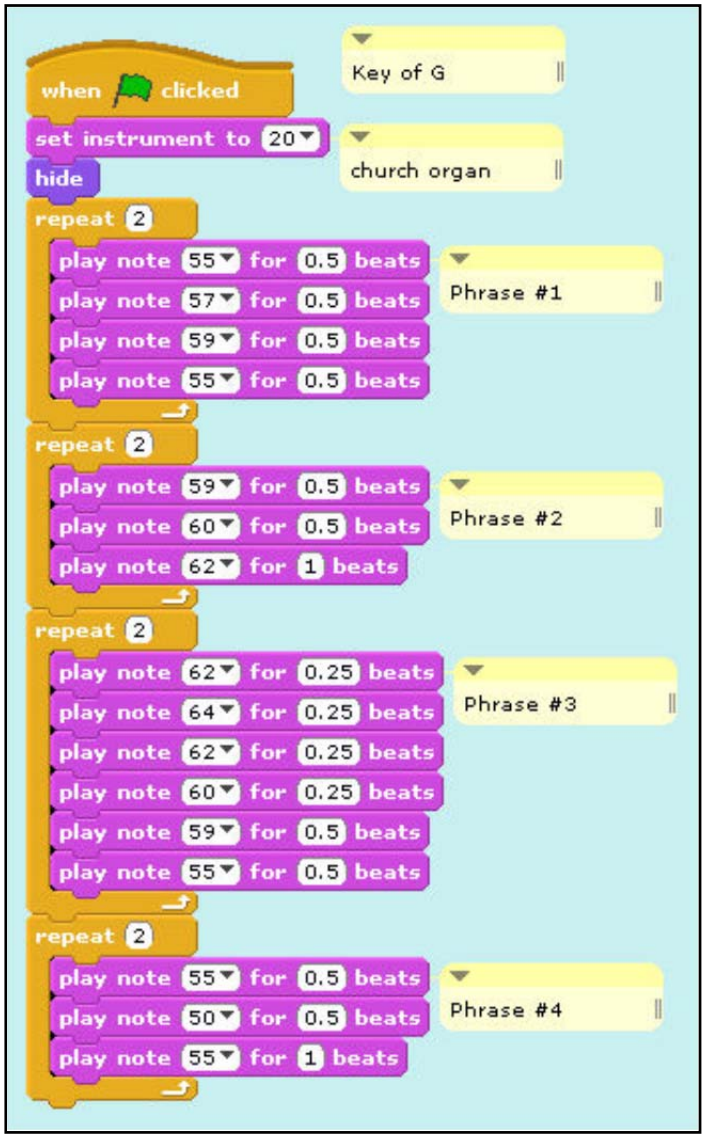


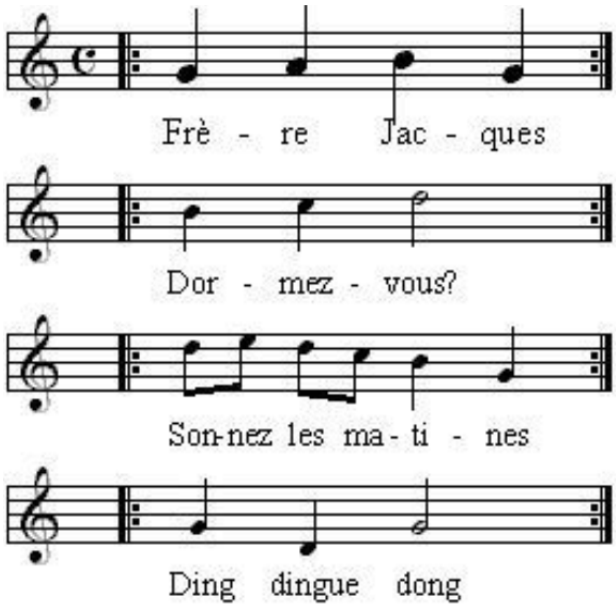


Remember Turbo Speed!

Frère Jacques

Version 2: Using Loops





Remember to set Turbo Speed to improve performance.

Acknowledgement: The scores on this and the previous page were adapted from www.csdraveurs.qc.ca/musique/flutalors/images/frere.gif and www.mamalisa.com/images/scores/frerejacques.jpg, respectively, but as of July 12, 2012, these URLs no longer appear to be valid.

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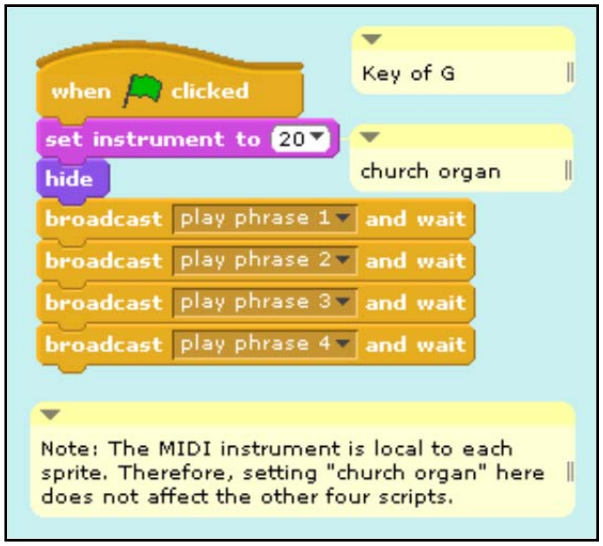
Frère Jacques

Version 3: Separating Phrases

Main Script



Phrases Scripts (4, cont'd on next page)

#1

Thought: We could set the instrument in each script, but that would contradict the **DRY** programming principle: "Don't Repeat Yourself."

Frère Jacques

Version 3: Separating Phrases (cont'd)

Phrases Scripts (cont'd)

#2

#3

#4

Challenge: How can we set the instrument **JUST ONCE** and have that setting apply to all scripts?

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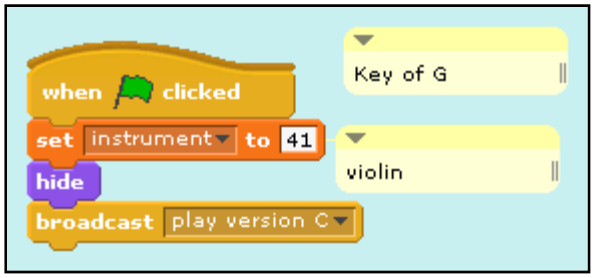
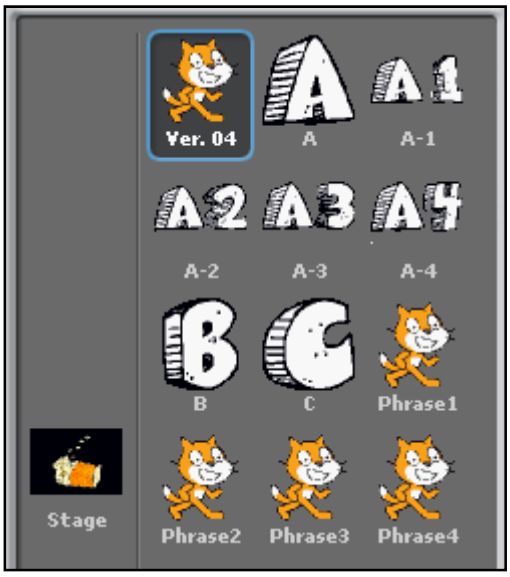
Frère Jacques

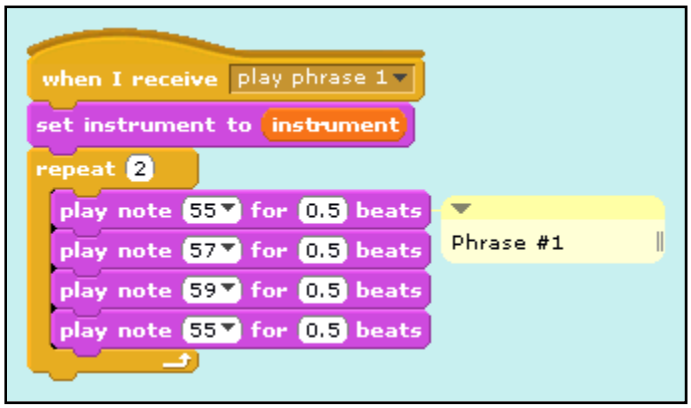
Version 4: Playing a Round

Main Script





Phrases Scripts



Note the addition of the **set instrument** block and the use of the **instrument** variable (set in the Main script) as the value to set. Other phrase scripts similarly contain this one revision.

continued on next page

Frère Jacques

Version 4: Playing a Round (cont'd)

Scripts A-1 through A-4

...

Others scripts are similar, differing only in **when I receive**.

Control Script A – single threaded

continued on next page

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Frère Jacques

Version 4: Playing a Round (cont'd)

Control Script B – multi-threaded

Control Script C – multi-threaded repeat

end of Version 4

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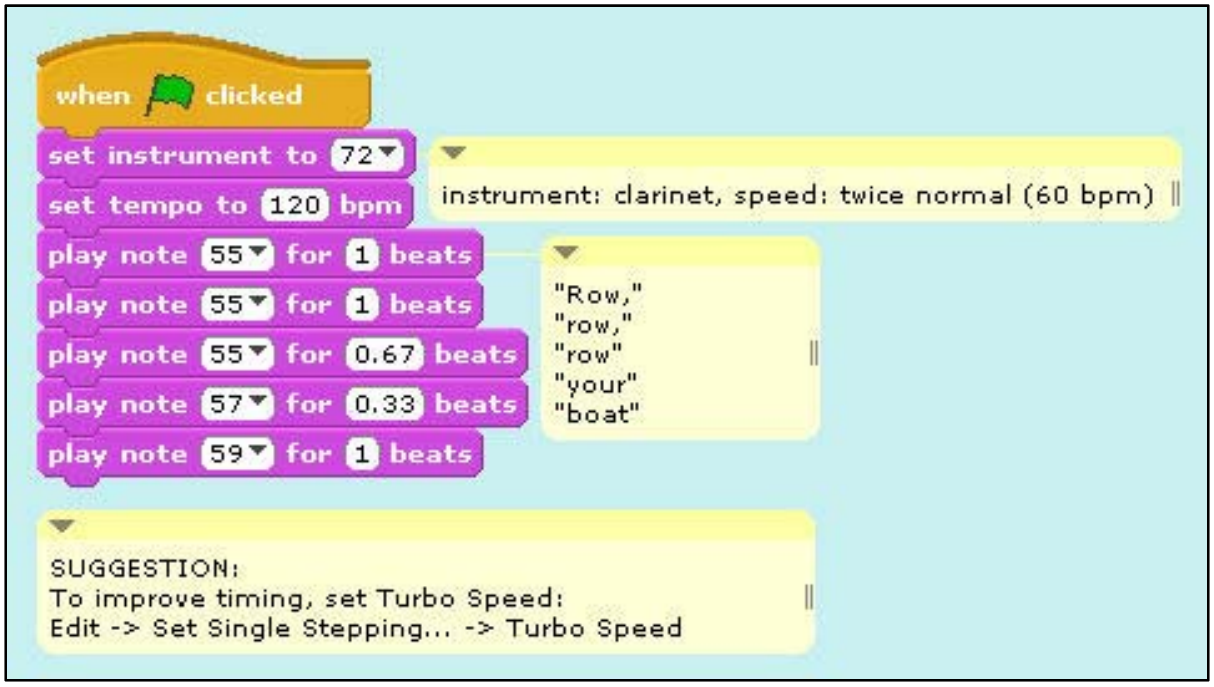
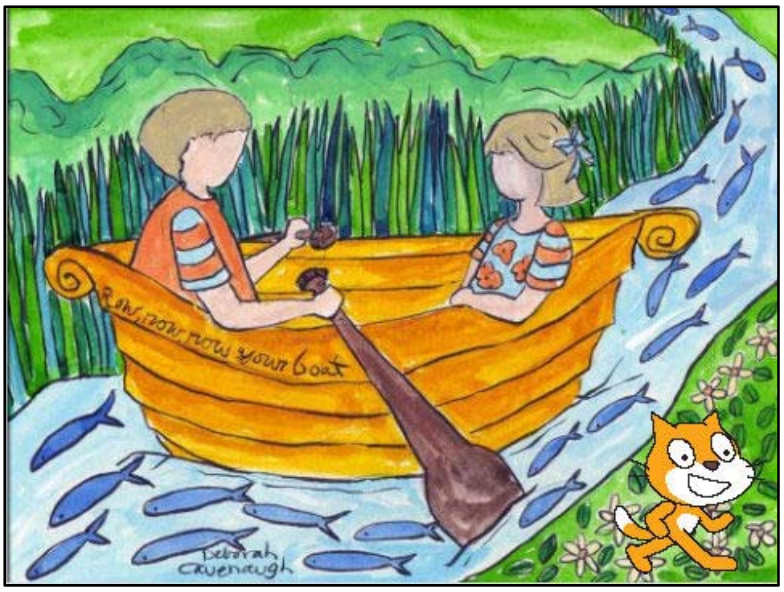
Row, Row, Row Your Boat

