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# The Paperoles Project: An analysis of paper use by music composers

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## ABSTRACT

Technologies such as Anoto offer a novel approach to supporting the creative design process, by integrating paper with on-line tools. However, creating successful 'augmented paper' applications requires a detailed understanding of the existing and potential roles of both paper and computers. This paper describes our study of contemporary music composers, who are highly skilled users of both. We challenge common assumptions, particularly that paper's key value lies in its flexibility and describe our early prototypes of 'augmented scores'. We conclude with implications for the design of augmented paper applications that support creative work.

## Author Keywords

Augmented paper, Participatory design, Musicians, Musical scores

## ACM Classification Keywords

H.1.2 [User/Machine Systems]: Human Factors, H.5.2 [User Interfaces]: Evaluation/methodology, Theory & methods, Proto-typing, User-centred design.

## INTRODUCTION

We have long been interested in the role of paper in human activity, ranging from biologists' lab notebooks, air traffic control flight strips or engineering drawings (Mackay, 1998). Each project focused on the balance that must be maintained by people who have excellent reasons for using both paper and electronic tools: each medium has its advantages and its disadvantages and we were interested in studying how to make optimal use of the two forms together.

This study is somewhat different. Our user population consists of professional musicians, who use both paper and computers to compose music. Here, our goal is not to increase efficiency or accuracy, per se, but rather to support a highly individual creative process. We began by interviewing professional musicians at IRCAM, in Paris, and observing them at work. This paper describes the results of those interviews, including some counter-intuitive conclusions with respect to their use of paper. We conclude with a design scenario that illustrates how one would take these findings into account when designing an Anoto-style application, in order to enhance the musician's use of both paper

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and electronic media when creating music.

## STUDY: INTERVIEWS OF COMPOSERS

IRCAM is a world-renowned centre for electronic and contemporary music, created in the 1970's by Pierre Boulez. Composers and musicians come from all over the world either to compose new works or to collaborate with other musicians on new projects. Composers pose an intriguing user interface problem: how can they use the computer as tool, but still feel like they are creating art? The problem is not to increase efficiency, but rather to enhance reflection and increase expressiveness. The composers clearly do not want a system that automatically composes for them. Instead, they need tools that help while leaving them the masters of the creative process.

We interviewed 12 composers and musical assistants at IRCAM. The composers were either proficient computer users themselves or else had extensive access to music assistants who can program for them. Most music assistants were computer scientists with additional training in musical. We interviewed both individual composers and composer-assistant pairs, in their offices or the laboratories where they composed music, to better understand the process by which they create new music. We also met with the *Analyses des Pratiques Musicales* team at IRCAM to discuss their longitudinal study with a single composer (P. Leroux) and how he used paper [Donin 2006].

## RESULTS

We analysed how these professional composers create their compositions and found that, despite access to the latest computer-music tools, they continue to use paper to edit, annotate and link their musical scores. Despite their technical proficiency, most composers continue to use paper documents as a fundamental part of the composition process. They are dissatisfied with the lack of connection between their off-line scores and other annotations and the on-line software that generates the resulting music. Letondal et al. (2007) report in more detail about the study: this paper concentrates on two sets of findings: First, when in the composition process do composers choose which medium, paper or computer? Second, when they have a choice, how do they choose between the two?

## Chronology of paper and computer use

Why haven't composers of electronic music shifted to an entirely computer-based composition process? It is due neither to fear of computers nor to particular problems with the user interface (especially since most of these tools are designed by and for musicians). Instead, like people in other fields, composers choose the medium that is best suited to the purpose at hand (Sellen and Harper, 2003).

We summarize the varying roles of paper and computer throughout the composition progress in Fig. 1. Composition

progresses from the initial creative stage to the final piece, with much iterative development in between. Throughout this process, the artefacts change, from quick sketches in the beginning, through progressive experiments in the middle, to the final composition at the end. During this process, the valued characteristics of paper and computer change: In the earliest stage, paper is valued for its flexibility and freedom of expression. In the interim stages, both paper and computers are valued for their ease of modification and power of expression. In the final stage, the paper version (with some exceptions) is valued because it acts as a reference artefact and permanent record of the work.

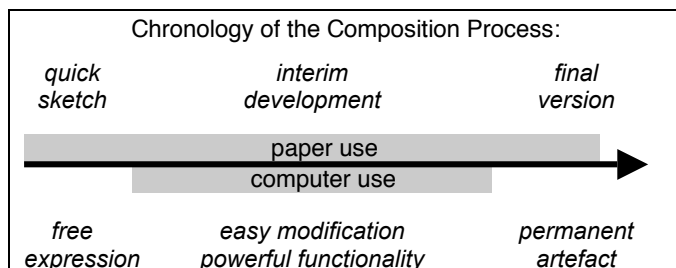


Figure 1: Paper is used from beginning to end of the composition process. Computer and paper are used together during the interim development phase.

In the initial idea-generation stage, composers use paper because it is flexible, easy to transport and less cumbersome than a mouse or a stylus on a graphics tablet. Most importantly, paper permits free associations: The user is not restricted to the particular input structure of the particular computer program, but can use any combination of drawing and text, enabling free expression of artistic ideas. We saw numerous innovative examples of using paper to sketch or capture initial ideas. One composer created a diagram to describe the structure of a symphony (Fig. 2a) and while another drew magic squares to determine the phrasing of his composition (Fig. 2b).

