



Audio Engineering Society

Convention Paper 9946

Presented at the 144th Convention
2018 May 23–26, Milan, Italy

This Convention paper was selected based on a submitted abstract and 750-word precis that have been peer reviewed by at least two qualified anonymous reviewers. The complete manuscript was not peer reviewed. This convention paper has been reproduced from the author's advance manuscript without editing, corrections, or consideration by the Review Board. The AES takes no responsibility for the contents. This paper is available in the AES E-Library, <http://www.aes.org/e-lib>. All rights reserved. Reproduction of this paper, or any portion thereof, is not permitted without direct permission from the Journal of the Audio Engineering Society.

A case study of cultural influences on mixing practices

Amandine Pras¹, Brecht De Man^{2,3}, and Joshua D. Reiss³

¹ Department of Music, University of Lethbridge, Alberta, Canada

² Digital Media Technology Lab, Birmingham City University, Birmingham, UK

³ Centre for Digital Music, Queen Mary University of London, London, UK

Correspondence should be addressed to Amandine Pras (amandine.pras@uleth.ca)

Abstract

While sound mixers of popular music may share common principles across cultures, different engineers produce different mixes, and different listeners judge a mix differently. We designed a mixed-methods approach to examine this highly multidimensional problem in both style and perceived quality. Five student sound engineers from the Paris Conservatoire mixed the multitrack source of two pop songs and fully documented their mixing process. The resulting mixes were then used as stimuli for a blind, multi-stimulus listening test in a high-quality listening room, that 13 students and one faculty member commented on and rated in terms of preference. Our outcomes highlight cultural and generational mixing specificities and offer a better understanding of the artistic side of the practice.

1 Introduction

1.1 Mixing practices in the digital era

The craft of sound mixing emerged with the introduction of multitrack recording in the 1960s. The profession of sound mixer in popular music first evolved from a union mode to an entrepreneurial mode that enabled innovative audio production techniques and created new aesthetics, to then reach an art mode where mixing became a collaborative process that fully followed the musicians' artistic vision [1]. Within the last thirty years, the democratisation and globalisation of Digital Audio Workstations (DAWs) has pushed the art mode further with more and more pop musicians using the studio as a musical instrument and mixing their own tracks [2], see for instance Ghanaian hip-hop producers' creative processes [3]. This paradigm questions the relevance of the sound mixer's professional expertise and contribution [4], and creates communication challenges between sound mixers and their musician clients [5]. However,

following the closure of most professional recording studios, the number of school programs that teach audio production techniques including mixing has skyrocketed, attended by a large number of self-taught DAW practitioners who seek to improve their music engineering skills [6].

Previous work suggested that mixing approaches vary depending on the cultural context, e.g. treatment of Spanish vs. English vocals [7] and differences in sound between UK and US productions [8]. In this study, we propose to highlight both the diversity of mixing approaches and the amount of shared mixing principles among student engineers from one school.

1.2 Previous research

Our present research builds on a series of studies which sought to further understanding of mixing practices and their perception by analysing and subjectively assessing several mixes for a number of songs in different cultures. First, tendencies in features extracted from the mixes and their

constituent tracks were revealed through statistical analysis [9], including a consistent vocal loudness across songs and engineers, and frequency-dependent panning habits. Later, the correlation with subjective preference ratings showed the impact of several features on overall mix appreciation [10], such as the adverse effect of low dynamic range. Textual analysis of mix reviews based on these mixes has provided insight in the relative focus on instruments and processes. Finally, a combination of the above has helped define some precepts as a function of objectively measurable features [11].

Other studies also analysed features of mixes in pop music, revealing four dimensions of mix-variation, namely amplitude, brightness, bass, and width [12], and showing that mixing styles also depend on budget and monitoring levels [13].

1.3 Research questions

The purpose of this study is to investigate the artistic and organisational aspects of mixing. We designed a mixed-method approach that is grounded in previous studies' methods to answer the following research questions:

- Q1. Which mixing principles and listening criteria are shared among sound engineer students of the Paris Conservatoire?
- Q2. Which mixing tools and processes do these students adopt when given a range of possibilities vs. a constrained set of tools and duration?
- Q3. What are the similarities and differences in students' mixing approaches across schools and song origins?

1.4 Study context and theoretical approach

We chose to conduct this case study in the Advanced music production program of the Paris Conservatoire (PC), a well-established and highly selective Master's program that conveys audio production techniques from an artistic perspective since 1989. Grounded in the *Tonmeister* concept [14], this program teaches young sound engineers how to achieve high-fidelity auditory scenes as well as to create virtual sonic worlds for a great variety of musical aesthetics [15]. To further examine the impact of school culture and country of origin on sound engineers' mixing

practices and listening tastes, we used two multitrack sources for our experiment, one recorded in France and one recorded in Canada. We applied a mixed-methods approach to explore the multidimensional aspects of sound mixing's art and cultures.

2 Methods

2.1 Data collection

2.1.1 Mixing process

Five sound engineer students (four male 3rd year students and one female 5th year student) mixed the multitrack source of *Cold Star*, an electronic-pop song by Paris-based Kabaret, and of *Lead Me*, a folk-rock song by Toronto-based The DoneFors. The lyrics of both songs were in English to avoid a language bias in the mix of the vocals. Instructions explicitly forbade recording new audio, sample replacement, pitch and timing correction, rearranging sections, or manipulating audio in an external editor. Beyond this, any kind of processing was allowed, including automation, subgrouping, and muting.