Version 1: Playing Notes

Single Script



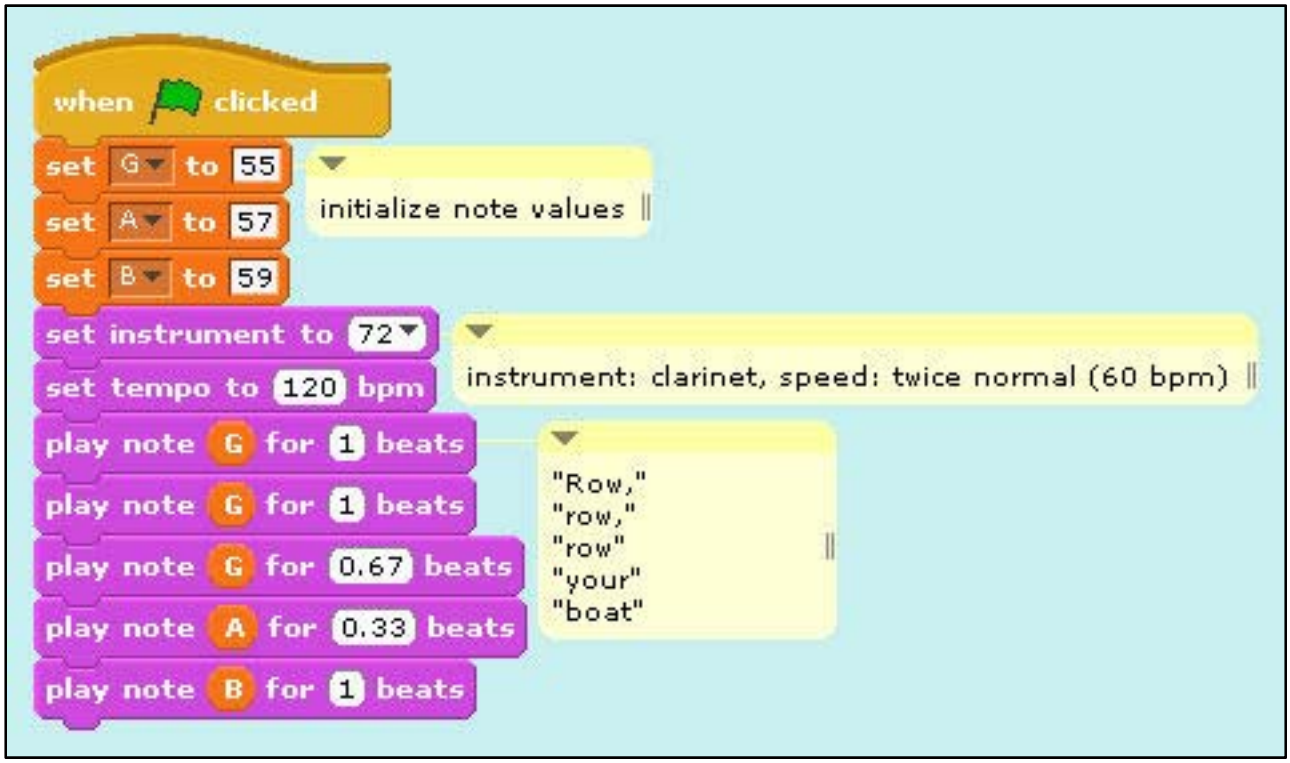
Output Window



Row, Row, Row Your Boat

Version 2: Playing Notes Using Variables

Single Script

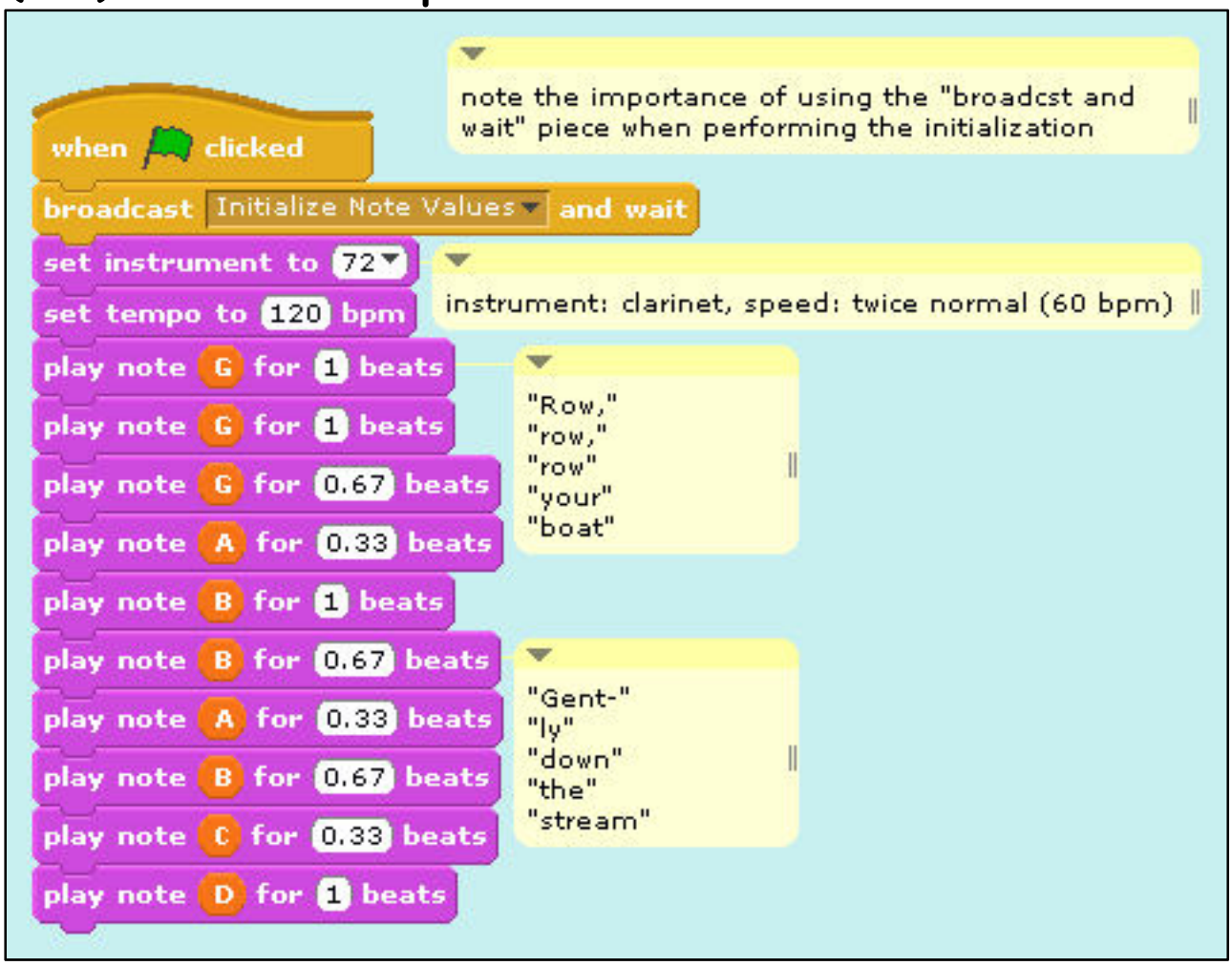


Row, Row, Row Your Boat

Version 3: Separating Initialization

Two Scripts

(3a) **Main** Script

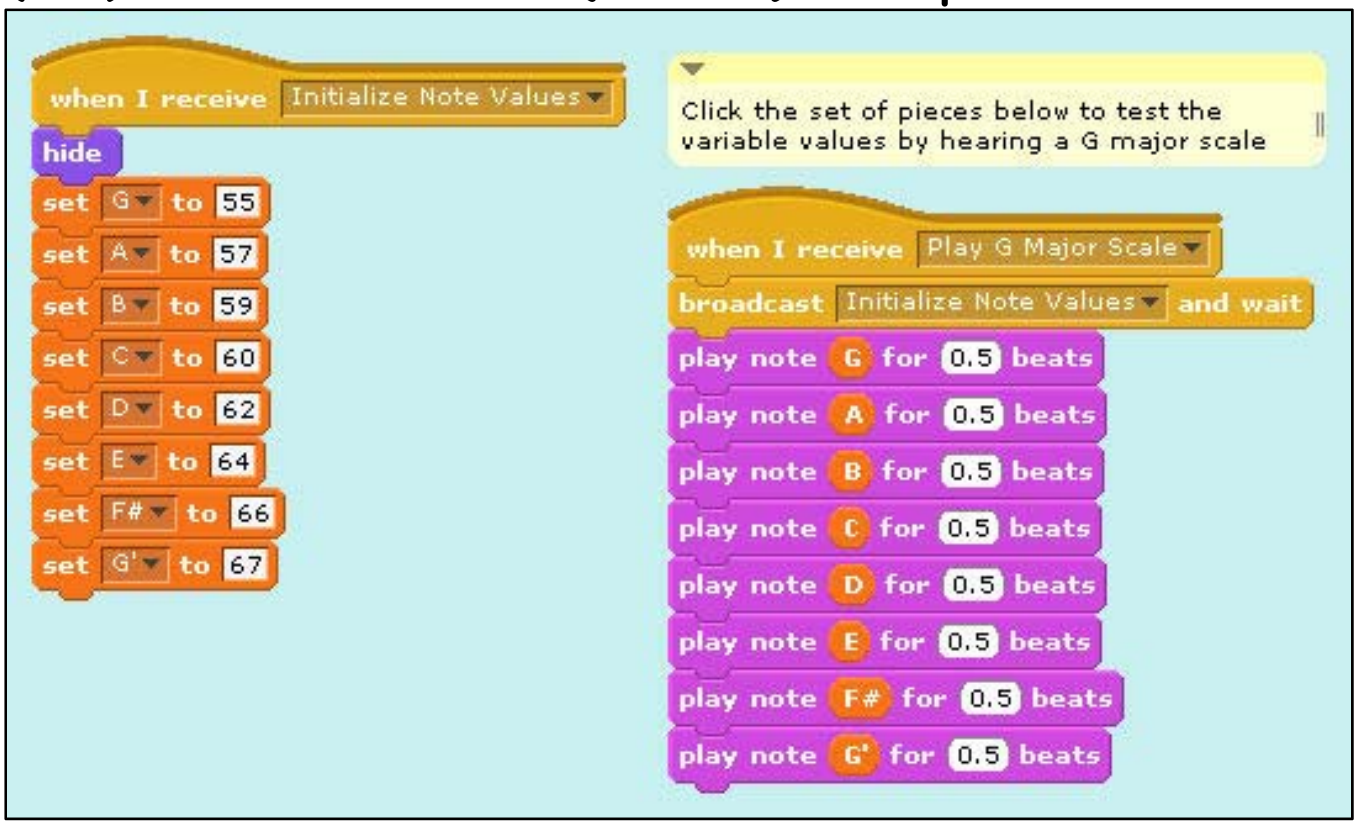


continued on next page

Row, Row, Row Your Boat

Version 3: Separating Initialization (cont'd)

(3b) **Initialization ("Init")** Script



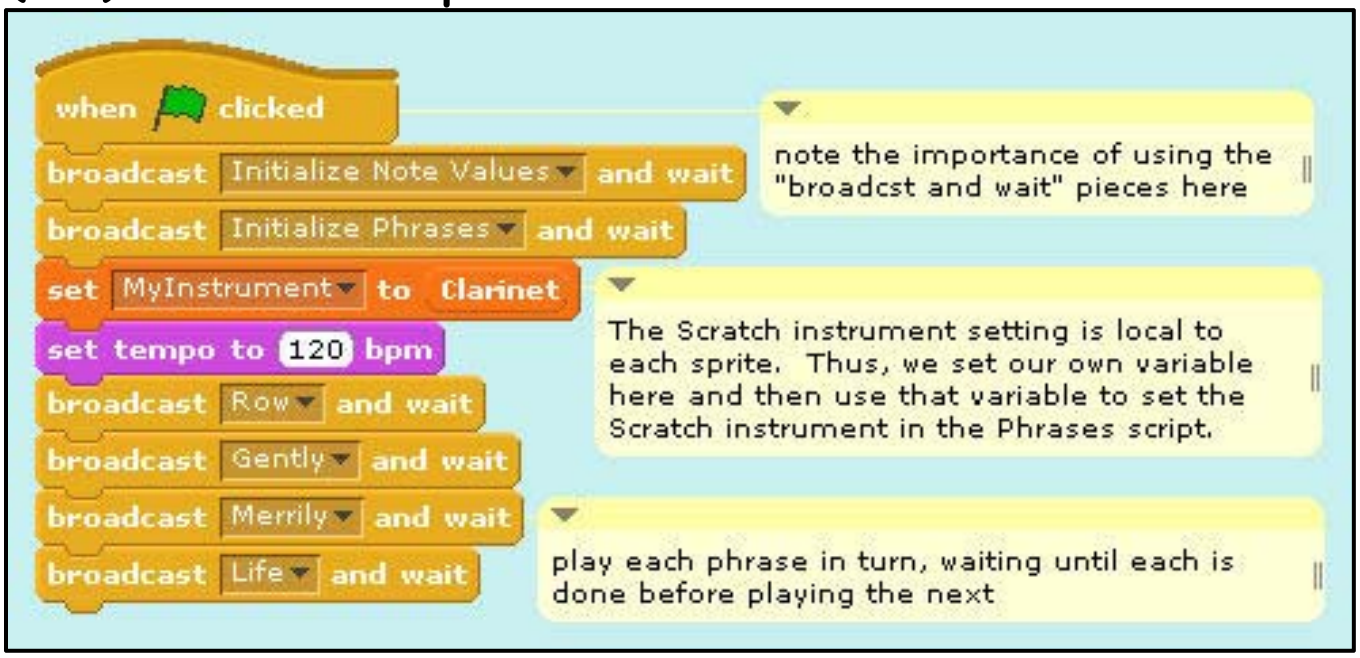
end of Version 3

Row, Row, Row Your Boat

Version 4: Separating Phrases

Three Scripts

(4a) **Main** Script

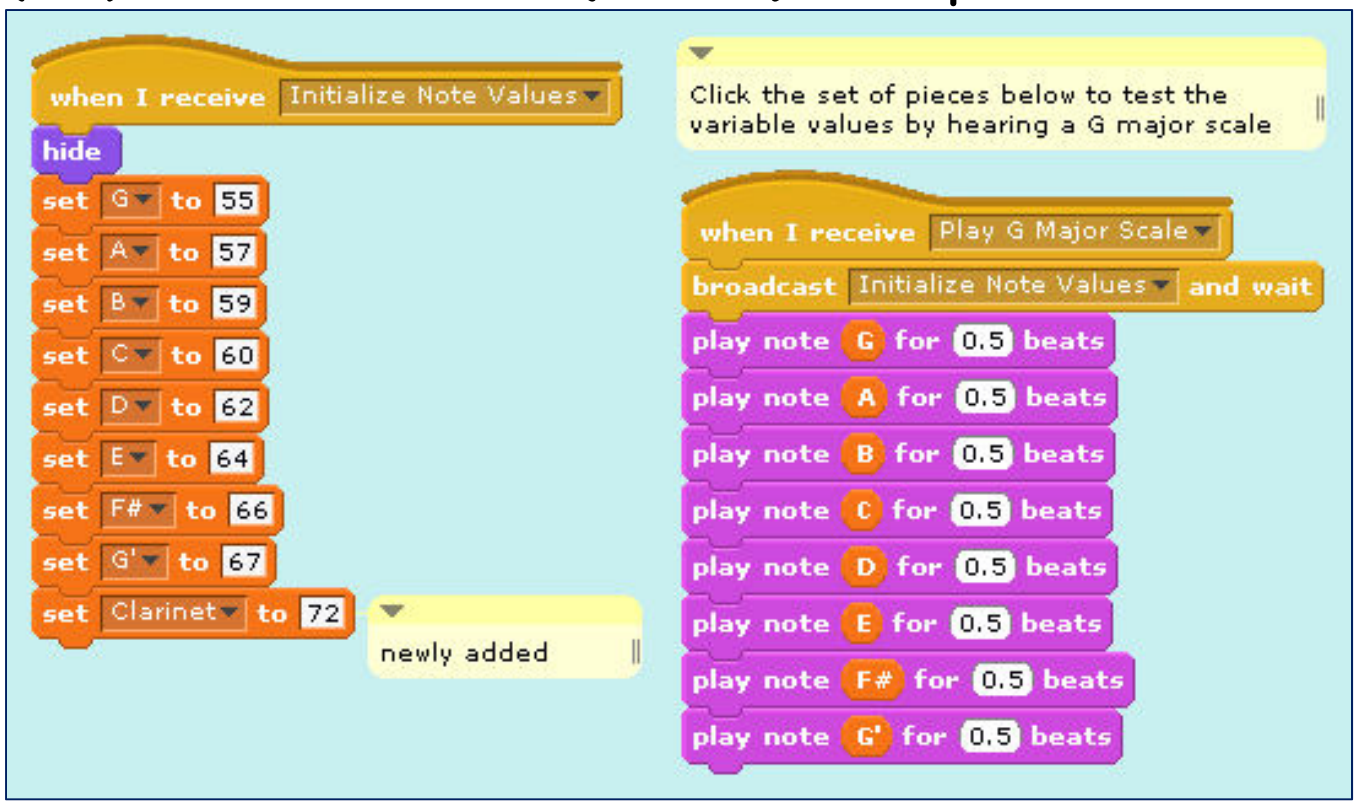


continued on next page

Row, Row, Row Your Boat

Version 4: Separating Phrases (cont'd)

