Making Mappings: Examining the Design Process

Travis West, Baptiste Caramiaux, Marcelo Wanderley

▶ **To cite this version:**

Travis West, Baptiste Caramiaux, Marcelo Wanderley. Making Mappings: Examining the Design Process. NIME'20 - New Interfaces for Musical Expression, Jun 2020, Birmingham, United Kingdom. hal-03046218

HAL Id: hal-03046218

https://hal.archives-ouvertes.fr/hal-03046218

Submitted on 8 Dec 2020

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Making Mappings: Examining the Design Process

Travis J. West
IDMIL, CIRMMT
McGill University
Montreal, QC, Canada
travis.west@mail.mcgill.ca

Baptiste Caramiaux
Université Paris-Saclay,
CNRS, Inria, Laboratoire de
Recherche en Informatique

Marcelo M. Wanderley
IDMIL, CIRMMT
McGill University
Montreal, QC, Canada

ABSTRACT

We conducted a study which examines mappings from a relatively unexplored perspective: how they are made. Twelve skilled NIME users designed a mapping from a T-Stick to a subtractive synthesizer, and were interviewed about their approach to mapping design. We present a thematic analysis of the interviews, with reference to data recordings captured while the designers worked. Our results suggest that the mapping design process is an iterative process that alternates between two working modes: diffuse exploration and directed experimentation.

Author Keywords

mappings, design process, digital musical instruments, creativity

CCS Concepts

•Human-centered computing → User studies; •Applied computing → Media arts; Sound and music computing;

1. INTRODUCTION

Digital musical instruments (DMIs) are often composed of independent and interoperable modular components, such as synthesizers and controllers [9]. Considering the widespread use of MIDI controllers, digital audio workstations, and other commercially available music technology, it is likely that most DMIs in use today are DMIs made from independently designed modules. It falls to the user of these modules to make the mapping, the designed connection between control signals and control parameters that creates the interdependencies between otherwise independent parts, making them into a whole: a musical instrument. This implies that, of all the aspects of a DMI that must be designed, the mapping is most likely to be designed by the music maker. This makes the mapping design process especially crucial to understand, because only by understanding this creative process can tools be designed that effectively facilitate it, helping users to create mappings that serve their creative purposes.

Given a certain DMI, changing only its mapping has a wide range of effects that fundamentally alter the instrument: the mapping influences the behavior and feel of the instrument [10], how engaging the instrument is to play [5], and even how enjoyable it is to watch a performance with it [3]. Because of the importance of mappings in DMI design, they have received significant research interest [1, 2]. Much of this research presents mapping representations, recommendations, and tools for designing mappings. Relatively little consideration has focused on the design process itself: how do skilled DMI designers and users devise mappings? How do they implement them? What criteria do they use to evaluate their implementations?

We conducted a user study to explore the mapping design process, described in section 2. Our hypothesis is that by directly observing skilled DMI users while they designed a mapping and interviewing them about their approach to this activity, we are able to gain clear insights into the way these designers approach making mappings (section 3).

2. METHODOLOGY

2.1 Overview

The participants (N=9) were all musicians with a range of backgrounds. All participants had at least four years (at most 25) of experience in composing, performing, or otherwise making music using DMIs. They were asked to take 20 to 60 minutes to design a mapping from a T-Stick to a subtractive synthesizer. When they finished their mapping, or time ran out, they were asked to demonstrate and explain their mapping, and then they were interviewed about their approach to the design process.

Participants were specifically asked to "create a mapping that, according to your understanding of the words, would be an effective mapping for a live performance." This wording was chosen to encourage participants to interpret how the mapping should be designed according to their own aesthetic and creative preferences; "effective" by definition depends on what you are trying to achieve.

Participants were required to use a T-Stick as a gestural interface, they were given a subtractive synthesizer to make connections to, and they were asked to use Webmapper to create these connections. These tools were chosen for their availability, and as representative examples of a gestural control interface, sound synthesizer, and mapping design environment respectively. The T-Stick is a cylindrical gestural controller originally designed by Joseph Malloch [8] which primarily uses touch, pressure, and motion sensors to measure a performer's movements and interaction with the device. Webmapper is a graphical user interface for libmapper [7], a flexible C library for connecting multimedia devices. Using this environment, the control signals from the T-Stick could be easily connected to the parameters of the synthesizer through Webmapper's simple drag and drop interface. Participants also had the flexibility to edit the transfer function of each signal-parameter association, including the possibility of creating arbitrary con-

Licensed under a Creative Commons Attribution 4.0 International License (CC BY 4.0). Copyright remains with the author(s).