Students could produce these mixes in their preferred mixing location, in the interest of achieving a natural and representative spread of environments without a bias imposed by a specific acoustic space, reproduction system, or playback level. However, toolset constraints differed for both songs: For The DoneFors' *Lead Me*, the mix had to be produced within six hours and 'in the box', using only Avid Pro Tools including its built-in plugins, so that each resulting DAW session could be faithfully recalled and analysed in depth later, and compared with previous mixes from other schools; for Kabaret's *Cold Star*, students could take the time that they needed and were encouraged to use any DAW, plugin, analog or digital console, or outboard equipment they wanted. For both songs, students were asked to describe their mixing process.

2.1.2 Audio material as stimuli

For the purpose of perceptual evaluation, fragments consisting of the second verse and chorus of each of the five mixes of both songs were used as stimuli. With an average length of one minute, this reduced the strain on the listeners' attention, likely leading to more reliable test results. It also placed the focus on a region of the song where the most musical elements

were active and with the elements which both songs have in common (drums, lead vocal, and a bass instrument). Each of these fragments was set to a loudness of -23 LUFS.

To increase the diversity and validity of the experiment, the original mix of Kabaret's *Cold Star* was added to the corpus, thus leading to a total of six mixes to be compared. Also, the five 'mostly preferred' mixes of The DoneFors' *Lead Me* from five other schools including McGill University and the Universidade Católica Portuguesa (UCP) were added to the corpus, thus leading to a total of ten mixes to be compared.

2.2 Peer-evaluation procedure

Thirteen sound engineering students (one 2nd-year, seven 3rd-year, one 4th-year, and three 5th-year; two female and eleven male) including all mixers, and one female faculty member (the 1st author), took part in a blind listening test in a dedicated high-quality listening room, using the Web Audio Evaluation Tool [16]. To account for order effects, the presentation order of stimuli and of the two songs was randomised.

Subjects were given a multi-stimulus, single axis ratings interface to rate and rank the different mixes according to their personal preference. Comment fields associated with the respective mixes would light up during playback of the perceptual experiment. The listeners were asked to motivate their ratings by detailing what they liked and disliked about the mixes. In addition to storing each listener's mix preference rating, the Web Audio Evaluation Tool allows researchers to log each participant's playback and slider movement over time, through which lack of effort or understanding can be spotted.

2.3 Verbal description analysis

Students' reports on their mixing process were analysed in terms of task order, duration and number of sessions, tools and use of effects. This analysis highlighted how the duration and choice of tools to mix Kabaret's *Cold Star* differed from the six hours and DAW constraints to mix The DoneFors' *Lead Me*. We then examined how each student's process differed between the two songs they mixed, and how similar it was to the mixing approaches of other students.

We applied a method inspired by *Grounded Theory* [17] as introduced in previous audio research [15] to analyse listeners' verbal descriptions of the mixes. This approach consists of extracting meaningful phrasings from the corpus to be manually classified into categories that emerge throughout the analysis process. It allowed us to identify mixing principles that may be specific to the cultural context where the study is conducted instead of referring to pre-established themes. We also used this analysis method to highlight similarities and differences in the way each song was described.

3 Results

3.1 Balance analysis

Extending the work in [9] and [18], the relative loudness was calculated for the isolated tracks of kick drum, snare drum, rest of drums (everything but snare and kick), lead vocal, and bass guitar, as processed by each mix engineer. Such in-depth analysis of low-level audio features is made possible by access to the DAW files and constraints on the plug-ins that were used. In this context, relative loudness is defined as the difference in loudness as defined in ITU-R BS.1770-4 [19] between the instrument in question and the total mix. The result is shown as a box plot in Figure 1, comparing the relative per-track loudness of the five Paris Conservatoire (PC) students' mixes to that of eight mixes by McGill University students and five mixes by Universidade Católica Portuguesa (UCP) students.

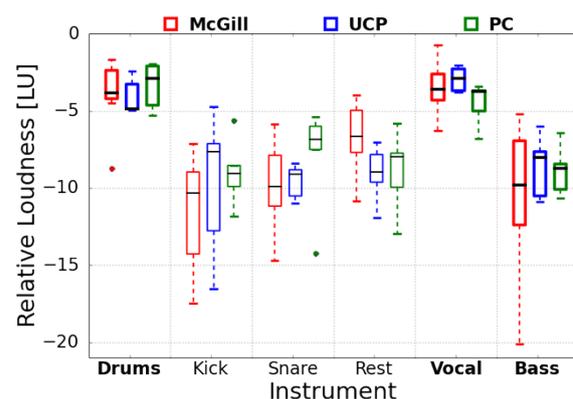


Figure 1 Balance of The DoneFors' *Lead Me* as set by students from McGill, UCP and PC

We observed that PC students mixed the snare at a relative higher loudness than McGill and UCP students. Also, we noticed a smaller loudness interval for PC students' kick and bass. Everything else including the rest of the drums (OHs, toms, high-hat) is fairly similar in loudness across schools.

3.2 Mixing processes

In the Appendix we display the details extracted from the mixing process documentation provided by the five students and the professional mixer for Kabaret's *Cold Star* (Table 3), and by four students for The DoneFors' *Lead Me* (Table 4). While students were free to use every tool that wanted to mix *Cold Star* (they have several options in the school, including an old SSL 4000 G+), all five students mixed in a DAW (one in Cubase and four in Pro Tools). In contrast, we observed that the professional mixer used several analog pieces of equipment, e.g. a Dangerous Music dbox summing mixer and a Neve Melbourne console.