(4b) **Initialization ("Init")** Script



continued on next page

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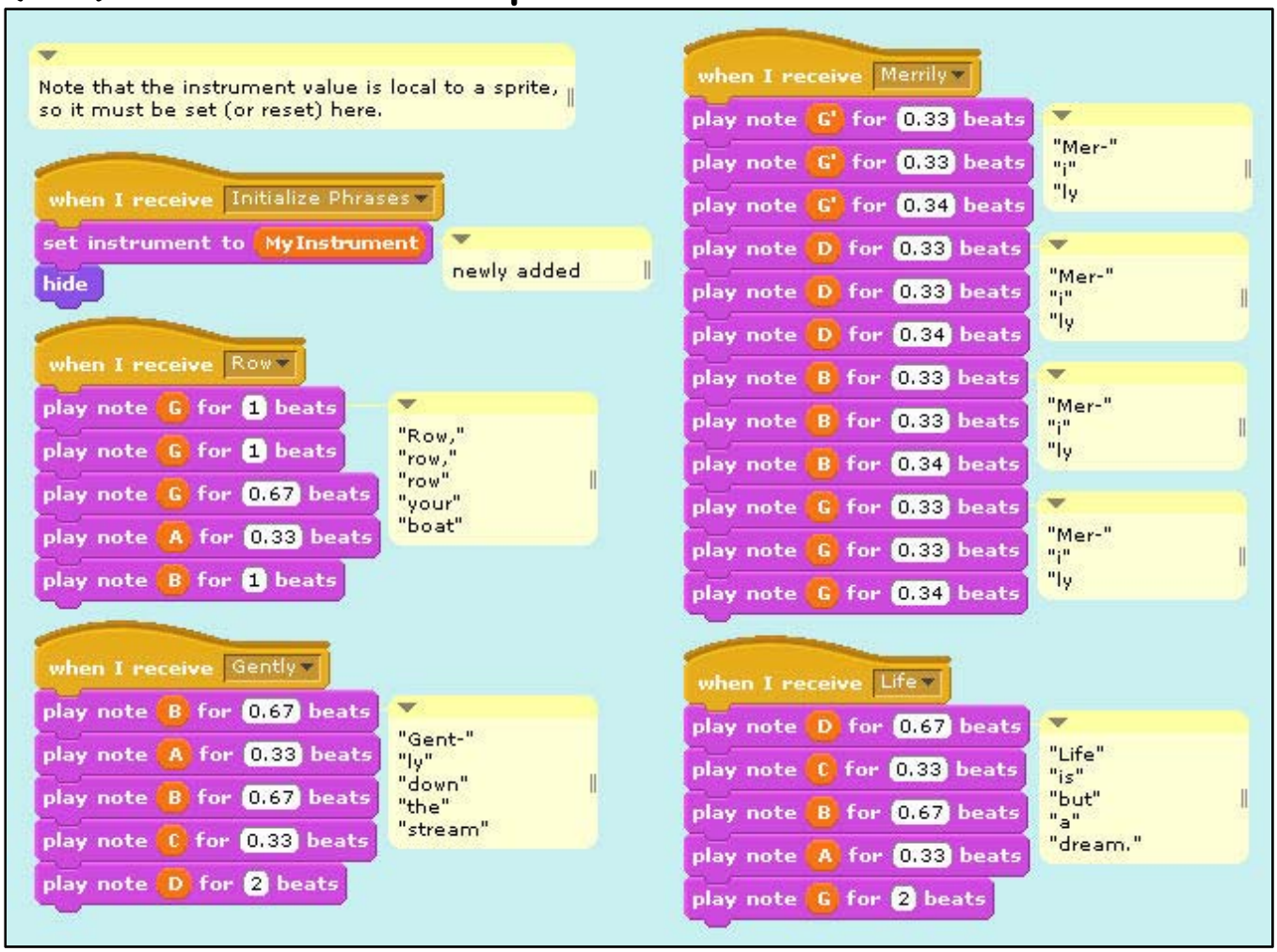
Row, Row, Row Your Boat

Version 4: Separating Phrases (cont'd)

(4c) **Phrases** Script



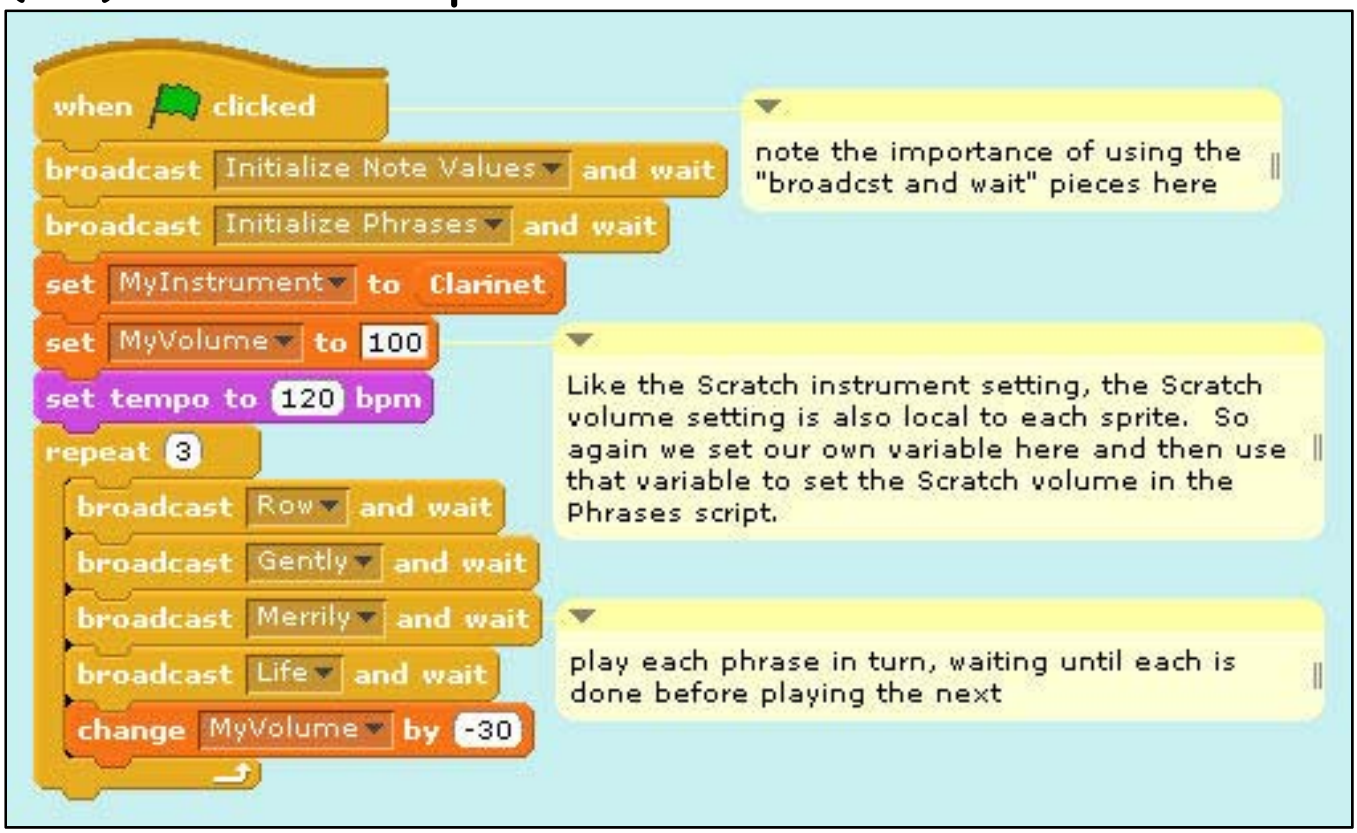
end of Version 4

Row, Row, Row Your Boat

Version 5: Looping and Fading

Three Scripts

(5a) **Main** Script



(5b) **Initialization ("Init")** Script

(*same as on page 34*)

continued on next page

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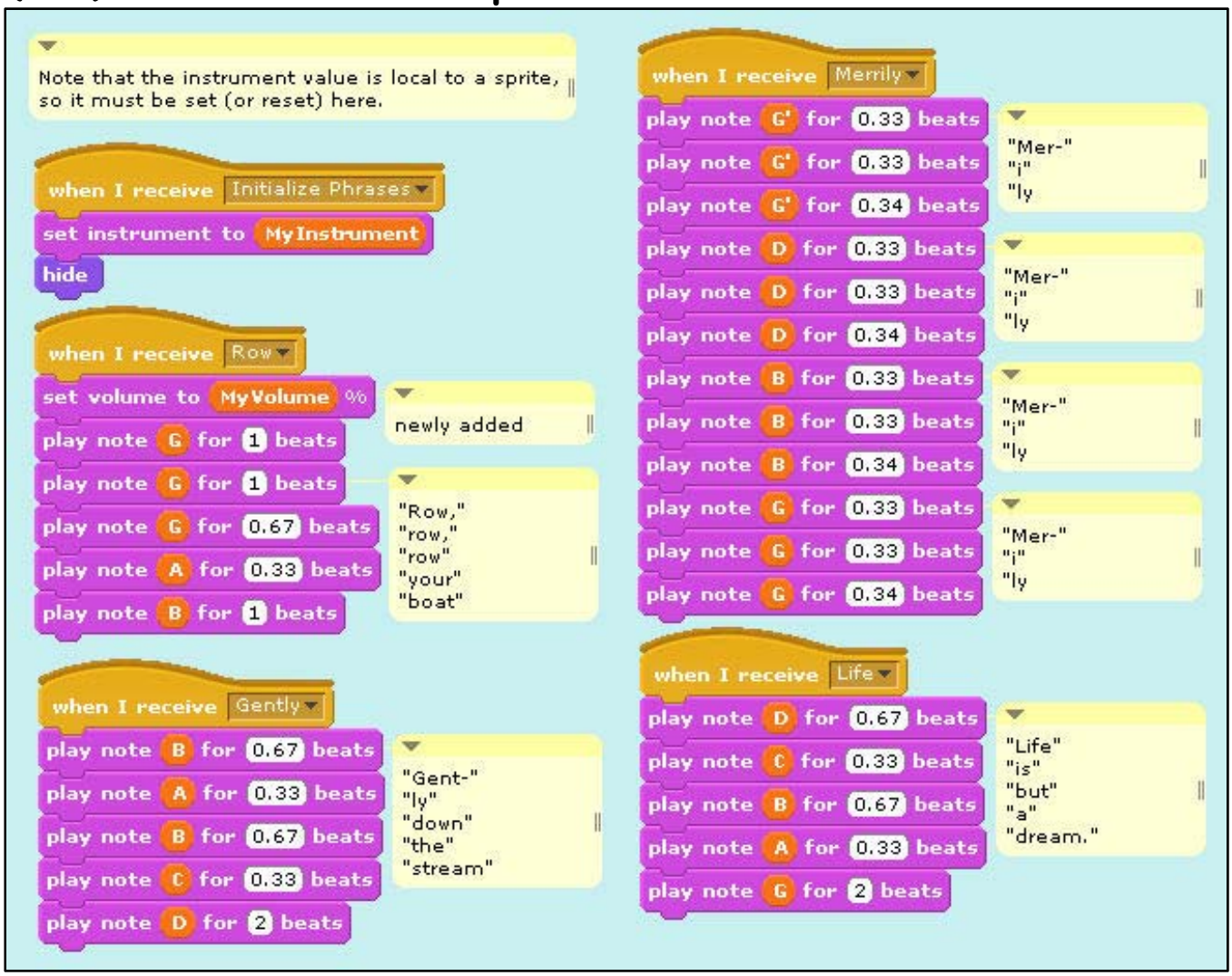
Row, Row, Row Your Boat

Version 5: Looping and Fading (cont'd)