NIME'20, July 21-25, 2020, Royal Birmingham Conservatoire, Birmingham City University, Birmingham, United Kingdom.

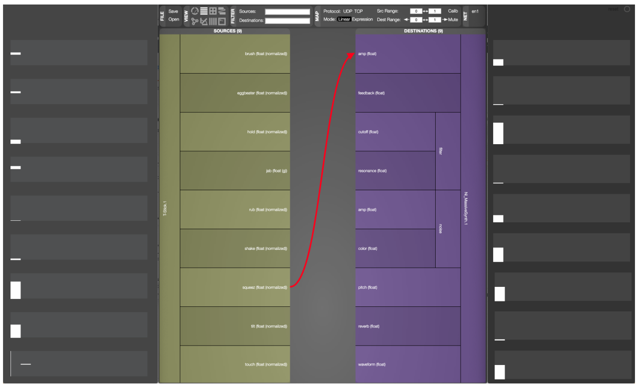


Figure 1: The display seen by participants. From left to right: graphs of recent gesture signals (light gray boxes), Webmapper list view (source signals in yellow, destination parameters in purple), graphs of recent synthesis parameter settings (light gray boxes). The full sized display can be viewed in the online appendix (see section 2.4).

vergent and/or divergent associations. The graphical user interface (GUI) seen by participants is shown in fig. 1. More details on the T-Stick [8], libmapper [7], and Webmapper [6, 16, 11] can be found in the citations and online appendix (see section 2.4).

2.2 Setup

Nine gesture-related features from the T-Stick were exposed as source signals to participants in the study, chosen based on prior developments with the T-Stick [8, 13]. Based on the accelerometer: jab, shake, eggbeater, and tilt signals were extracted. Based on the capacitive touch sensors: average touch position, number of touch sensors activated, brush, and rub signals were extracted. The output of the force sensitive resistor was normalized to the range [0-1] and exposed as a squeeze signal. Recent value of these signals were visualized on screen using a simple Max/MSP program, which was also used to connect the gestural signals to libmapper. Each signal was demonstrated to the participant and pointed out on screen before participants began to make their mapping.

For ease of implementation, a commercial subtractive synthesis plugin (Native Instruments Massive) was used as the basis for the sound synthesizer. The plugin was configured to follow a simple signal flow as outlined in fig. 2. Nine sound parameters were exposed to the user: the fundamental frequency of the oscillators, the cross-fade between the square and sawtooth waveforms, the spectral centroid of the noise generator, the amplitude of the noise generator, the overall low pass filter cutoff frequency, the overall low pass filter resonance, the amount of feedback from the output of the filter back to its input, the amount of reverb, and the overall amplitude at the output. As with the T-Stick, recent values of each parameter were visualized on screen, and each parameter was demonstrated to participants before they began to make their mapping.

2.3 Data Recording and Analysis

During the study, the libmapper network administrative bus traffic [7] was recorded (referred to as the activity data below). This allows participants' actions during their mapping design process to be reconstructed, including each signal-parameter association made and removed and all modifications to the transfer functions of these associations. After participants completed their design, their final mapping was exported from Webmapper. In addition, the signals from the T-Stick and parameter values of the synthesizer were also recorded in real time. Only the interviews and activity data are used here; the signal recordings and mappings are left for future consideration.

The main analysis of the data comprised a thematic analysis of the interview transcriptions. These were read and re-read, coded and re-coded, multiple times. Participants' remarks were ultimately coded into two main categories (mapping process and mapping efficacy) and several themes. Only the three themes pertaining to the mapping design process are presented here. In addition, various ad-hoc methods were employed to analyse the activity data: the period of time between different actions, the period of time during which given mappings were active, the number of times a mapping was tested before keeping or rejecting it, and other metrics were considered.