The professional mixer spent about 15 hours mixing the track before pre-mastering, including two hours of collaborative work with the band in between two solo mixing sessions of respectively 7 and 6 hours. One student spent between 10 and 12 hours mixing the track. Three students mixed the track in four sessions, which took them a total of approximately 5 hours for one, 14 hours for another one, and an unspecified duration for the third one. The fifth student did not send us session information.

The professional mixer and two out of the five students used effects on the master bus for both songs. All used sub-groups that they set early in their mixing process. Automation was always mentioned at the end of the process. All except one started by listening to the track with all the faders at 0 dB, some of them did so several times and wrote down technical issues to solve, creative ideas they had, or the direction that they wanted to take. We did not see any other trend in their way of creating a balance or applying effects. However, most of them justified their choice of effects with aesthetic goals, e.g. *To me, the vocals in the rough mix were quite 'abandoned', and I wanted to achieve a 'sexy and mysterious' vocal sound which represented the atmosphere of the track (Pro); when there is only the Trilian [a virtual bass module], I did an EQ to fit the same frequency repartition than the other basses, to make the illusion that all the song is*

just only one bass (PC-D); I didn't use this modulator in the bridge, to make the voice be really simple, naked, kind of weak, but really close and dry. I felt that it could be an interesting illustration of the situation, in the story (PC-E).

Focusing on students' individual mixing approaches, we observed that their tendency to use more or less effects remained the same for both songs. Also, two students used the same specific techniques for both songs, i.e. aligning the vocals at -23dBFS (PC-A), using delays and parallel processing (PC-E).

3.3 Mix ratings

The students spent an average of 23 minutes on each song. All evaluated both songs in one session, in randomised order. The duration was further affected by order (the first page took 24 minutes, the second page took 22 minutes on average) and by song or number of mixes (25 minutes for The DoneFors' *Lead Me*, which had 10 mixes, versus 21 minutes for Kabaret's *Clold Star*, which had 6 mixes).

Mix ratings of Kabaret's *Cold Star* (Figure 2) show that the original mix (Pro) was overall preferred, and mix ratings of The DoneFors' *Lead Me* (Figure 3) show that the McGill mix was overall preferred. We observed that mixes by PC-D and PC-A were in the preferred group of mixes for both songs, and that PC students rated their mixes quite similarly, as opposed to the McGill's mix that they clearly preferred and the Other school 1's mix that they clearly did not like.

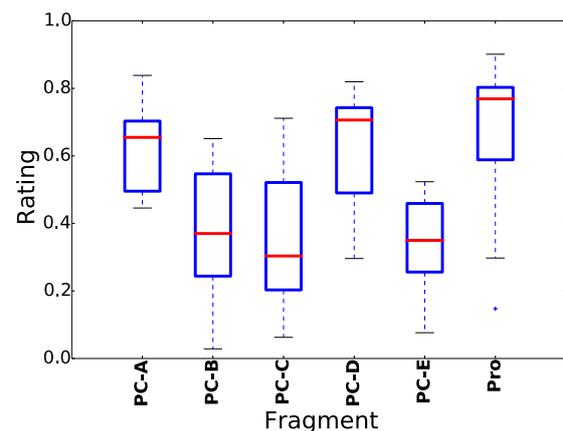


Figure 2 Box plot of ratings awarded to different mixes of Kabaret's *Cold Star*

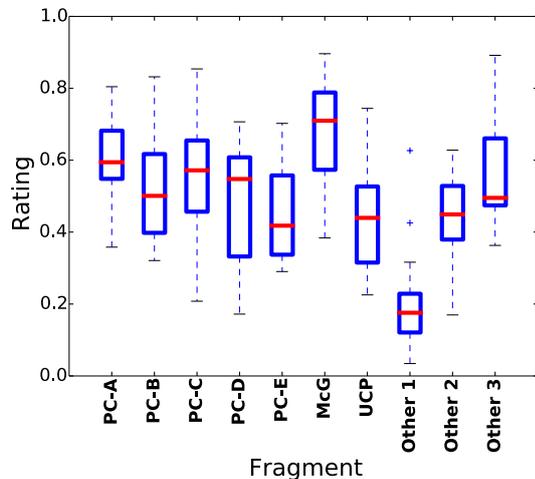


Figure 3 Box lot of ratings awarded to different mixes of The DoneFors' *Lead Me*

3.4 Mixes' verbal descriptions

We identified 19 criteria that listeners used to describe the different mixes of the songs. Seven criteria referred to the balance, namely the spectral balance, a good or a bad balance, and comments about the levels of the vocals, bass, rhythmic section (including kick and snare that were often mentioned alone) and the harmonic elements. Three criteria referred to the spatial components of the mix, namely the stereo image, the use of reverberation and the depth (sometimes in terms of layers). Very often, students commented on specific parts of the song (i.e. intro, verse, bridge, chorus, outro) and on the use of effects. They qualified the dynamics of the mix and the use of compression as good or bad. Finally, four criteria concerned their general appreciation of the mix as positive and/or with critics regarding the understanding of the aesthetics, and/or with energy (e.g. *punchy*, *groovy*) and/or with creative ideas.