(5c) **Phrases** Script



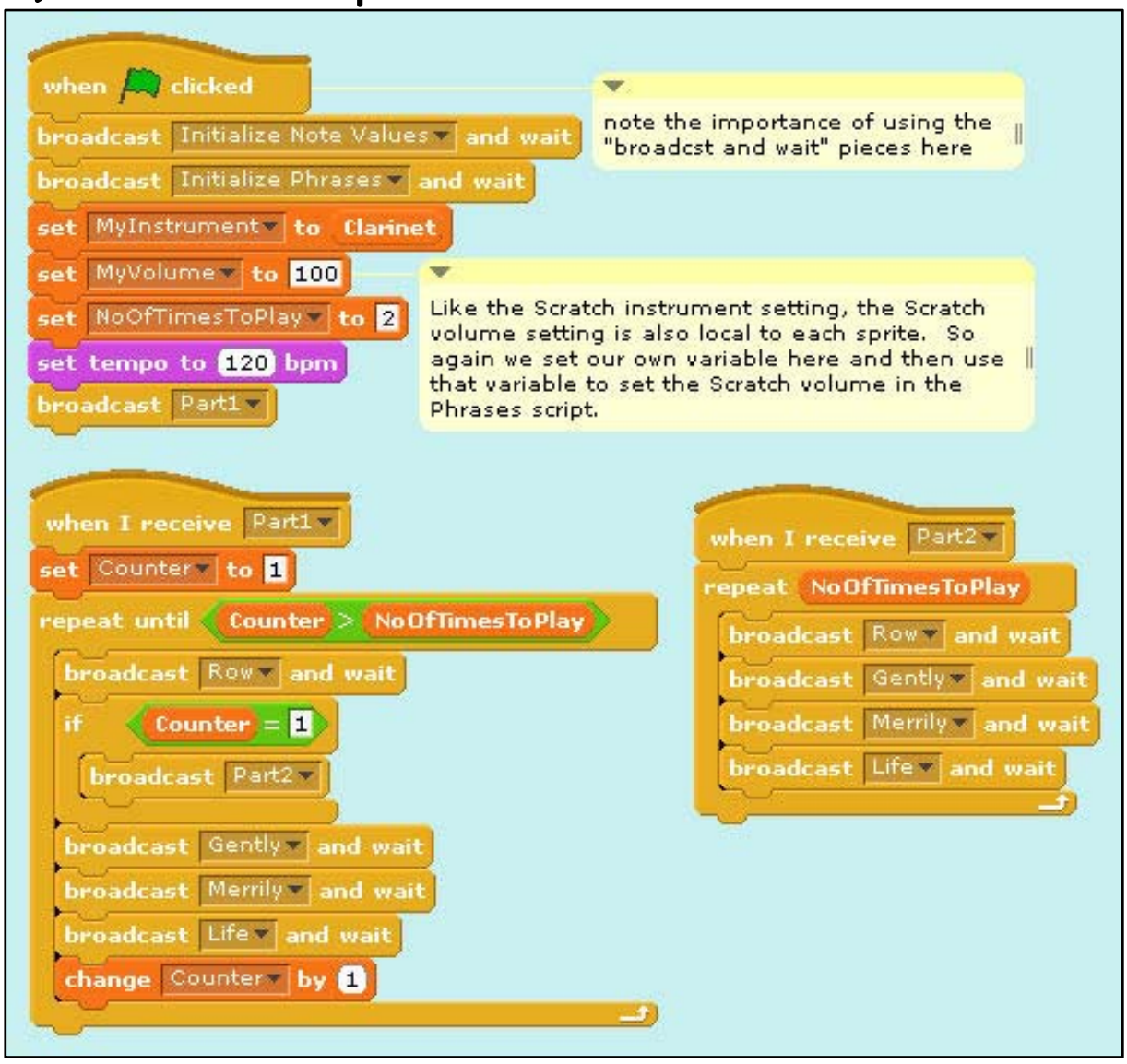
end of Version 5

Row, Row, Row Your Boat

Version 6: Playing a Round with One Instrument

Three Scripts

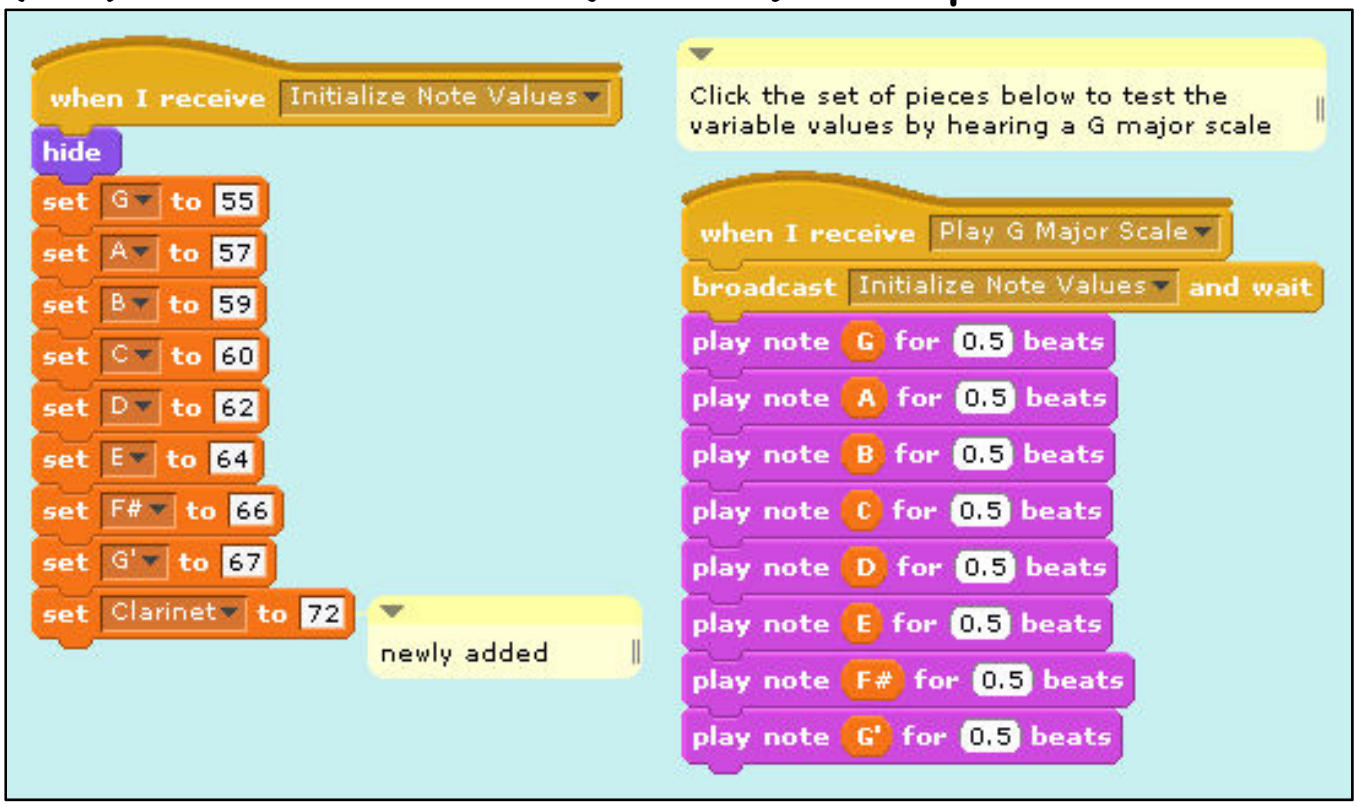
(6a) **Main** Script



Row, Row, Row Your Boat

Version 6: Playing a Round with One Instrument (cont'd)

(6b) **Initialization ("Init")** Script



(6c) **Phrases** Script

(*same as on page 37*)

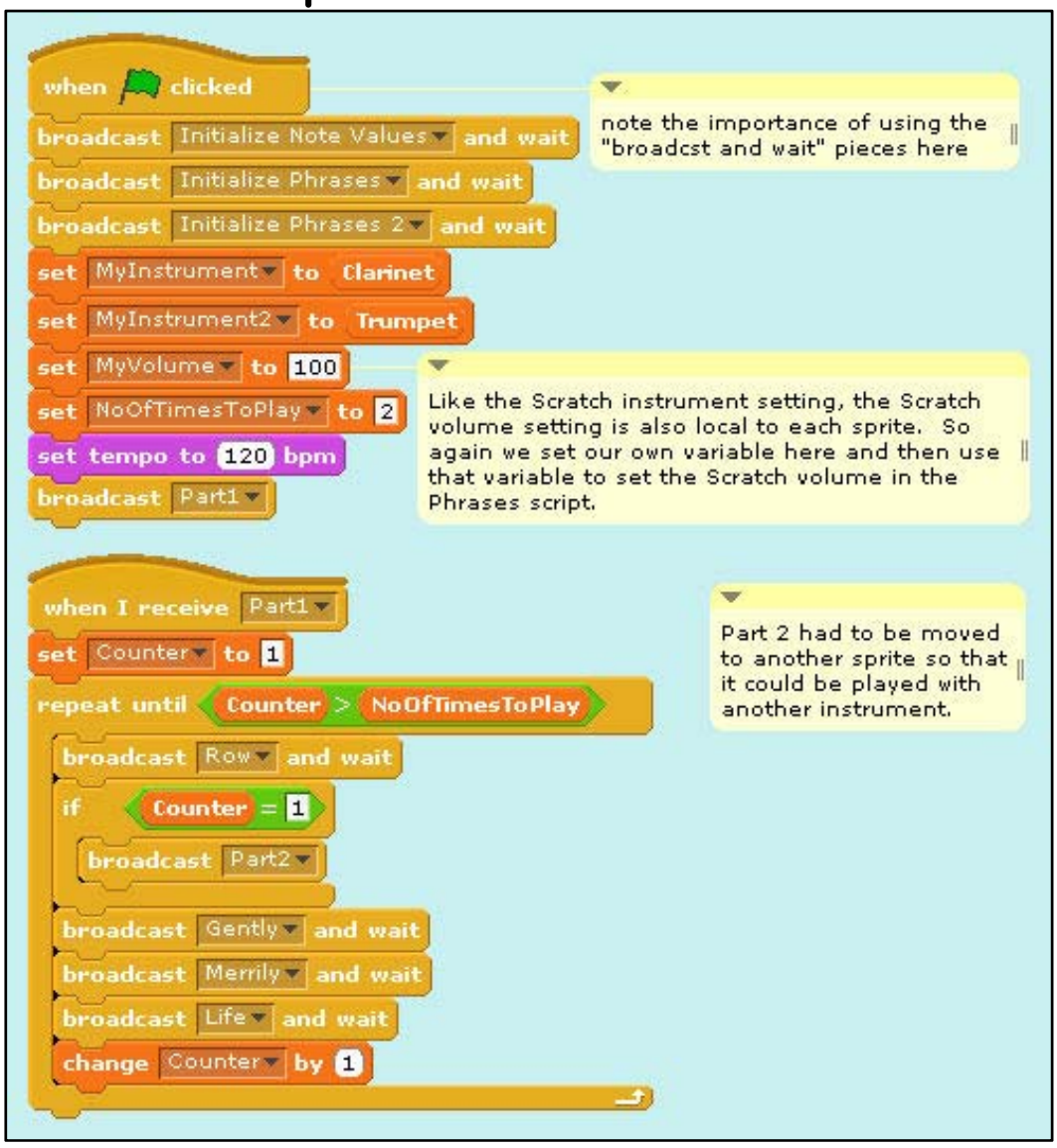
end of Version 6

Row, Row, Row Your Boat

Version 7: Playing a Round with Two Instruments

Five Scripts

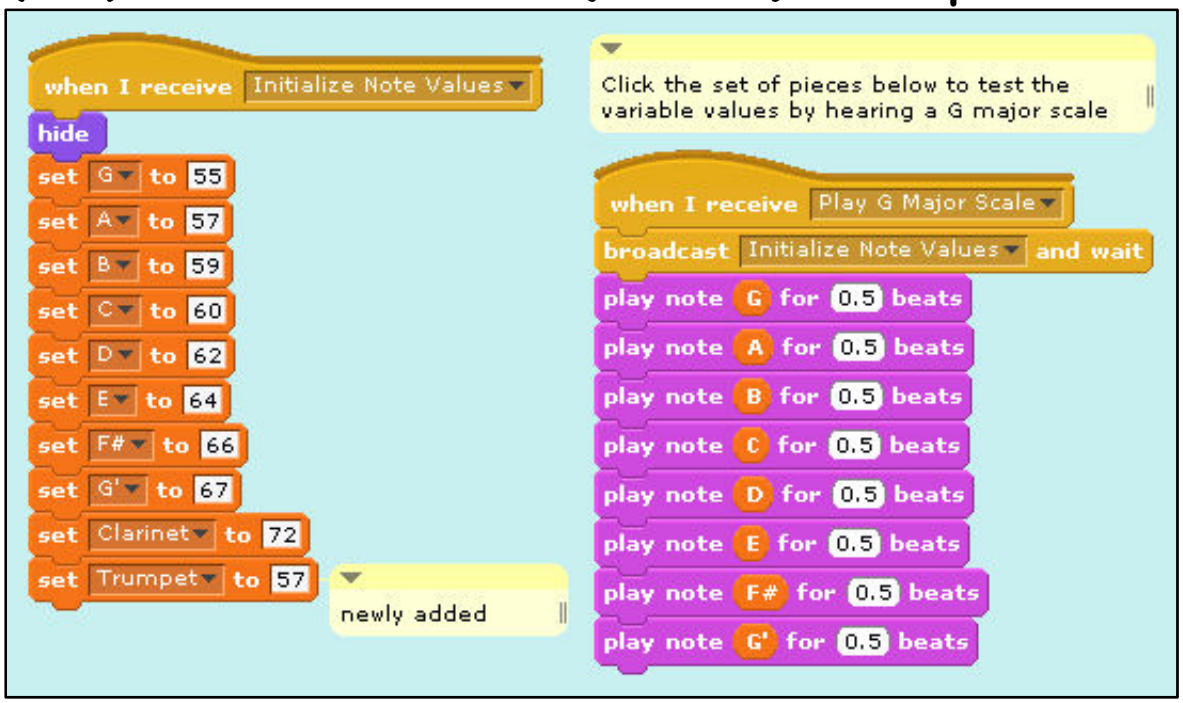
(7a) **Main** Script



Row, Row, Row Your Boat

Version 7: Playing a Round with Two Instruments (cont'd)

(7b) **Initialization ("Init")** Script



(7c) **Phrases** Script

(*same as on page 37*)

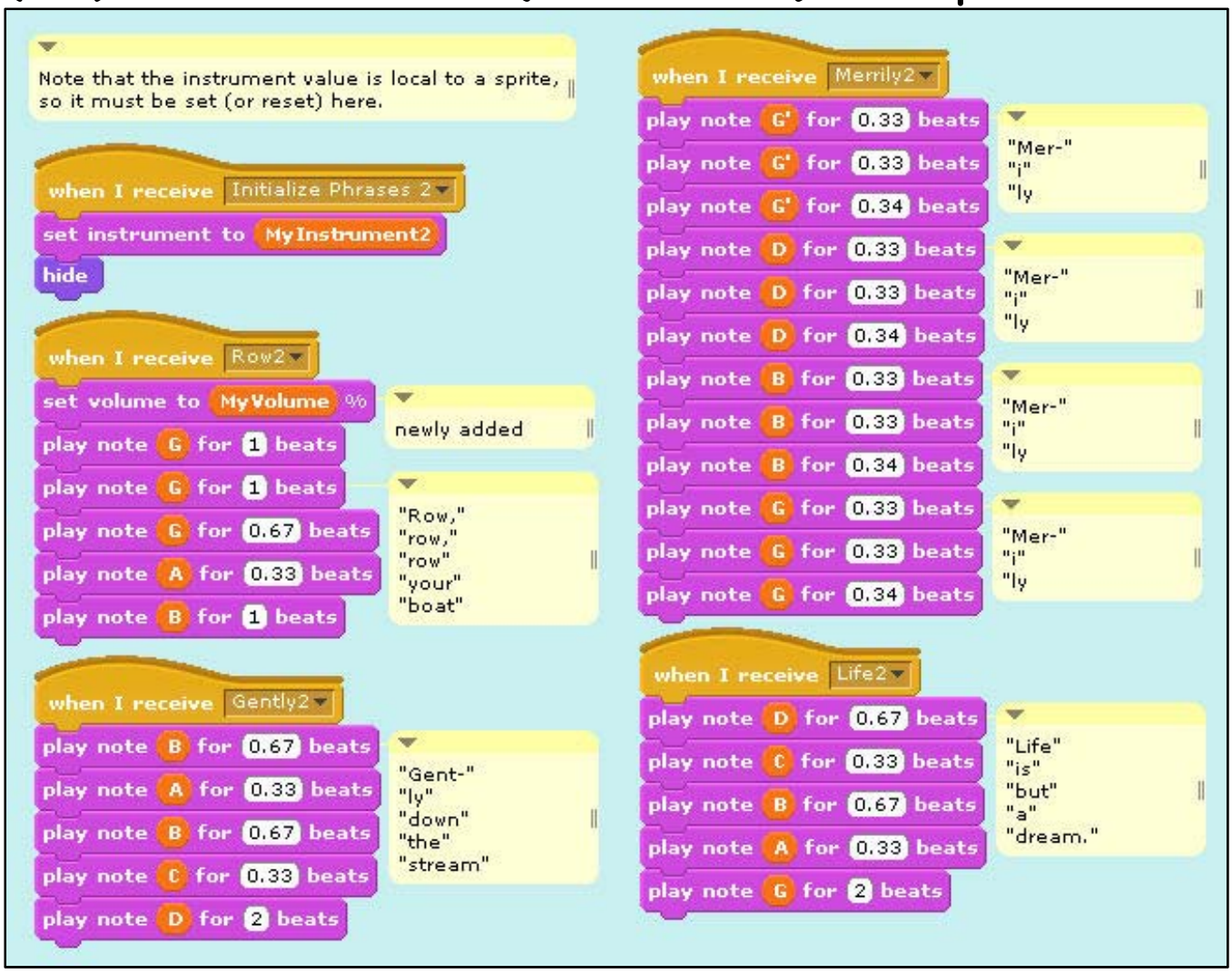
(7d) **Part2** Script ➔

continued on next page

Row, Row, Row Your Boat

Version 7: Playing a Round with Two Instruments (cont'd)