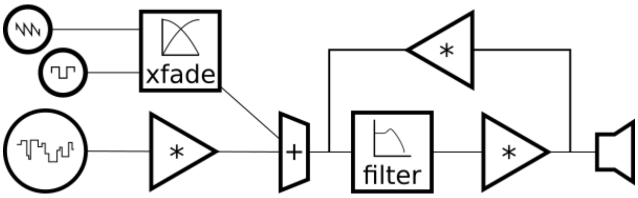


Figure 2: Block diagram of the synthesis algorithm used in the study.

2.4 Replication

For more details on the study design, the reader may find the programs used for gesture-feature extraction and libmapper bindings, the data recorder, the verbal script for introducing participants to the study, as well as the interview guide, all available as an online appendix[1]. The source code for libmapper and Webmapper are available online[2], as well as design files and firmware for the T-Stick[3]. In addition, the full dataset produced in the study is also available in the online appendix, including the signal recordings, libmapper activity data, mappings, demographic data, and interview transcriptions, as well as additional charts and analyses outside the scope of this publication.

3. RESULTS

3.1 Learning

8 out of 9 participants described learning as part of the process of designing their mapping. 5 participants specifically mentioned having to learn how the T-Stick works as an input device. 3 participants specifically mentioned having to learn about the coupling between the gestural signals from the T-Stick (for example, tilting the T-Stick also activates the shake signal). 7 participants mentioned learning about both the input device and the synthesizer. 5 participants described learning as the first step in the design process.

> "I think I would start with what is capable from the instrument, what is capable from the side of synthesis, and then do some internal organization of those features and actually move [the instrument]." (Participant C)

Considering the activity data, 7 participants can be seen to have spent over a minute at the beginning of the activity before making any mappings, which may be attributable

[1] http://idmil.org/project/making-mappings, https://traviswest.ca/making_mappings
[2] https://github.com/libmapper
[3] https://github.com/IDMIL/TStick

to a period of learning. If we consider the time between mapping changes made by a participant, e.g. the time between making two connections, we can see that 8 out of 9 participants had periods of duration over two minutes at some point during the task. If we suppose that periods of learning correspond with these long periods of time during which no connections or mapping modifications are made, we may hypothesize that mapping design involves learning throughout all stages of the design. Figure 5 charts two typical participants' actions over the course of the activity, for example.

3.2 Trial and Error

8 out of 9 participants described the mapping design process as one in which insights emerged from action: participants especially used the terms trial and error (6/9), experimentation (4/9), discovery (3/9), and/or exploration (3/9). Participants described their process as "messing around", "playing around," and then "finding," "realizing," or "discovering" what works and what doesn't. The process is experimental: the designer supposes that a certain change to the mapping might improve it, then they test their hypothesis by making the change and playing with the modified instrument. Participants did not know in advance what would work well and what wouldn't, but rather discovered this over the course of the activity.

> "I think it just evolved from like a less useful system to a useable one, and I think further evolution would come with more experimentation with the instrument, and the system. That sort of thing. But yeah, it doesn't feel like too much of an elegant evolution as much as it is just discovery, trial and error, and then sort of trial and confirmation, and satisfaction." (Participant A)

In the activity data, we can observe that most participants roughly alternate between periods of more rapid activity, during which many changes are made to the mapping, and more sparse periods as described above, where the mapping is left unchanged or modified less frequently (fig. 5). We may hypothesize that the periods of rapid changes correspond to the "trial" part of the process, while the more static periods are related to the evaluation of the "errors". This cyclic view of the mapping process, alternating between two working modes, is also supported by the 7 participants who described the design process as requiring iteration.

3.3 First Impressions

Finally, 6 participants described a moment where their first impressions of a new connection immediately informed their decision of what to do with it. 7 participants described themselves recognizing an effective change immediately. 3 participants mentioned keeping such changes through to the end of the activity. On the other hand, 6 participants described making a change that worked unexpectedly poorly.