We present the number of occurrences of each of these listening criteria per mix for *Cold Star* (Table 1) and for *Lead Me* (Table 2), as well as the normalised distribution of the listening criteria for both songs calculated as the average number of occurrences of criteria per song (Figure 4). The spectral balance and the vocals were the two main criteria that listeners used to describe the mixes, while depth and phase issues were barely mentioned. It should be noted that the spectral balance was commented on for *Cold Star*

almost twice as much as for Paris' mixes of *Lead Me*; in contrast, the vocals were mentioned for *Lead Me* almost twice as much as for *Cold Star*. While the balance was qualified good or bad almost equally, the dynamics were mainly negatively pointed out. Regarding the general appreciation, critics outnumber positive comments, though they are counterbalanced by the criteria energy and creativity which are mainly positive. Below we detail some of the verbal descriptions that refer to the highlighted cells with more than eight occurrences (Table 1 & Table 2).

Cold Star's original mix (Pro) received ten positive general appreciations, nine references to good energy and eight comments on the reverberation that was qualified *great*, *cool* and *interesting* by three listeners, *too much* by four, and *awful* by one. The second highest rated mix (PC-D)'s spectral balance was described as generous in the low-end and low-mids without enough highs, and with the bass being too loud. The fourth highest rated mix (PC-B) got eight comments about the spectral balance that lacked low-end and a bit of low-mids. The ten comments on the fifth one (PC-E)'s spectral balance did not reach a consensus except that the mix was spectrally unbalanced. The least rated one (PC-C) received nine comments on its spectral balance that lacked low-end, had too much mids and high frequencies.

Lead Me's highest rated mix (McGill) received nine comments about the spectral balance but without reaching a consensus regarding the low-end and the mids. Most comments about the second highest rated mix (PC-A)'s balance agreed that the second vocal was richer and louder than the lead, and that there was too much snare. The third one (PC-C) got ten comments about the vocals' colour that was either appreciated either criticized. A large amount of critical comments on the fourth one (PC-D) referred to the strong use of effects, especially the 'phone effect' on vocals described as interesting but not controlled enough. The fifth one (PC-B) received ten comments on the lead vocal being too much in the background, and eight comments on the delays and reverberation being too strong. Most comments on the sixth one (Other 3)'s balance agreed that the guitars overpowered the vocals. Eventually, nine comments on the stereo image of the least rated one (Other 1) pointed out that the mix was almost mono.

MIXES From most to least preferred	BALANCE							SPACE			Parts of the song	FX	DYNAMICS		GENERAL APPRECIATION				Phase issues
	Spectral	Good	Bad	Vocals	Bass	Rhythmic section	Harmonic elements	Stereo image	Reverb	Depth			Good	Bad	Positive	Critics	Energy	Creativity	
Pro	6	7	0	6	0	2	3	3	8	1	6	6	3	2	10	2	9	2	0
PC-D	8	5	5	6	8	3	4	4	1	3	7	4	0	0	4	2	2	2	0
PC-A	5	4	0	4	4	6	0	5	3	1	4	3	2	1	3	3	4	1	0
PC-B	8	2	4	5	5	3	4	4	1	0	6	2	2	5	3	4	2	2	0
PC-E	10	0	4	6	2	4	3	2	0	1	6	2	0	2	1	9	2	0	1
PC-C	9	2	2	1	4	5	3	0	5	0	7	4	1	2	2	10	2	1	0
All (normalised)	7.7	3.3	2.5	4.7	3.8	3.8	2.8	3.0	3.0	1.0	6.0	3.5	1.3	2.0	3.8	5.0	3.5	1.3	0.2

Table 1 Number of occurrences of the listening criteria per mix of *Cold Star* (highlighted cells for 8+ occ.)

MIXES From most to least preferred	BALANCE							SPACE			Parts of the song	FX	DYNAMICS		GENERAL APPRECIATION				Phase issues
	Spectral	Good	Bad	Vocals	Bass	Rhythmic section	Harmonic elements	Stereo image	Reverb	Depth			Good	Bad	Positive	Critics	Energy	Creativity	
McGill	9	0	3	4	2	3	6	3	3	1	3	0	3	0	7	3	1	0	1
PC-A	3	2	3	8	3	8	2	2	1	0	2	1	0	1	3	4	1	0	0
PC-C	2	1	6	10	2	4	7	0	6	0	4	1	0	4	2	3	1	0	0
PC-D	6	1	6	7	0	6	2	3	2	0	6	10	0	2	3	8	2	4	0
PC-B	5	3	3	10	1	7	7	2	5	1	4	8	0	1	3	3	2	2	0
Other 3	3	2	1	11	5	7	11	2	1	0	2	0	0	3	5	3	3	0	0
Other 2	7	1	1	7	0	5	7	6	2	0	2	4	0	2	2	5	0	1	1
UCP	8	1	3	11	2	7	2	2	3	1	4	1	0	3	1	5	1	1	0
PC-E	2	4	0	8	0	5	7	2	3	1	2	1	0	6	1	2	0	0	0
Other 1	6	4	0	5	2	4	5	9	1	0	2	9	0	0	0	7	0	3	2
Paris (normalised)	3.6	2.2	3.6	8.6	1.2	6	5	1.8	3.4	0.4	3.6	4.2	0	2.8	2.4	4	1.2	1.2	0
Others (normalised)	6.6	1.6	1.6	7.6	2.2	5.2	6.2	4.4	2	0.4	2.6	2.8	0.6	1.6	3	4.6	1	1	0.8
All (normalised)	5.1	1.9	2.6	8.1	1.7	5.6	5.6	3.1	2.7	0.4	3.1	3.5	0.3	2.2	2.7	4.3	1.1	1.1	0.4

Table 2 Number of occurrences of the listening criteria per mix of *Lead Me* (highlighted cells for 8+ occ.)