(7e) Instrument2 ("Instru2") Script



end of Version 7

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Row, Row, Row Your Boat

Version 8: Storing Notes and Rhythms in Lists

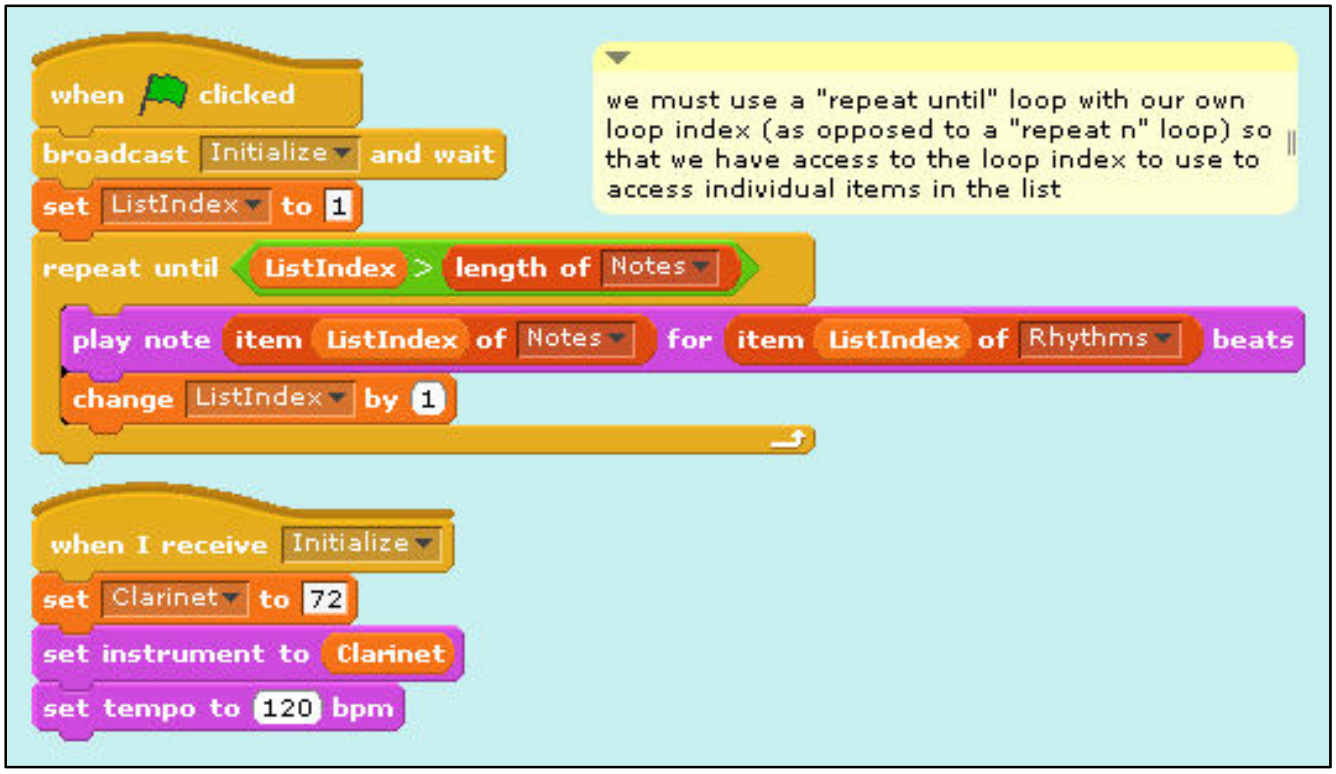
Output Window

continued on next page

Row, Row, Row Your Boat

Version 8: Storing Notes and Rhythms in Lists (cont'd)

Single Script



end of Version 8

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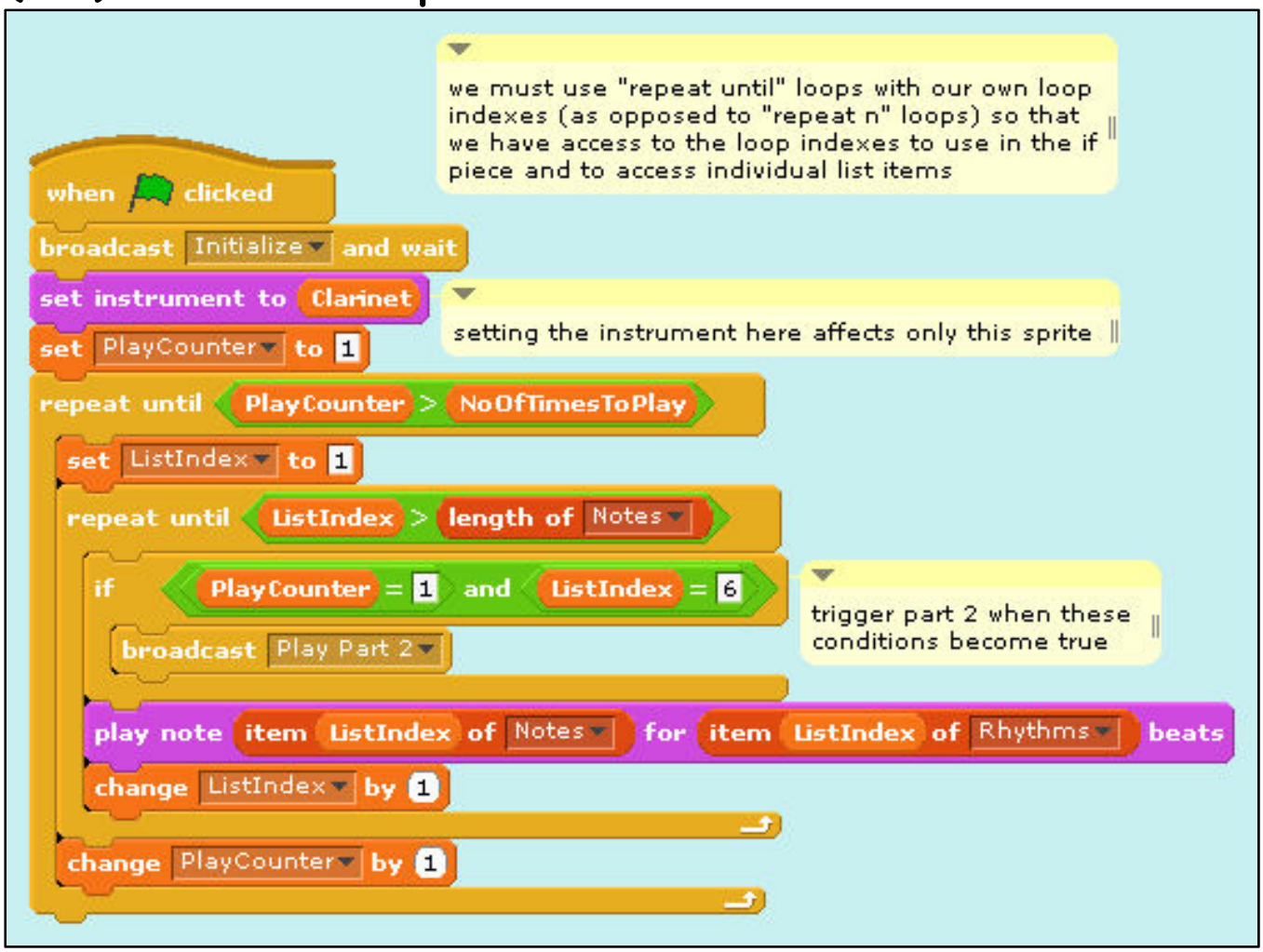
Row, Row, Row Your Boat

Version 9: Playing a Round Using Lists

Three Scripts

(9a) **Main** Script



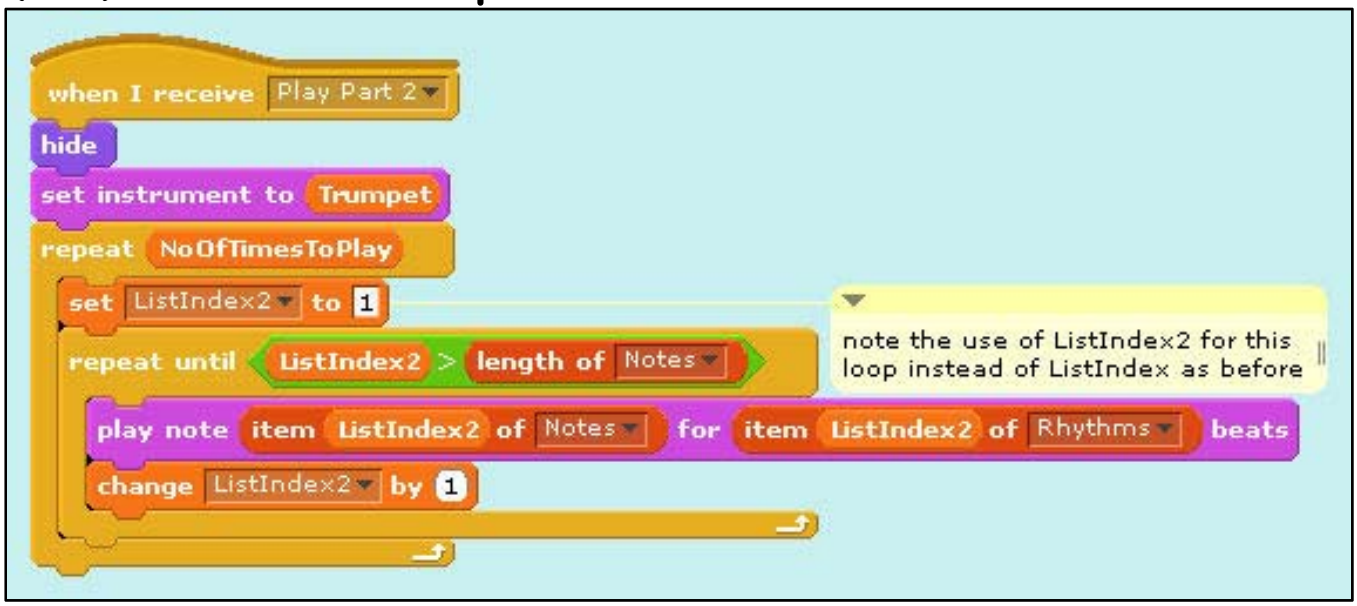
continued on next page

Row, Row, Row Your Boat

Version 9: Playing a Round Using Lists (cont'd)

(9b) **Initialization ("Init")** Script

(9c) **Part2** Script



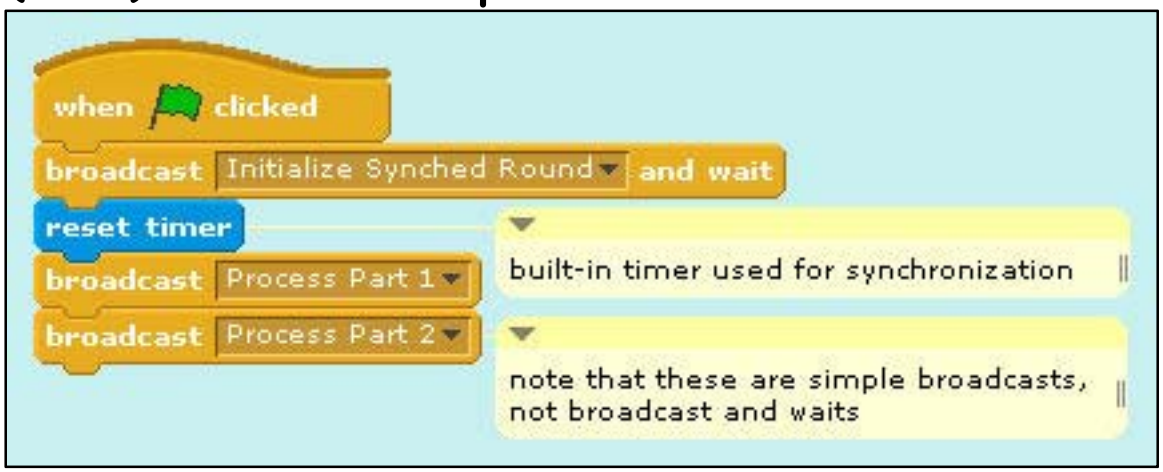
end of Version 9

Row, Row, Row Your Boat

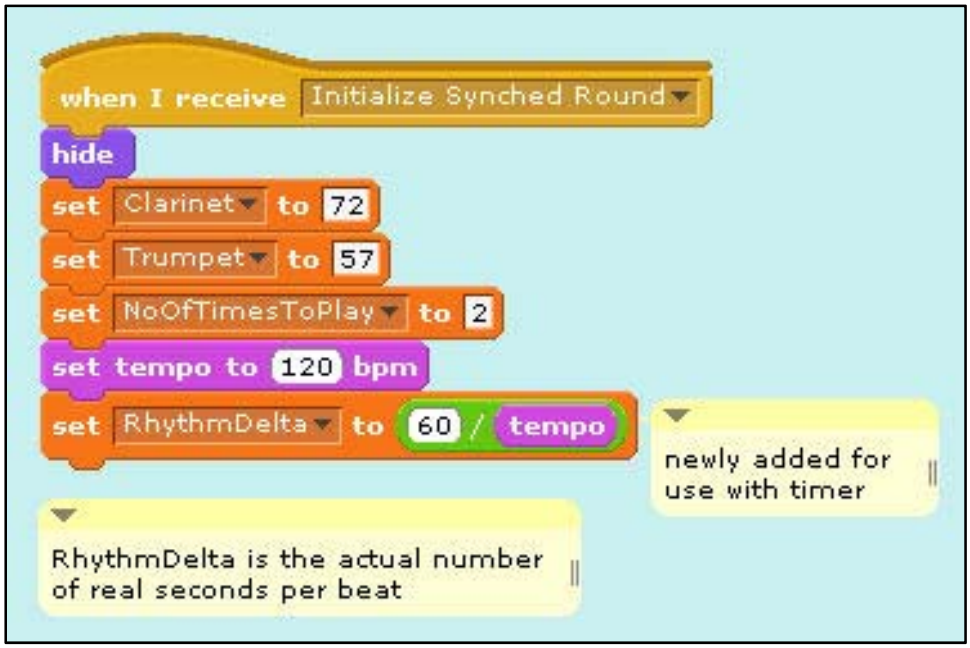
Version 10: Synchronizing Play from Lists