> "The first thing I did was definitely the rub. The rub for me–I guess for me reverb, sometimes you put some sometimes you don't, and like, I know if I go like this (rubs the instrument)... For me it's only natural, and I know I was like, 'yo, this is what I like.' It was the first one that I did, and I've never changed it since." (Participant A)

Most of the time, participants only had to try a mapping connection once to determine whether or not it was worth keeping. Of 182 different associations which participants tried, 133 (73%) were only tried once, and 40 (22%)

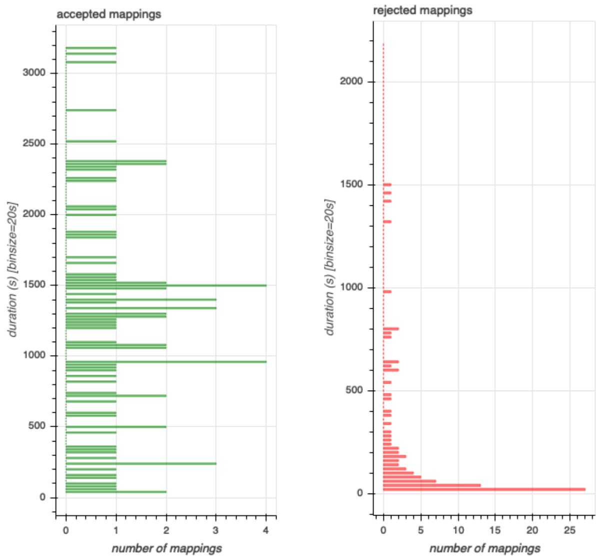


Figure 3: Comparison of the active duration of the associations participants kept compared to those they rejected. The active duration of an association is the number of seconds that it was present during a given participant's design activity.

were only tried twice. The remaining 9 associations were tried three or four times. Furthermore, considering the period of time during which each association was active, we can observe very different distributions of durations between associations which participants retained and those they rejected (fig. 3). The active duration of retained connections is evenly distributed from nearly the whole duration of the task to just a few seconds. This is consistent with what would be seen if we expected participants to find connections worth keeping from the very beginning of the experiment up to the very final moments. On the other hand, the duration of rejected associations is distributed exponentially with 25% of rejected associations being active for less than 20 seconds, and a full 50% active for less than a minute.

3.4 Finishing Touches

Participants were also asked how they would proceed if they had more time to work on their mapping. All 9 participants said they would continue to work on their mapping; none felt that it was completely finished or exactly ideal. Other than that, there was relatively little consensus among participants about how exactly they would proceed. 5 participants felt they would continue to refine the mapping they had already made. 3 participants said they would begin to focus on performing with the instrument in order to learn how best to continue to change it. 3 participants would continue to work on a specific detail of their mapping which they found difficult to get just right during the activity. 1 participant would specifically have wanted to change the sound synthesis output, as well as the mapping. 1 participant thought that after a bit more refinement they would want to freeze the mapping and make no further changes, in order to focus only on learning how to play it.

4. DISCUSSION

Although relatively little research has considered the creative process of designing a mapping in a DMI, conceptual frameworks have been developed in the broader field of creativity research which model creative processes in general. Based on this research, R. Keith Sawyer [12] describes eight stages of the creative process: 1) Find the problem, 2) acquire the knowledge, 3) gather related information, 4) incubation, 5) generate ideas, 6) combine ideas, 7) select the best ideas, and 8) externalize the ideas. In our study, we observed participants working in two main modes of activity: diffuse exploration and directed experimentation. These correspond roughly with stages 2-5 and 6-8 of Sawyer's eight stages of the creative process [12].

In the exploratory mode, designers mainly manipulate the input device and un-connected synthesis parameters and accumulate embodied experiences about the instrument given its current mapping. They are focused on learning the affordances of the input and output systems, and the way the two relate to each other, presently and in the imagination. They are generally getting a feel for their mapping so far, developing a sense for what the instrument is doing that they like and generating ideas about how they might improve their mapping moving forward. During this mode, designers make relatively few changes to the mapping, with periods of roughly one to two minutes between changes (depending on the designer). This mode comprises a mix of problem finding, learning, incubation, idea formation, and idea externalization.