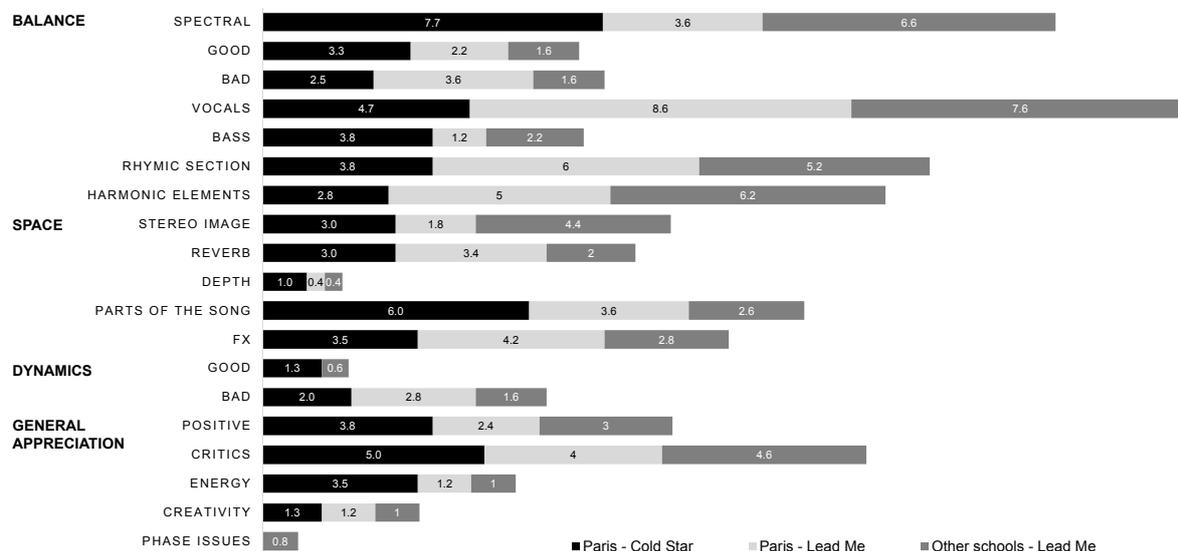


Figure 4 Normalised distribution of the listening criteria for *Cold Star* and *Lead Me* (Paris and other schools)

4 Discussion

Q1. Which mixing principles and listening criteria are shared among sound engineer students of the Paris Conservatoire?

Results show that each student's mixing process was unique regarding task order, balance principles, and use of effects. However, the analysis of the documentation of their mixing process suggests that a few mixing principles are shared across students in this school, such as listening to the song with all faders at 0 dB before starting the mix, creating subgroups, developing a scenario by applying different effects and balancing the instruments differently for different parts of the song, and justifying their use of effects with aesthetic goals.

While students described both songs with the same criteria, they emphasised different aspects, i.e. the spectral balance for Kabaret's *Cold Star* and the lead vocal treatment for The DoneFors' *Lead Me*. We observed that they do not always reach a consensus on these aspects. For instance, they tend to disagree among each other regarding the relevance and the amount of reverberation or delays according to their opinion on the song aesthetics. They may also describe a spectral balance differently. Their comments about the dynamics were mostly negative. In contrast, they largely used positive criteria to qualify their general appreciation of a mix related to energy and creativity. In keeping with results about their mixing process, they often reported on the changes between different parts of the mix.

Q2. Which mixing tools and processes do students adopt when given a range of possibilities versus a constrained set of tools and duration?

All five students mixed Kabaret's *Cold Star* 'in the box' when they could have used consoles and/or outboard gear in the school studios. This observation is interesting as classes in this school are still taught on consoles. Also, the original mix was produced with a fair amount of analog equipment. This choice may have been driven by the ProTools constraints for The DoneFors' *Lead Me*. However, students did not seem to be influenced by the six hours constraint for *Lead Me*, i.e. two of them spent more than ten hours on the mix of *Cold Star*. Therefore, more research is

needed to investigate whether or not, and for which types of songs, the new generation of sound engineers would choose to mix on consoles and potentially with analog outboard equipment when available.

Q3. What are the similarities and differences in students' mixing approaches across schools and song origins?

The quantitative comparison of the mixes' balances from students' DAW sessions suggest that Paris Conservatoire students mix the snare louder and set the kick and the bass levels within a smaller range of relative loudness than students from McGill University and students from Universidade Católica Portuguesa. For the other instruments including the rest of the drums and the lead vocal, we did not observe different practices across schools. It would be interesting to examine further this approach in drum mixing, how much it is taught by professors and/or influenced by a French mixing practice.

Results show that each student approached the mix quite differently for both songs, despite a couple of individual habits that we identified in their mixing process documentation. This indicates that the art of mixing at the Paris Conservatoire is not conveyed as a recipe with a specific order of task and techniques.