Four Scripts

(10a) **Main** Script



(10b) **Initialization ("Init")** Script

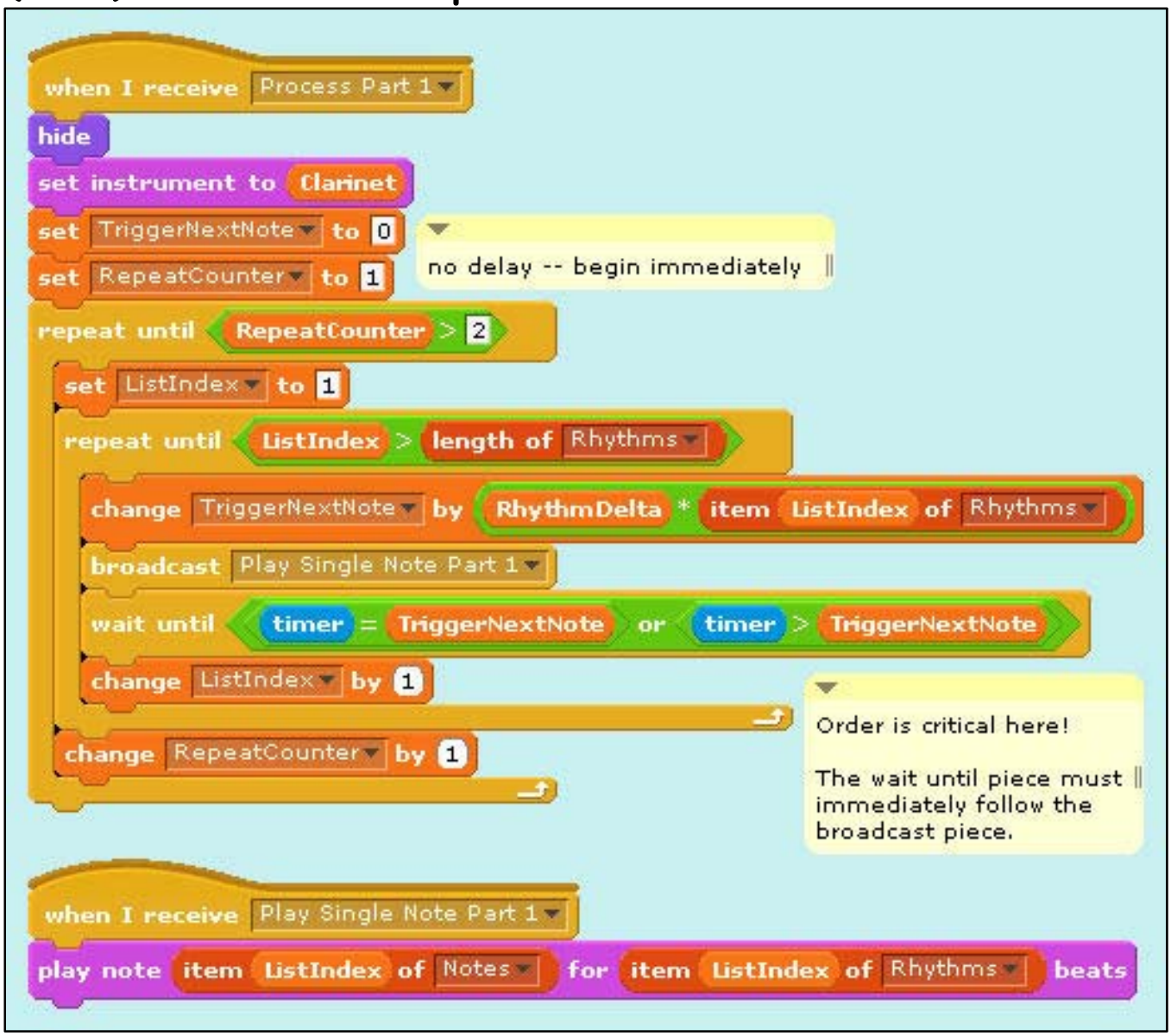


continued on next page

Row, Row, Row Your Boat

Version 10: Synchronizing Play from Lists (cont'd)

(10c) **Part 1** Script

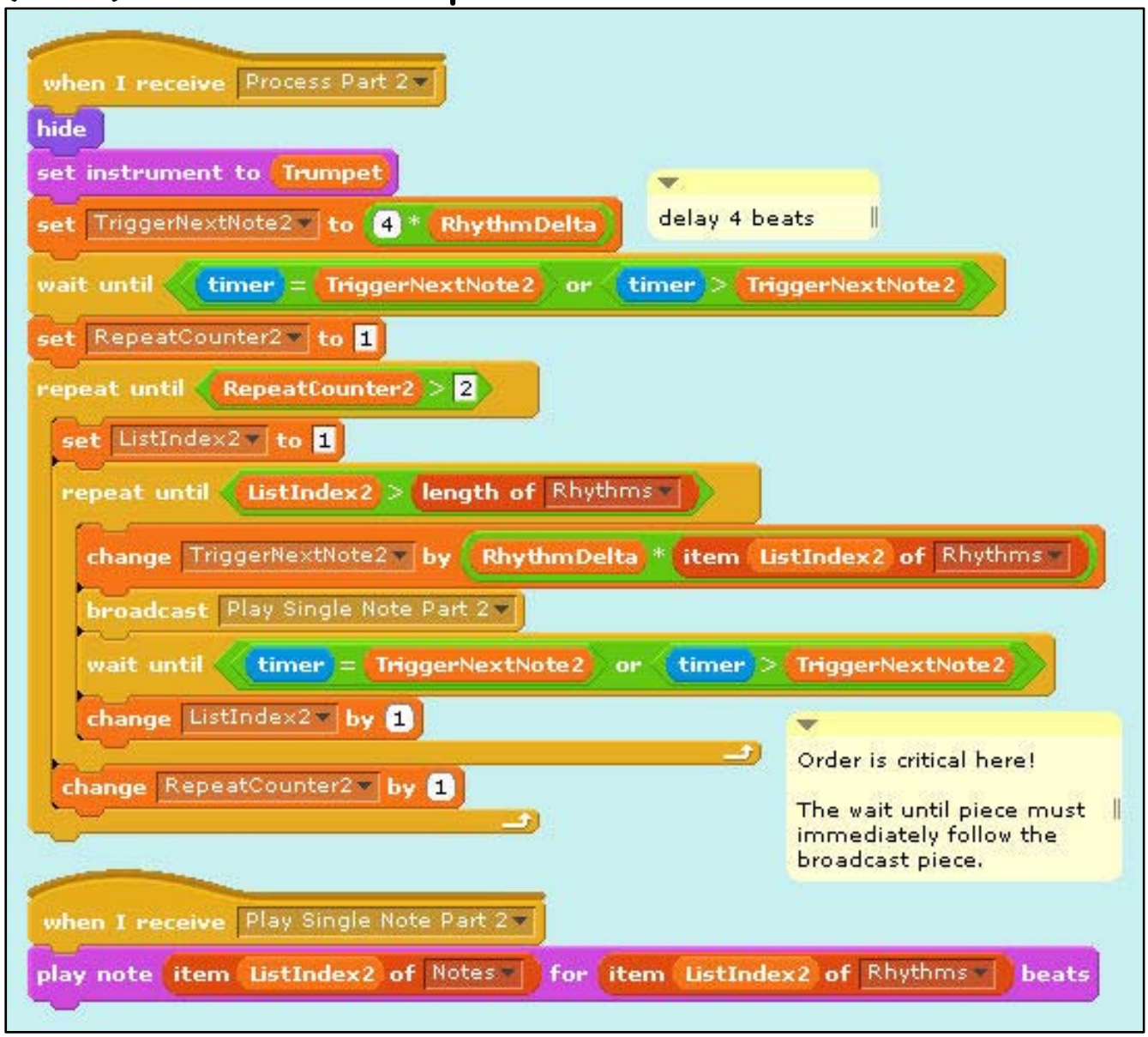


continued on next page

Row, Row, Row Your Boat

Version 10: Synchronizing Play from Lists (cont'd)

(10d) **Part 2** Script



end of Version 10

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Extending the Examples

1. **Use a variable to set the tempo.**
   - Add a slider to the variable so that you can change the tempo in real time.
   - Find all the places you need to use the variable to reset the tempo when you change it in real time.
   - Which version of playing the round best stays synchronized when you change the tempo?

2. **Transpose the melody to another key.**
   - Create a variable to hold a pitch offset.
   - Find all the places you need to use that variable to play the melody in the new key.

3. **Increase the number of times that the round repeats.**
   - Do the parts stay in synch?

4. **Increase the number of parts that play simultaneously.** (Be sure to set Turbo Speed to do this!)
   - When should each part "come in"?
   - How much should the first beat of each part be offset?

Extending the Examples (cont'd)

5. **Play the melody backwards.**
   - Can you play multiple parts backwards, too?

6. **Increase the number of times that the round repeats.**
   - Do the parts stay in synch?

7. **Increase the number of parts that play simultaneously.** (Be sure to set Turbo Speed before you try this!)
   - When should each part "come in"?
   - How much should the first beat of each part be offset?

8. **Make a round using the G-major scale.**
   - Put the note values for a G-major scale into a list. See page 32 for code that initializes and plays a G-major scale, but remember that you must use the integer values, not the variable names, to play notes from a list.
   - Start Part 2 when Part 1 plays its third note (B, MIDI note #59).
   - Add Part 3, starting when Part 1 plays its fifth not (D, #62).

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Extending the Examples (cont'd)

9. **Play random notes in the G-major scale.**
   - Start with the list created for the previous exercise.
   - Use the "pick random" piece in the Operators group to pick a random note from the list.
   - Play each note for 0.25, 0.50, 0.75, or 1.00 beats, also selected randomly.
   - Does the result sound musical?

10. **Create a program that can play any <u>major</u> scale given any starting note.**
    - Store the starting note in a variable.
    - For a major scale, the number of half-tones between each note is:
      2, 2, 1, 2, 2, 2, 1
    - Another way to think about this is:
      Do + 2 ➔ Re + 2 ➔ Mi + 1 ➔ Fa + 2 ➔
      Sol + 2 ➔ La + 2 ➔ Ti + 1 ➔ Do
    - Create a list containing the changes between the notes, and then use a loop to process the list and play the scale.

Extending the Examples (cont'd)

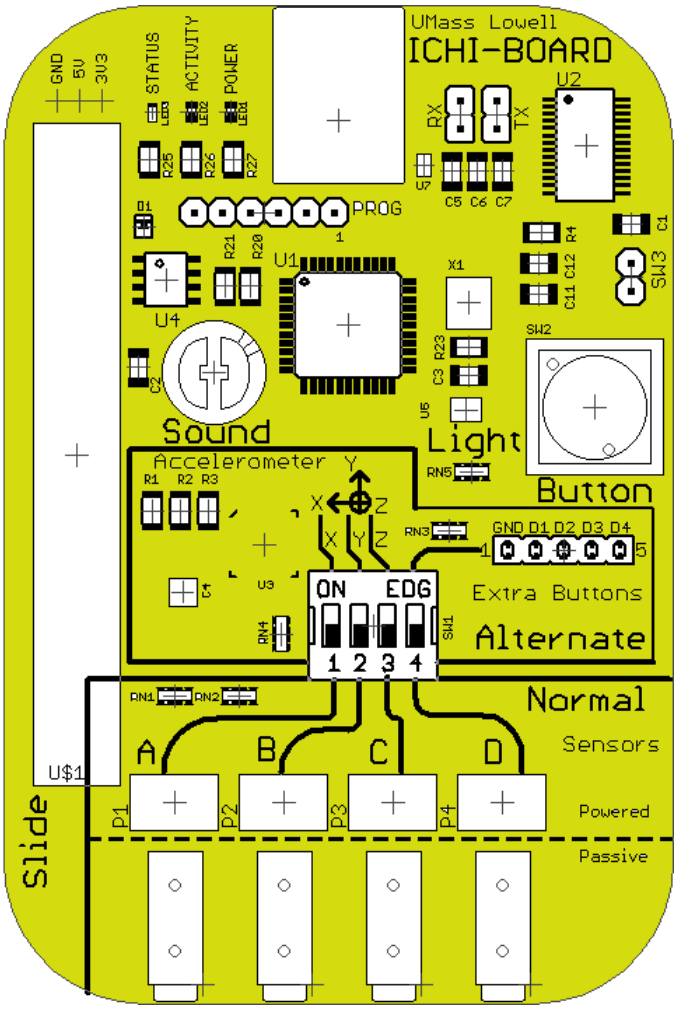
11. **Create a program that can play any <u>harmonic minor</u> scale given any starting note.**
    - For a harmonic minor scale, the number of half-tones between each note is:
      2, 1, 2, 2, 1, 3, 1
    - Create a new list containing these changes, but use the same loop that you created for the previous exercise to play this scale.

12. **Create a program to play a major chord.**
    - A major chord is the 1st, 3rd, and 5th notes of the scale, usually complemented by the octave above the 1st note. Thus, a G-major scale has notes G (#55), B (#59), D (#62), and G' (#67).
    - Another way to think about this is to compute the half-tone difference from the starting note: 0, 4, 7, 12.
    - Set a starting note and then use a "broadcast" to play the four notes simultaneously.