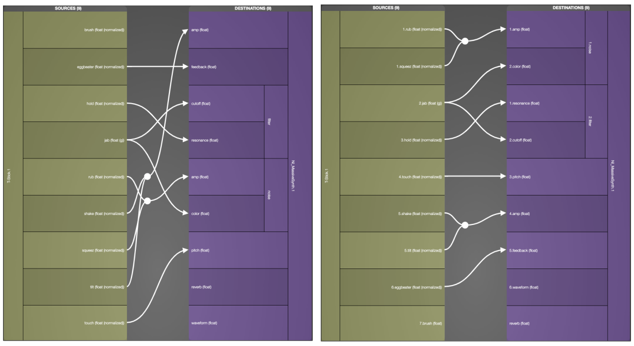
In the experimental mode, participants mainly make changes to the mapping, briefly moving the instrument in between changes to compare the result of the modification with their expectation. In this mode, participants test the hypotheses they developed while exploring the instrument. They work in a directed manner to try to achieve any short term goals established during their exploration and bring their mapping closer to the ideal. During experimentation, every change is evaluated within seconds. Whether something works or not is recognized immediately. When it works, participants generally keep it. When it doesn't, they move on, perhaps testing other hypotheses or else switching back into the explorative mode. Designers make many more changes while experimenting, with periods of a few seconds to half a minute between changes (again depending on the designer). This mode is a combination of idea combination, evaluation, and externalization.

These two modes of activity roughly alternate and probably overlap at times. Some designers more heavily favor the exploratory mode, others alternate between the two often, and others spend most of their time making rapid changes in the experimental mode.

Gradually, each designer builds up their mapping one association at a time, until finally they reach a point where either further changes seem unnecessary or their allotted work time has run out. At this point the mapping is considered "finished," but the work is likely not done. Given more time to continue developing their mapping, most designers expect that further refinements could be made, the instrument could be adapted further for a specific context or performance, and generally there remains room for improvement.

5. FUTURE WORK

Based on this model of the mapping design process, tools such as Webmapper could be modified to better support designers' work. For instance, the iterative connection-by-connection approach favoured by the participants in the study suggests a way of organizing the layout of signals. In the current version of Webmapper's list view, signals are displayed in alphabetical order from the top of the screen towards the bottom. This is advantageous insofar as the signals have a fixed order and relative location in the list, but it often results in a jumble of arrows forming in the



(a) signals sorted by name (b) signals sorted by last edit

Figure 4: The same mapping with signals sorted differently.

middle of the display as the mapping is built up. A typical mapping is shown in fig. 4a. An alternative would be to display signals in the order with which they are added to the mapping, e.g. shifting signals to the top of the table when a connection is made involving them. Using this approach, connections are less likely to cross on screen, seen in fig. 4b, which makes it easier to read each association in the mapping. This also keeps the connection which the user is most likely to want to edit (the one they just made) in a consistent location on screen. Allowing the user to switch between these two approaches may be especially useful, preserving the benefits of both.

6. LIMITATIONS

There are many ways in which the participants' approach to mapping design may have been influenced by the design of the study, limiting the generality of these results and suggesting avenues for future inquiry. In particular, participants had at most one hour to make their mapping, and they were given an open-ended design goal ("make an effective mapping for a live performance"), and they were required to use a T-Stick, subtractive synthesizer, and Webmapper.

The one hour time constraint, the open ended design goal, and the unfamiliarity of the T-Stick may all have encouraged participants' exploratory approach and bias towards intuitive decision making. This suggests that the process seen in this study may best reflect that adopted upon initial contact with a new instrument or set of modules, but it may not generalize to long term design processes. A longitudinal study, following designers as they develop a mapping over a greater period of time, may provide insight into how the design process changes as the designer becomes more familiar and proficient with their instrument.

Webmapper presents a connectionist or systems-level view of mappings [15]. This may have encouraged participants to adopt an iterative one-at-a-time strategy. Future studies, using different mapping tools (e.g. those presenting a functional view of mappings, such as LOM [14] or Wekinator [4]) may show if and how different mapping tools encourage different approaches to mapping design. This may be especially interesting if different tools favour significantly different approaches; such results may suggest ways in which different tool-favoured approaches may be combined in novel mapping tools so as to facilitate multiple ways of working.

User design studies of the kind presented here may also be valuable sources of information about how designers evaluate mappings. What makes a mapping effective for a given set of goals? What kinds of goals do music makers bring to the activity of making mappings? The dataset produced in this study offers information regarding these questions, and analysis has already been conducted, but it is outside the scope of this publication. The dataset is also available online for further analysis by the reader (see section 2.4).