While our mix-methods approach could highlight some interesting findings despite the multi-dimensional challenge of investigating cultural influences on mixing practices in school, results call for further studies to focus on drum mixing approaches in different countries, on the new generation's tendency to mix 'in the box' when consoles and analog equipment are available, and on the aesthetic aspects of the art of mixing in pop music.

5 Acknowledgments

We would like to thank Guillaume Jay and all the members of Kabaret for sharing the multitrack source and original mix of *Cold Star* with us. We would also like to thank Denis Vautrin and Paris Conservatoire students Paul Alkhallaf, Valentin Bauer, Samuel Debias, Noé Faure, Anaïs Georgel, Paul Giroux, Baptiste Lagrave, Aloïs Lang-Rousseau, Louis Machto, Luc Montaudou, Alice Ragon, Théo Terracol, Clément Tranchant, and Nicolas Widmer for participating in or helping with the organization of this study.

Data of the study including raw tracks can be found on the Mix Evaluation Dataset [18] and at this link¹.

References

- [1] E. R. Kealy, "From Craft to Art: The Case of Sound Mixers and Popular Music" *Sociology of Work and Occupations* vol. 6, no.1, pp.3—29 (1979).
- [2] A. P. Bell, *Dawn of the DAW: The Studio as Musical Instrument*, Oxford University Press (2018).
- [3] L. Adu-Gilmore, "Studio Improv as Compositional Process Through Case Studies of Ghanaian Hiplife and Afrobeats" *Critical Studies in Improvisation* vol. 10, no.2 (2015).
- [4] B. Anthony, "Mixing As A Performance: Creative Approaches To The Popular Music Mix Process" *Journal on the Art of Record Production* vol.11 (2017).
- [5] Z. Lindhammar, "Perfecting the Groove when the Client is Not in the Room", Bachelor Thesis (2016).
- [6] A. Pras, "From Sound Production to Music Engineering", *Proceedings of Researching Music – Education – Technology* in London, UK (2016).
- [7] B. Owsinski, *The Mixing Engineer's Handbook*, Course Technology (2006).
- [8] S. Zagorski-Thomas, "The US vs the UK Sound: Meaning in Music Production in the 1970s," in *The Art of Record Production* (2012).
- [9] B. De Man et al., "An Analysis and Evaluation of Audio Features for Multitrack Music Mixtures," 15th International Society for Music Information Retrieval Conference (2014).
- [10] B. De Man et al., "Perceptual Evaluation of Music Mixing Practices," Audio Engineering Society Convention 138 (2015).
- [11] B. De Man, & J. D. Reiss, "Analysis of peer reviews in music production," *Journal of the Art of Record Production* vol. 10 (2015).
- [12] A. Wilson, & B. Fazenda, "Variation in multitrack mixes: analysis of low-level audio signal features" *Journal of the Audio Engineering Society* vol. 64, no.7/8, pp. 466—473 (2016).
- [13] E. Deruty, F. Pachet, & P. Roy, "Human-Made Rock Mixes Feature Tight Relations Between Spectrum and Loudness" *Journal of the Audio Engineering Society*, vol. 62, no.10, pp. 643—653. (2014).
- [14] J. Borwick, "The Tonmeister Concept," Audio Engineering Society Convention 46 (1973).
- [15] A. Pras, M. Lavoie, & C. Guastavino, "The Impact of Technological Advances on Recording Studio Practices" *Journal of the American Society for Information Science and Technology* vol. 64, no.3, pp. 612—626 (2013).
- [16] N. Jillings et al., "Web Audio Evaluation Tool: A browser-based listening test environment," 12th Sound and Music Computing Conference (2015).
- [17] B. G. Glaser, *The discovery of grounded theory: Strategies for qualitative research*, Aldine Pub. Co (1967).
- [18] B. De Man and J. D. Reiss, "The Mix Evaluation Dataset," Proceedings of the 20th International Conference on Digital Audio Effects (2017).
- [19] Recommendation ITU-R BS.1770-4, "Algorithms to measure audio programme loudness and true-peak audio level," Radiocommunication Sector of the International Telecommunication Union (2015).