The IchiBoard

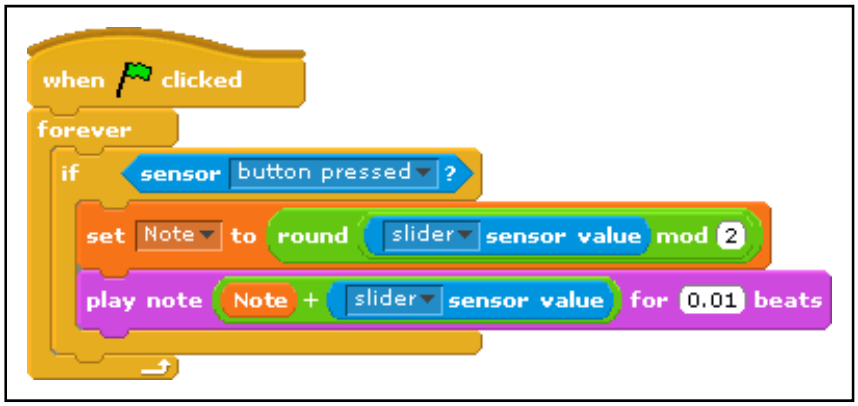
Board Layout

(courtesy of Mark Sherman, UMass Lowell Computer Science Engaging Computing Group)



Scratch Code for an IchiBoard Musical Instrument

(courtesy of Alex Ruthmann)



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The PicoBoard

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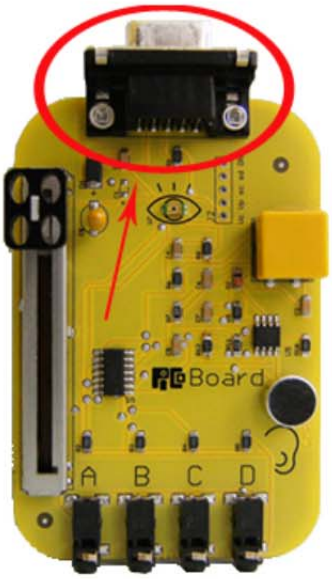
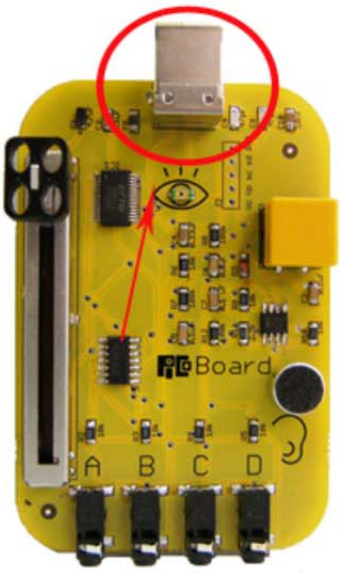
Which version of the PicoBoard do you have?

Serial
Does your PicoBoard connect to your computer using a Serial to USB Cable? All PicoBoards purchased before June 2009 are Serial PicoBoards.

USB
Does your PicoBoard connect to your computer using a USB to USB Cable? All PicoBoards purchased after June 2009 are USB PicoBoards.





info@playfulinvention.com
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CREATE · PROGRAM · PLAY

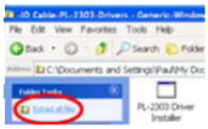
PicoBoard Serial to USB Setup

Windows Instructions

Windows XP (and older) users: Download the PicoBoard **Windows Driver (1471 KB)**

Windows Vista/7 users should just plug the USB to Serial cable in their computer and let the operating system choose the correct driver. Then skip to step #3 below.
If you do not have internet access on your computer, download the PicoBoard **Windows Driver (1471 KB)**.

1 First, open the file that you just downloaded. Click the link that says "Extract all files".



2 Then double-click on the file that you just extracted, and follow the on-screen instructions.

Mac Instructions

Mac OS X Driver (61 KB)

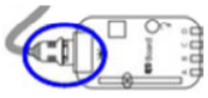
1 First, open the file that you just downloaded by clicking the magnifying glass in the Download panel.

2 Then double-click on the file that you just extracted, and follow the on-screen instructions.

Both Operating Systems:

3 Connect the USB part of your USB-Serial Cable to a USB port on your computer.

4 Connect the serial part of your USB-Serial Cable to the serial port on the PicoBoard.



5 Read **Getting Started with PicoBoards** to start making projects in **Scratch** with your PicoBoard.

Scratch is developed by the Lifelong Kindergarten Group at the MIT Media Lab. See http://scratch.mit.edu. Performamatics is an interdisciplinary project at UMass Lowell funded by the National Science Foundation. See http://performamatics.org.

PicoBoard USB to USB Setup

Windows Instructions

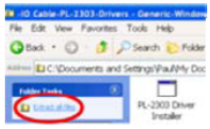
Windows XP users: Download the PicoBoard **Windows Driver (1.71 MB)**

Windows Vista/Windows 7 users should just plug the USB cable in their computer and let the operating system choose the correct driver. Then skip to step #3 below.
If you do not have internet access on your computer, download the PicoBoard **Windows Driver (1.71 MB)**.

Mac Instructions

Mac OS X Driver (419 KB)

1 First, open the file that you just downloaded. Click the link that says "Extract all files".



1 First, open the file that you just downloaded by clicking the magnifying glass in the Download panel.

2 Then double-click on the file that you just extracted, and follow the on-screen instructions.

2 Then double-click on the file that you just extracted, and follow the on-screen instructions.

Both Operating Systems:

3 Connect the USB Cable to a USB port on your computer.

4 Connect the other part of the USB Cable to the USB port of the PicoBoard.

5 Read **Getting Started with PicoBoards** to start making projects in **Scratch** with your PicoBoard.

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Computing and Music: What Do They Have in Common?

Computing and music share deep structural similarities. For starters, both rely on notational symbol systems. Programming loops are typically delineated with opening and closing curly brackets { }, parentheses, or levels of indentation. Music loops are delineated with begin and end repeat signs {} or initiated by "D.S." (Italian: *dal segno*), which instructs musicians to "repeat back to the sign," typically designated as 𝄋. As in programming, musical iteration can also make use of loop control variables. For example, Figure 1 shows a loop in which the music changes the second time through.

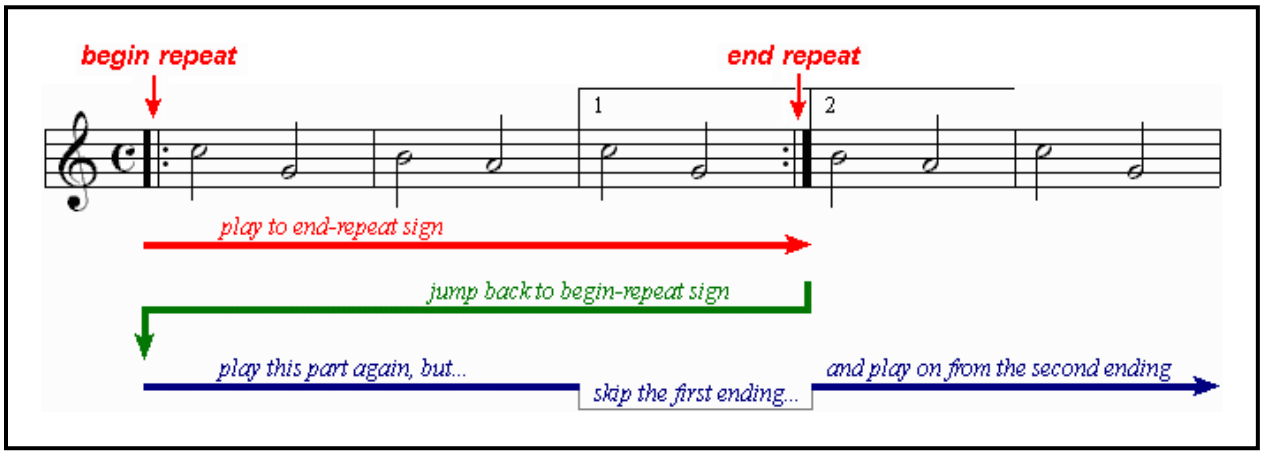


Figure 1. Musical iteration with a loop control variable. [6]

Both computing and music have logic and flow. Figure 2 shows the logic one student saw in The Beatles' All You Need Is Love. If one were to turn this flowchart into a computer program, it would not only contains loops, but if and switch statements as well.

One can also go the other way, converting musical concepts into computer programs. For example, the Scratch [2, 3] program in Figure 3a plays Jimmy Page's famous guitar riff from Led Zeppelin's Kashmir. This code works properly, but consider the many computational thinking (CT) concepts learned by transforming the code in Figure 3a to 3b, which plays exactly the same riff.

Computing and Music (cont'd)

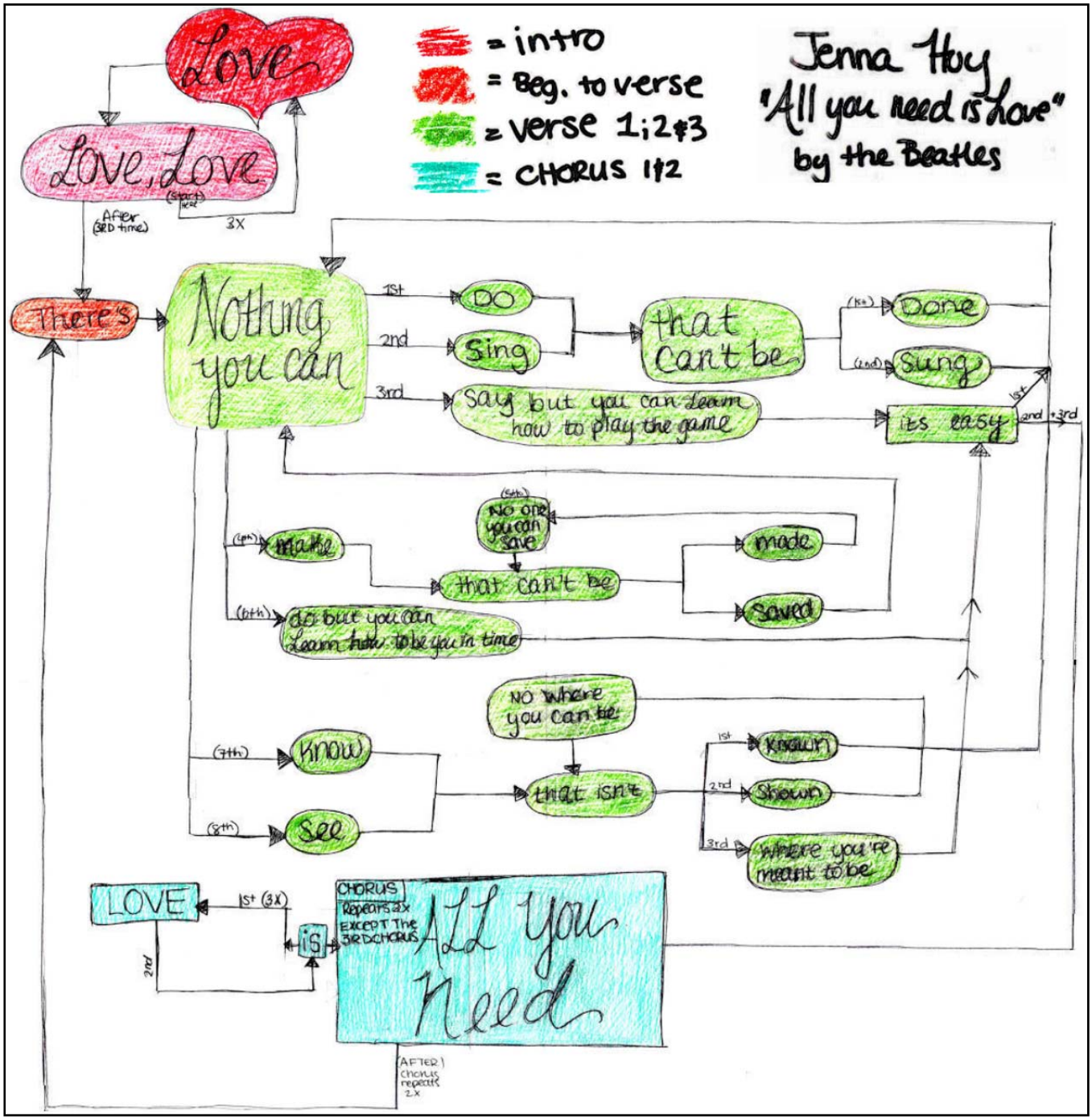
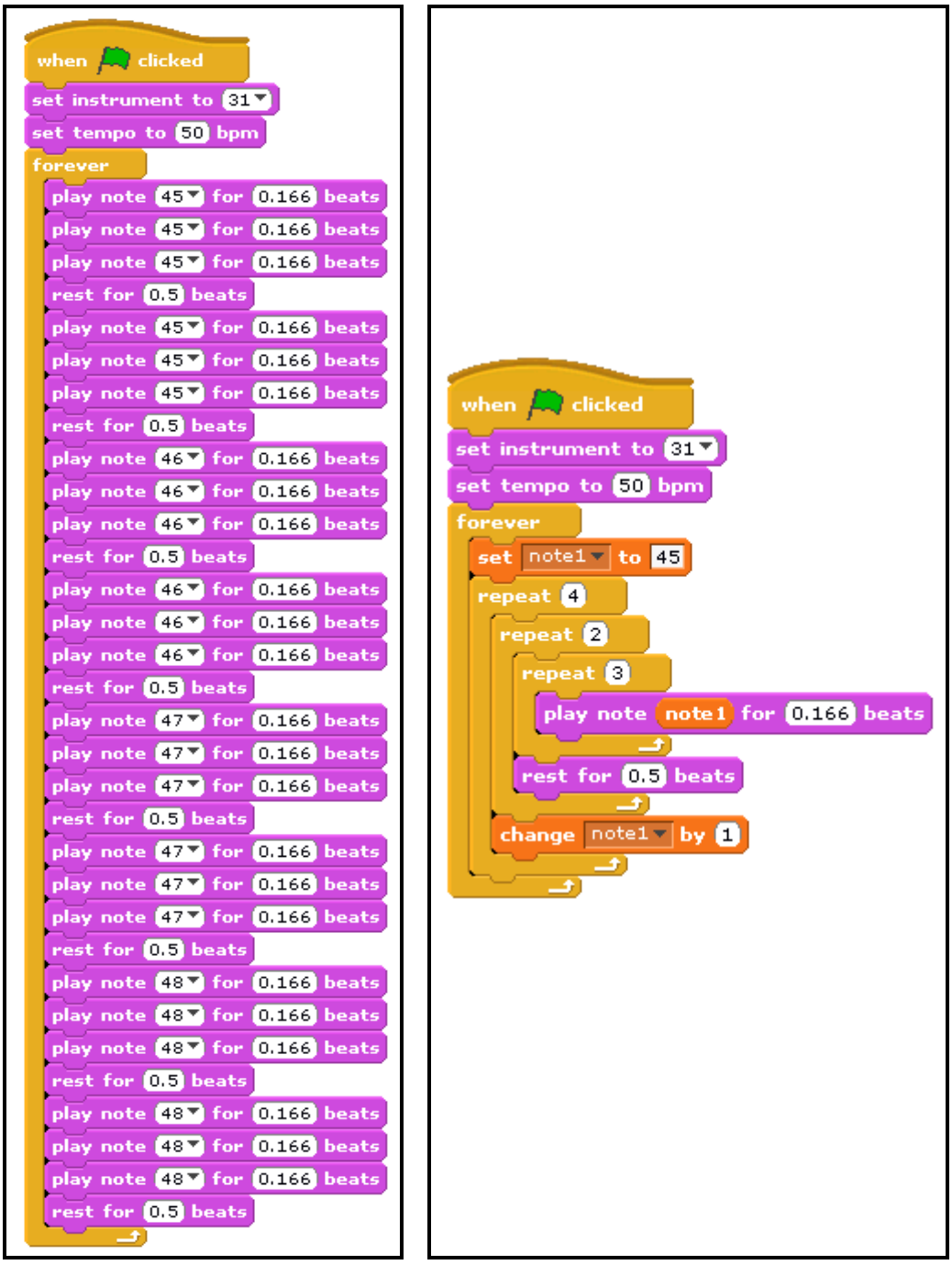