7. CONCLUSION

Mappings are one of the most important aspects of a DMI design, and the aspect that users themselves are most likely to have to design. In order to develop mapping tools which facilitate users design of mappings, the process of making a mapping should be well understood. In this study, we gain initial insights into this creative process. Designers alternate between exploration and experimentation, learning how the instrument and the mapping works and how it might work better, and then making small changes to try to improve it. They rely on intuitive and immediate decision making processes throughout, trusting their first impressions and spending little time on approaches which don't work well immediately. Through iterative cycles of explore and experiment, the mapping is gradually built up a connection at a time. Future research will continue to clarify how mappings are made, leading to the design of new mapping tools that will better help DMI users to achieve their creative goals.

8. ACKNOWLEDGEMENTS

This research was funded in part by a grant from the Social Sciences and Humanities Research Council of Canada. The authors also extend an enormous thanks to all the participants in the study. Special thanks also to Benjamin Muzart for his work on an earlier pilot study on which this research was based.

9. ETHICAL STANDARDS

The Research Ethics Board II of McGill University reviewed and approved this project in accordance with the requirements of the McGill University Policy on the Ethical Conduct of Research Involving Human Participants and the Canadian Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans.

10. REFERENCES

[1] Special Issue on Mapping. In M. M. Wanderley, editor, *Organised Sound*, volume 7, 2002.

[2] Special Issue on Mapping. In M. M. Wanderley and J. Malloch, editors, *Computer Music Journal*, volume 38, 2014.

[3] G. Emerson and H. Egermann. Gesture-sound causality from the audience's perspective: Investigating the aesthetic experience of performances with digital musical instruments. *Psychology of Aesthetics, Creativity, and the Arts*, 12(1):96–109, 2018.

[4] R. Fiebrink and P. R. Cook. The Wekinator: A System for Real-Time, Interactive Machine Learning in Music. In *International Society for Music Information Retrieval Conference*, volume 4, page 2005, 2010.

[5] A. Hunt, M. M. Wanderley, and M. Paradis. The importance of parameter mapping in electronic instrument design. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 1–6, 2002.

[6] A. H. Krajeski. *A Flexible Tool for the Visualization and Manipulation of Musical Mapping Networks.* Master of arts, McGill University, 2013.

[7] J. Malloch. *A Framework and Tools for Mapping of Digital Musical Instruments.* PhD thesis, Schulich School of Music, McGill University, 2013.

[8] J. W. Malloch. *A Consort of Gestural Musical Controllers: Design, Construction, and Performance.* PhD thesis, McGill University, 2008.

[9] E. R. Miranda and M. M. Wanderley. *New Digital Musical Instruments: Control and Interaction Beyond the Keyboard.* A-R Editions, Inc., 2006.

[10] J. B. Rovan, M. M. Wanderley, S. Dubnov, and P. Depalle. Instrumental Gestural Mapping Strategies as Expressivity Determinants in Computer Music Performance. *Kansei-The Technology of Emotion Workshop. Proceedings of the AIMI International Workshop*, pages 68–73, 1997.

[11] V. Rudraraju. *A Tool for Configuring Mappings for Musical Systems using Wireless Sensor Networks.* Master of arts, McGill University, 2011.

[12] R. K. Sawyer. *Explaining Creativity: The Science of Human Innovation.* Oxford University Press, New York, 2 edition, 2012.

[13] D. A. Stewart. Vigorous Music-Making: The Inherent "Liveliness" Of A T-Stick Instrumentalist. In *Proceedings of the International Computer Music Conference*, pages 116–122, 2010.

[14] D. Van Nort and M. M. Wanderley. The LoM Mapping Toolbox for Max/MSP/Jitter. In *Proceedings of the International Computer Music Conference*, pages 397–400, 2006.

[15] D. Van Nort, M. M. Wanderley, and P. Depalle. Mapping Control Structures for Sound Synthesis: Functional and Topological Perspectives. *Computer Music journal*, 38(3):6–22, 2014.

[16] J. Wilansky. *A Software Tool for Creating and Visualizing Mappings in Digital Musical Instruments.* Master of arts, McGill University, 2013.