¹ <http://c4dm.eecs.qmul.ac.uk/multitrack/MixEvaluation/>

Appendix

MIXES From most to least preferred	MIXING PROCESS	
	Task order and duration	Use of FX
Pro	<p>Listened to the track w/ faders at 0dB, identified 2 artistic challenges to focus on. Found levels for the bass drum, the snare and the percs tracks. Lopped the chorus to find good levels. Focused on the duo synth/brass and treated the brasses. Compressed the analog master chain and inserted an EQ. Treated the vocals. With the band: changed the kick to get the "bouncing effect" that they liked in their rough mix. Printed analog treatments on the tuned vocal and separated drums tracks that the band sent to him, and on the bass. Adjusted levels and often compared the mix with the rough mix. Added digital effects on vocals. Last session with the band and pre-mastering (but not in the mix that we used for the study). 15 hours before the pre-mastering, i.e. 2 hours with the band in-between 2 sessions.</p>	<p>Kick and snare sent to the Neve Melbourne console. Chorus effect on the brasses. 2 compressors and Warm Audio Egpa on the analog master chain: About 1-2 db compression on both compressors, slow attack and fast release. Federal compressor to Mercury EQ to a distressor to get vocals sound fatter. Kick and snare sent to the Neve Melbourne console; bass into a fuzz guitar pedal. Digital effects on vocals to make them "sexy and mysterious".</p>
PC-D	<p>Listened to the track w/ faders at 0dB; decided on which tracks to mute. Created subgroups - decided to add the kick in the bass group. Treated the kick. Treated the basses in order to avoid phase issues and to sound just above the kick. Treated the Trilian (virtual bass) to make the illusion that there is only one bass. Compressed the bass group. Treated the vocals. Tuned previous settings. Added and treated the brasses. Fixed the vocals compression. Went back to the percs and treated them as a group. Removed the sample snare from the percs group, treated it and added it to the kick/bass group. Treated the kick and snare. Treated the synths divided into plucks and pads categories. Treated the effects (whoshes etc.). Treated the Vox Redux. Went back to the brasses. Compressed and limited the master. Between 10 and 12 hours in total.</p>	<p>Compression on the bass/kick group with a slow attack and a fast release; low cut filter in side chain to simulate the bass being sidechained by the kick. Slightly boosted the low resonance of the kick with a large Q, took out some mids and boosted the attack in the high-mids. More low-end on the bass that is full of low-end, took out some low-end and slightly added some resonance in the low-mids on the bass that has more mids. EQed the Trilian (virtual bass) to fit the same frequency repartition than the other basses. Parallel-compressed the bass that has more mids with a slow attack and noticeable yet sweet saturation. Boosted very lightly the high mids of the vocals to make them more aggressive and to compensate for the lack of the brass on those parts. Got rid of unnecessary low mids in the vocals' reverb. Boosted the highs of the brasses; bass and brass reverbs sent to chonuses. Compression on the vocals and reverb to make it pump, have them in your face but with still a lot of reverb. Cut a lot of low-end on the percs so that they stand out more; parallel-compressed the percs' group with a slow attack and a slow release to avoid the sustain to get the cymbals to pump; sent the percs and the sampled snare in reverb. Largely boosted the low mids of the sampled snare to highlight the fundamental; limited the sampled snare with a slow release and a fast attack. Gated the organic snare followed by a comp to make it more punchy; sent the kick and snare in a guitar amp emulation. Filtered the lows of the Saurus to make it fit with the bass; compressed the Diva synth to bring back some attack; modulated delay on the diva chords to have another space effect; basic eqing on the pads; sent the pads and some effects to a long hall with a low cut at 2kHz. Filtered the lows of the Saurus to make it fit with the bass; a low-mid boost and a high boost with a high Q on the whoshes to cut more through the mix. A slight high boost on the Vox Redux to give it some presence; sent the vocals and the Vox Redux to a room with a bit of pre-delay to preserve speech intelligibility. Sent the brasses to a short plate with a noticeable pre-delay and a very low bass RT multiplier; compressed the brasses with a very slow attack to get more transients. On the master: Opto compressor with a low ratio, very slow attack, an internal side chain low cut and dry signal reinjection; 2nd compressor with a high threshold, low ratio, faster attack, slow release; limiter on just to prevent from 2 or 3 peaks.</p>
PC-A	<p>Listened to the multitrack twice with quick levels adjustments. Setup the PT session with busses and track colors. Focused first on the rhythmic section which was a bit complicated since it had many elements. Worked on levels, tonal corrections, and space for the rest of the mix. Treated vocals and harmonic sections. Added automations and creative effects. Exported a raw mix with nothing on the master. Approximately 5 hours in 4 sessions.</p>	<p>No available details regarding the use of effects for this mix.</p>
PC-B	<p>Listened to the piece entirely several times and created subgroups. Did a first balance. Listened to the draft and wrote down technical issues to solve. Listened to the draft again and wrote down artistic ideas with effects and colors. Applied technical solutions for noted problems and new issues. Worked on the sources with an artistic approach to find a particular colors and the effects that could serve the piece. Automated levels. Worked on the stems to change some color, fine-tune the volume and effects. Listened to the mix on different systems and solved problems noted when listening. No available information about duration, but 4 different sessions.</p>	<p>No available details regarding the use of effects for this mix.</p>
PC-E	<p>Created 8 subgroups. Balanced the synths and FX with delays for each part of the song. Treated kick and the military snare of the outro. Added the bass synth to make it melt with the drum sound. Added the bass. Added the lead vocal with a modulator. Added the backup vocals. Readjusted levels. Added effects on the master. Automated levels and effects depending on the parts of the song. Created a mono to stereo transition in the intro with gradual EQs. No available information about duration and number of sessions.</p>	<p>Several delays on the synths and FX to fill the rhythmic holes and to find something groovy. Parallel compression on the kick and the snare. Strong EQ on bass to fusion it in the global sound. Modulator on vocals to spread it strongly in the stereo but not on the bridge to make the voice really simple, naked, kind of weak, but really close and dry (illustrating the story). Side-chain compression on the master using the kick level as a trigger, EQ and limiter. Removed the modulation of the voice in the bridge, changed the panning of the synths.</p>
PC-C	<p>Listened to the song one time. Listened to the song several times to rediscover the music, to identify technical issues, and to find a direction to take. Focused on the vocals levels, aligned them at -23dBFS approximately in the chorus and verse to build the mix around them. Focused on the chorus. Created subgroups. Put all the levels down and started over except for the vocals. Mixed the chorus until it sounds good. Focused on the intro to make it blow up, put everything in mono and then open to stereo. Went back to the different choruses. Worked on the verses and treated the vocals. Added the same reverbation on drums. Changed a few levels in the bridge. Worked on the outro and realized that the mix was saturating. Readjusted the levels to avoid overloading the summing bus. 14 hours in 4 sessions.</p>	<p>EQ and compressor on the verses' vocals to remove the pops. EQ on the bass drum to make it bigger. EQ on the keyboard to make it sound like a "piano bastringue". Delay and Lexicon plate reverb on the vocals to make them more alive in the verses that felt empty compared to the choruses.</p>