Figure 2. A song flowchart. [1]

Computing and Music (cont'd)

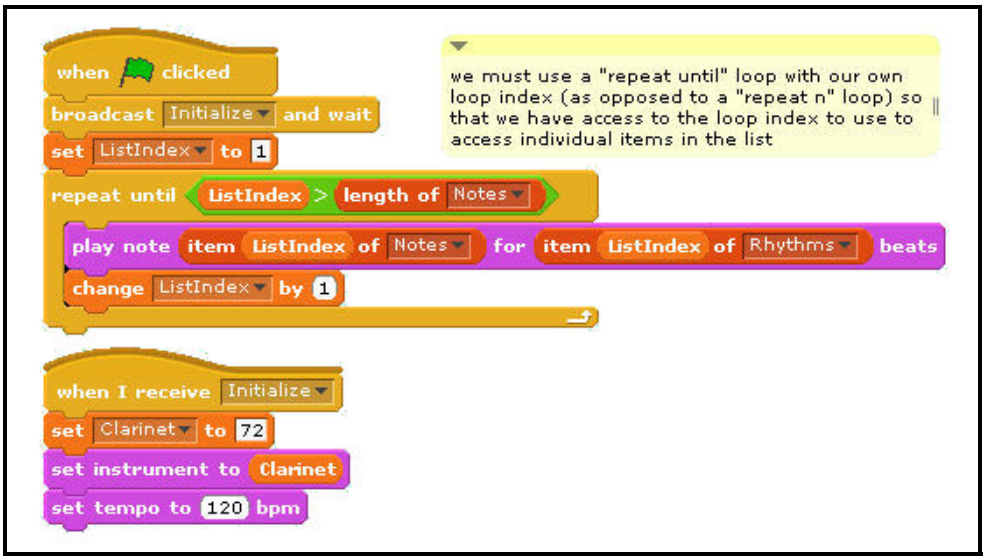


3a 3b

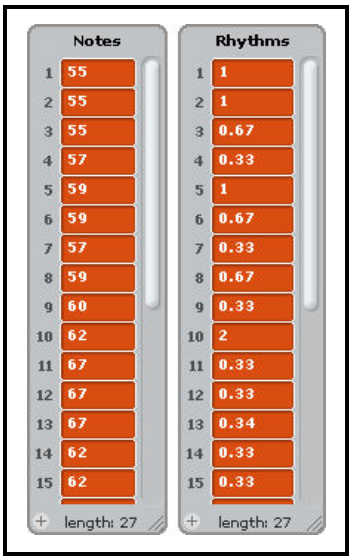
Figure 3. Two versions of Jimmy Page's *Kashmir* riff programmed in Scratch. [4]

Computing and Music (cont'd)

List and array data structures can be used to represent pitches and durations. Figure 4 shows an array (or indexed list) of MIDI note values paired with an array of note durations (in fractions of beats) that plays part of Row, Row, Row Your Boat. Using such structures, one can explore synchronization when the values are read by multiple threads with entrances staggered in time, resulting in the performance of a canon (or round).



4a



4b

Figure 4. Processing Scratch lists of notes and rhythms for *Row, Row, Row Your Boat*. [5]

References Cited

[1] Hoy, J. (2010). *Song flowchart for The Beatles' "All You Need is Love."* Created for a course assignment in "Sound Thinking."

[2] MIT Scratch Team (2009). *Scratch*. scratch.mit.edu accessed Dec. 21, 2009.

[3] Resnick, M., Maloney, J., Monroyhernández, A., Rusk, N., Eastmond, E., Brennan, K., Millner, A., Rosenbaum, E., Silver, J., Silverman, B., & Kafai, Y. (2009). *Scratch Programming for All*. Comm. of the ACM 52(11):60-67.

[4] Ruthmann, S.A. (2009). *Computational Zeppelin*. scratch.mit.edu/projects/alexruthmann/736779 accessed Jan. 5, 2010.

[5] Ruthmann, S.A., & Heines, J.M. (2010). *Exploring Musical and Computational Thinking Through Musical Live Coding in Scratch*. Scratch@MIT. Cambridge, MA.

[6] Smith, D.E. (1997). *Repeats, Second Endings, and Codas*. www.scenicnewengland.net/ uitar/notate/repeat.htm accessed Dec. 25, 2009.

Scratch is developed by the Lifelong Kindergarten Group at the MIT Media Lab. See http://scratch.mit.edu. Performamatics is an interdisciplinary project at UMass Lowell funded by the National Science Foundation. See http://performamatics.org.

Computer Science, Math, and Music: Concepts Covered in Scratch

Computer Science

- statements
- sequential control flow
- iteration
- conditional execution
- arithmetic operators
- Boolean operators
- objects
- concurrency
- variables
- lists
- event handling
- user interaction
- optimization

Math

- positive and negative numbers
- real numbers
- decimal notation
- built-in functions with inputs
- angles
- Cartesian coordinates
- trigonometric operators
- random numbers

Music

- pitch
- rhythm (as duration)
- melodic fragments
- modes and scales
- polyphony
- synchronization
- harmony
- composing
- performing
- transposition
- balance and dynamics
- digital audio (as sound files)
- MIDI notes and timbres
- tempo
- form and structural analysis

Scratch is developed by the Lifelong Kindergarten Group at the MIT Media Lab. See http://scratch.mit.edu. Performamatics is an interdisciplinary project at UMass Lowell funded by the National Science Foundation. See http://performamatics.org.

Additional Readings

Heines, J.M., Greher, G.R., Ruthmann, S.A., & Reilly, B. (2011). **Two Approaches to Interdisciplinary Computing+Music Courses.** *IEEE Computer* 44(12):25-32, December 2011.

http://teaching.cs.uml.edu/~heines/academic/papers/2011ieee/ieee2011paper-v33-forWebsite.pdf

The intersection of computing and music can enrich pedagogy in numerous ways, from low-level courses that use music to illustrate practical applications of computing concepts to high-level ones that use sophisticated computer algorithms to process audio signals. This paper explores the ground between these extremes by describing our experiences with two types of interdisciplinary courses. In the first, arts and computing students worked together to tackle a joint project even though they were taking independent courses. In the second, all students enrolled in the same course, but every class was taught by two professors: one from music and the other from computer science. This course was designed to teach computing and music together, rather than one in service to the other. This paper presents the philosophy and motivation behind these courses, describes some of the assignments students do in them, and shows examples of student work.

Ruthmann, S.A., Heines, J.M., Greher, G.R., Laidler, P., & Saulters, C. (2010). **Teaching Computational Thinking through Musical Live Coding in Scratch.** *41st ACM SIGCSE Technical Symposium on CS Education.* Milwaukee, WI, March 12, 2010.

http://teaching.cs.uml.edu/~heines/academic/papers/2010sigcse/SoundThinking-SIGCSE-2010.pdf

This paper discusses our ongoing experiences in developing an interdisciplinary general education course called Sound Thinking that is offered jointly by our Dept. of Computer Science and Dept. of Music. It focuses on the student outcomes we are trying to achieve and the projects we are using to help students realize those outcomes. It explains why we are moving from a web-based environment using HTML and JavaScript to Scratch and discusses the potential for Scratch's "musical live coding" capability to reinforce those concepts even more strongly.

Additional Readings (cont'd)

Maloney, J., Resnick, M., Rusk, N., Silverman, B., and Eastmond, E. (2010). **The Scratch Programming Language and Environment.** *ACM* Transactions on Computing Education 10(4). Article 16.

http://web.media.mit.edu/~jmaloney/papers/ScratchLangAndEnvironment.pdf

Scratch is a visual programming environment that allows users (primarily ages 8 to 16) to learn computer programming while working on personally meaningful projects such as animated stories and games. A key design goal of Scratch is to support self-directed learning through tinkering and collaboration with peers. This article explores how the Scratch programming language and environment support this goal.

Martin, F., Greher, G.R., Heines, J.M., Jeffers, J., Kim, H.J., Kuhn, S., Roehr, K., Selleck, N., Silka, L., and Yanco, H. (2009). **Joining Computing and the Arts at a Mid-Size University.** *2009 Conference of the Consortium for Computing Sciences in Colleges — Northeastern Region (CCSCNE 2009).* Plattsburgh, NY, April 24, 2009.

http://teaching.cs.uml.edu/~heines/academic/papers/2009ccscne/JoiningComputingAndArts.pdf

This paper describes two NSF-funded collaborations among faculty members in the Computer Science, Art, Music, and English departments at a public university in the Northeast USA. Our goal has been to create undergraduate learning opportunities across the university, focusing on connecting computer science to creative and expressive domains. In past publications, we have focused on student learning outcomes. This paper reports on the motivations, opportunities, and challenges for the faculty members involved.

Resnick, M., Maloney, J., Monroy-Hernández, A., Rusk, N., Eastmond, E., Brennan, K., Millner, A., Rosenbaum, E., Silver, J., Silverman, B., and Kafai, B. (2009). **Scratch: Programming for All.** *Communications of the ACM* 52(11):60-67.

http://web.media.mit.edu/~mres/papers/Scratch-CACM-final.pdf

"Digital fluency" should mean designing, creating, and remixing, not just browsing, chatting, and interacting. In this article we discuss the design principles that guided our development of Scratch and our strategies for making programming accessible and engaging for everyone.

Scratch is developed by the Lifelong Kindergarten Group at the MIT Media Lab. See http://scratch.mit.edu. Performamatics is an interdisciplinary project at UMass Lowell funded by the National Science Foundation. See http://performamatics.org.

Additional Readings (cont'd)

Heines, J.M., Greher, G.R., & Kuhn, S. (2009). **Music Performamatics: Interdisciplinary Interaction.** *40th ACM SIGCSE Technical Symposium on CS Education.* Chattanooga, TN, March 7, 2009.

http://teaching.cs.uml.edu/~heines/academic/papers/2009sigcse/fp119-heines.pdf

This paper describes how a graphical user interface (GUI) programming course offered by the Dept. of Computer Science (CS) was paired with a general teaching methods course offered by the Dept. of Music in an attempt to revitalize undergraduate CS education and to enrich the experiences of both sets of students. The paper provides details on the joint project done in these classes and the evaluation that assessed its effect on the curriculum, students, and professors.

Urban, J. (organizer), Heines, J.M., Fox, E.A., & Taylor, H.G. (2009). **Panel on Revitalized Undergraduate Computing Education.** *40th ACM SIGCSE Technical Symposium on CS Education.* Chattanooga, TN, March 5, 2009.

http://teaching.cs.uml.edu/~heines/academic/papers/2009sigcse/sigcse2009panel-JMH-accepted.pdf

There is an imbalance in the supply and demand for computing professionals that has generated shortages in meeting personnel needs within industry. A major program was developed by the U.S. National Science Foundation to encourage innovations in undergraduate computing education. There are a variety of new projects that are revitalizing undergraduate computing education. One approach to such revitalization is the introduction of interdisciplinary courses to expand the scope of computing education. The basic idea is to have students from various disciplines work together on computing projects to expand their educational horizons and make computing courses more appealing. This panel brings together research managers with educators who have developed and taught interdisciplinary courses with these goals in mind.

Additional Readings (cont'd)

Heines, J.M., Jeffers, J., & Kuhn, S. (2008). **Performamatics: Experiences With Connecting a Computer Science Course to a Design Arts Course.** *The International Journal of Learning* 15(2):9-16.

http://teaching.cs.uml.edu/~heines/academic/papers/2008learning/AsPublished-IntlJrnlLearning.pdf

This paper describes our efforts to stem the tide of declining CS enrollments by introducing innovations into our curriculum to give students more flexibility in course selection, especially in the freshman and sophomore years. Our approach is based on a partnership between the CS and Art, Music, and English departments in the area of exhibition and performance technologies.

In addition to describing our work, this paper provides the results of an evaluation conducted by an independent research. It reports on the impact this work has had on the CS and Art students and their respective projects, as well as on the professors and the way they teach their courses. It also describes steps that are being taken to improve the courses in the future.

Scratch is developed by the Lifelong Kindergarten Group at the MIT Media Lab. See http://scratch.mit.edu. Performamatics is an interdisciplinary project at UMass Lowell funded by the National Science Foundation. See http://performamatics.org.

Related Websites

Performamatics Website and Scratch Gallery and YouTube Channel

http://www.performamatics.org → http://teaching.cs.uml.edu/~heines/TUES/
http://www.scratchmusic.org → http://scratch.mit.edu/galleries/view/90913
http://www.youtube.com/performamatics

Scratch Projects by Performamatics People

http://scratch.mit.edu/users/alexruthmann (Music Prof. Alex Ruthmann)
http://scratch.mit.edu/users/drjay (CS Prof. Jesse Heines)
http://scratch.mit.edu/users/performamatics (additional collections)

Scratch Software

http://scratch.mit.edu (home page)
http://scratch.mit.edu/download (download page)
http://scratch.mit.edu/forums (discussion forums)

Scratch Resources for Teaching and Teachers

http://scratched.media.mit.edu (learn – share – connect for educators)

Scratch Project Galleries

http://scratch.mit.edu/channel/featured (featured projects)
http://scratch.mit.edu/galleries/browse/newest (members' personal galleries)

Scratch Information and Support

http://info.scratch.mit.edu/Support/Get_Started (getting started instructions)
http://info.scratch.mit.edu/sites/infoscratch.media.mit.edu/files/file/ScratchGettingStartedv14.pdf (Getting Started Guide)
http://info.scratch.mit.edu/Support/Reference_Guide_1.4 (Reference Guide)
http://info.scratch.mit.edu/Support (support page)
http://info.scratch.mit.edu/Video_Tutorials (video tutorials)
http://info.scratch.mit.edu/Support/Scratch_Cards (single-topic lessons)

Lifelong Kindergarten Group and Collaborators' Websites

http://llk.media.mit.edu (John Maloney and Mitchel Resnick)
http://teaching.cs.uml.edu (Jesse Heines)
http://www.alexruthmann.com (Alex Ruthmann)