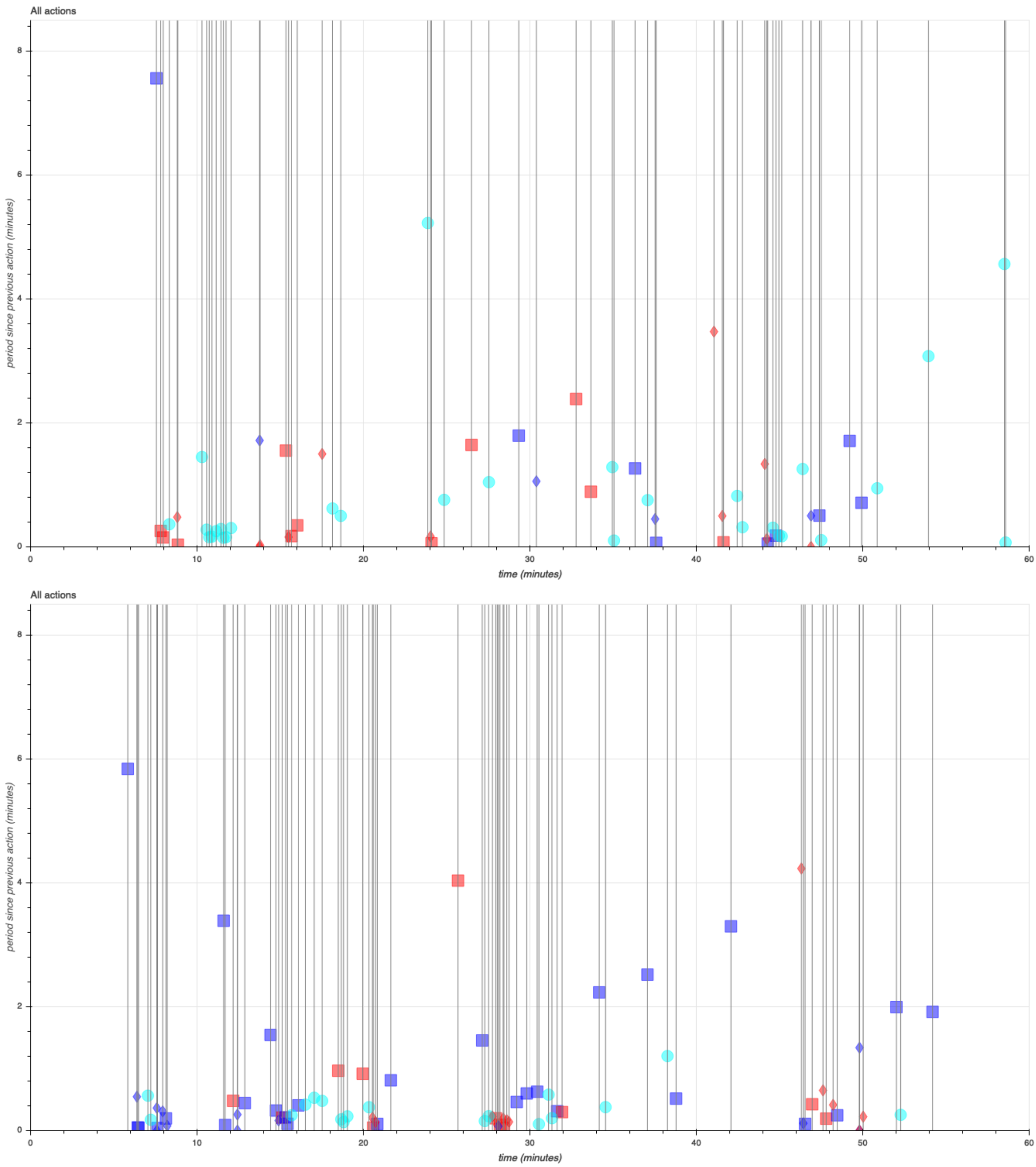


Figure 5: Example activity data. Each vertical line crosses through a single glyph which represents a user action: squares are newly created associations, diamonds are removed associations, and cyan circles are modifications to a transfer function. Blue glyphs are edits to an association which was retained in the final mapping. Red glyphs are edits to an association which was not retained. The period of time between actions is visible both by the horizontal distribution of edits (i.e. how close together the vertical lines are), as well as by the vertical position of the glyphs (higher means the action was taken after a period of inactivity). Notice that both timelines have long periods of inactivity scattered throughout the timeline, and that periods of inactivity somewhat alternate with periods of rapid changes.