Table 3 Details of mixing processes of Kabaret's *Cold Star*

MIXES From most to least preferred	MIXING PROCESS	
	Task order and duration	Use of FX
PC-A	<p>Treated the rhythmic sections. Did a balance between the kick, bass and lead vocals. Added and treated the rest layer by layer: an harmonic element (guitar) then a rhythmic counterpoint (snare), then a lead counterpoint (harmonica) etc. Adjusted the reverbs. Automated levels, mainly on the leads. Approximately 5hrs30 with 3 breaks</p>	<p>Added 'EQ, compression and reverb on everything' but no specific available details regarding the use of effects for this mix.</p>
PC-C	<p>Created subgroups and track colors. Listened to the entire song at 0dB. Did a short balance and figured out the structure. Aligned the leads at -23dBFS VU throughout the mix as reference. Treated the leads. Added the "choir" but quietly as they sang out of tune. Checked the phase between OHs and other drums elements, phase-flipped the snare bottom mic. Treated both microphones on the kick and the snare, got rid of the snare bottom mic. EQed the high-hat. Treated the toms. Treated the OHs and the drums in general. Did the balance of the drums. Worked on the balance between the kick and vocals. Treated the bass DI. Worked on the balance between the vocals, drums and bass on the verse. EQed acoustic and electric guitars, only used the stereo acoustic guitar and bring the accordion and the keys. Automated levels for the chorus. Adjusted levels at different parts. 6hrs with breaks</p>	<p>Removed low-mids and compressed the leads to reduce dynamics. Added reverb. Removed low-mids and compressed kick and snare. Added the same reverb on leads and drums, and a reverb on the kick to make it longer in order to unmask it. Removed low frequencies of the high-hat and some snare leakage. EQed and gated the toms to make their resonance sound better and to reduce leakage of other drums elements. EQed the bass DI to make it sound like a bass.</p>
PC-D	<p>Listened the entire song with faders at 0dB. Created subgroups and adjusted group levels. Solved main technical issues: removed a snare mic, and fixed phase issues between kick and OHs. EQed the acoustic guitar. Added reverb on acoustic guitars, accordion and keys. Added the same reverbs on electric guitars. Treated the lead vocals. Treated the bass. Treated kick and snare. Treated OHs and drum room mics. Added the same reverb on snare and vocals, EQed the reverb. Added effects on the lead. Went back to the guitars and treated them. Adjusted levels and made corrections. Added reverb on everything for calm moments, treated the reverb. Improved the effects on the leads. Compressed the master. Limited the master. No available information about duration and potential breaks.</p>	<p>Brought up low-mids on acoustic guitar to match the bass. Added a long reverb with a medium predelay for accordion, keys, acoustic and electric guitars. Used both reverbs for the guitars (one of each guitar mic): a weird long reverb, almost like a shimmer and a bit like a freezed reverb made of modulated delays, and a church reverb with long predelay. Added harmonic delays and parrallel distortion on the leads with an EQ before to make some frequencies more distorted, automated the amount of distortion. Compressed the bass with a slow attack and a fast release. Brought up low-mids on kick and snare to match the bass. Compressed the kick and snare with a slow attack and a fast release. EQed the OHs with a low-cut filter to remove the kick, a slight cut at 500Hz because of the room acoustics, and a 10kHz boost to get the cymbals shiny. Compressed the OHs with a slow attack and compressed the drum room mics heavily. Added a plate reverb with 20ms predelay on snare and vocals, with more low-mids. Added a low and low-mid boost and compressed the 'weird reverb' for calm moments. Compressed the master to glue everything with a very slow attack and release, a 2:0 ratio and a threshold that makes the compressor work a little bit all the time. Limited the master to avoid clipping at the end of the track.</p>
PC-E	<p>Created 6 subgroups. Added an aux bus to add parrallel compression on the drums. Added the bass DI. Worked on the guitars looking for a natural and envelopping sound for the acoustic guitar, and a more crunchy sound for the electric one. Balanced the guitars with drums and bass - the snare is directly linked to the electric guitar, the bass and kick with the acoustic one. Added some delays on the electric guitar. Added and panned the keys and accordion so that the accordion balanced with the second voice and the keys melted with the other instruments. Treated the vocals. Readjusted some levels. Limited the master. No available information about duration and potential breaks.</p>	<p>Parrallel-compressed the drums to add some punch and energy using the kick, the snare and the OHs. Used a 'Sans Amp' plugin on the electric guitar to add some drive, punch and EQ. Added delays on the electric guitar to fill the holes in the rhythm and to make it more groovy and get the stereo picture more dynamic. EQed the lead vocals to make it more intelligible in the ensemble even if it is very low. Added ping-pong delays on the lead vocals like a really small echo. Added two reverbs on the vocals: one short (165ms) to create some presence and one longer (3sec) with a big predelay (48ms) to make it fusion with the band. Limited the master to bring a special color and some dynamic.</p>

Table 4 Details of mixing processes of The DoneFors' *Lead Me*