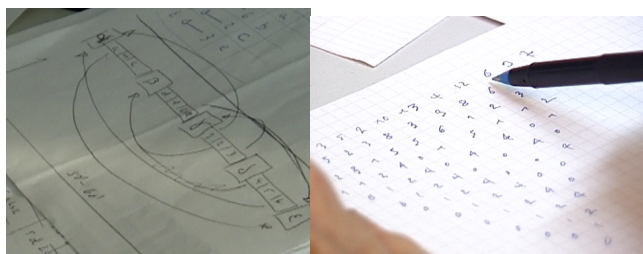


Fig. 2a: Organising the components of a symphony  
2b : Using a magic square to denote phrasing

Composers also annotate hand-written scores. In Fig. 3, the composer has added numbers under each instrument part to indicate loudspeaker assignments to give a spatialisation effect.

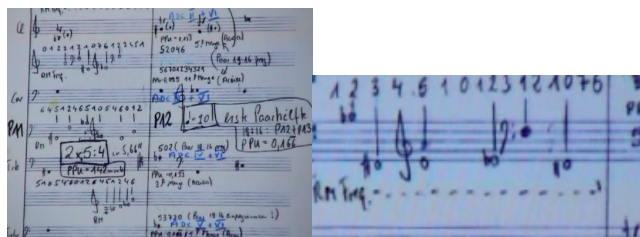


Fig. 3: Annotations to a hand-written score

At the other end of the composition process, the choice of paper has less to do with the flexibility of input, but rather its status as an archival object. One composer reported that he even paid someone to hand rewrite his scores, from the 'final' version on the computer, so as to create the true, 'original manuscript'.

### Choosing between paper and computer

Between these two extremes, during the interim development process, composers use both paper and electronic media, often shifting back and forth between them to take advantage of the characteristics of each. Thus, composers use paper when they need a free format, such as we saw in figures 2 and 3. Similarly, they use the computer when they need computation or when they want to build new musical sounds (timbre, etc...).

In many cases, there is no conflict between paper and the computer and the composer moves easily back and forth between the two forms. For example, in Fig. 4a, the composer goes back and forth from the printed score to various musical materials such as programs, drawings (Fig. 4b), text documents containing a poem used as seminal data to build sounds, a rhythm series for the piece, etc. The printed score can be browsed rapidly, examined and compared to an electronic document displayed on the screen. This composer uses paper folders, containing various sheets of paper, sometimes cut from larger sheets, in order to keep track of the structure of his piece.

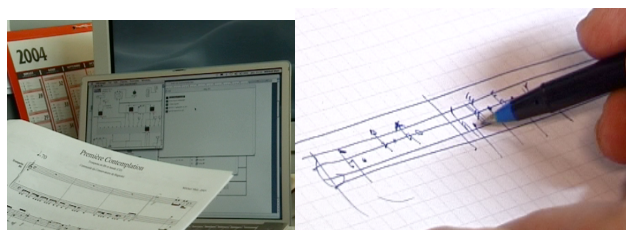


Fig. 4a: Navigating between paper score & on-line files  
4b: Extended musical notations for 1/4 and 1/8 tones

Fig. 5 illustrates a more complex interaction between the two forms. The composer has drawn an arbitrary s-curve on paper to define a particular sound segmentation. After annotating this acoustic shape, he explained that he would now have to input it again to a dedicated software tool that calculates the spectral envelope. Although this particular composer happens to be a skilled LISP programmer, he does not use either mouse or pen-input to draw such curves. He prefers to sketch curves on paper first because it is easier and more direct, and then use a scanned and/or re-implemented version on the computer.

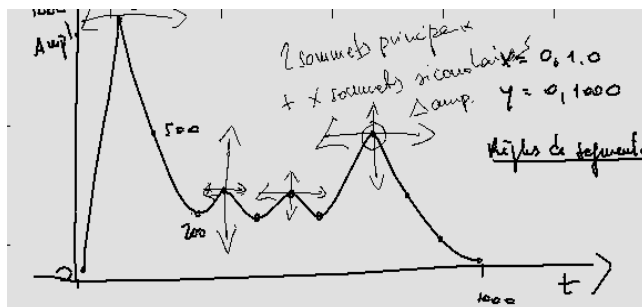


Figure 5: Hand-written drawing of an acoustic envelope. By recording of the strokes coordinates, the drawing can also be displayed on the computer screen.

Rather than creating one specific program for each creative idea, paper enables these composer to spontaneously generate any idea that occurs. Then, these ideas are translated into music, perhaps via paper score for human musicians or as input to a computer music program.

In some situations, however, composers face a conflict, because neither medium suffices by itself, but they do not work well together and it is not easy to decide. Time is not the issue: when asked whether paper or computers were faster, one composer said that, in the end, neither was faster. Another commented that the computer allowed him to “lose time in order to gain space”. In classical music, instruments provided composers with the opportunity to explore and interact with the music as it was being composed. In electronic music, computers serve the same function, allowing composers to create new instruments and sounds and interactively explore a musical space. But the preferred medium for imagination and writing remains paper, *because it is slow and static*. We observed that electronic editors for writing music, such as Finale, are used mostly for the non-inventive part of the composition or for traditional composers.

Composers must decide on which medium to use for the final representation of the score. In classical music, each work is transformed into the “original score”, on paper. This serves as an the authoritative reference for the piece, which can then archived and copied. But with electronic music, the choice of the final format is more complex. For example, in Fig. 6, the composer has pushed his software tool to the limits by including graphical notations that indicate particular sounds the choir must make, in addition to standard notes. These symbols must be defined separately and linked the associated sounds, which are stored on the computer. So the “original score” is archived in a mixed paper and electronic form.

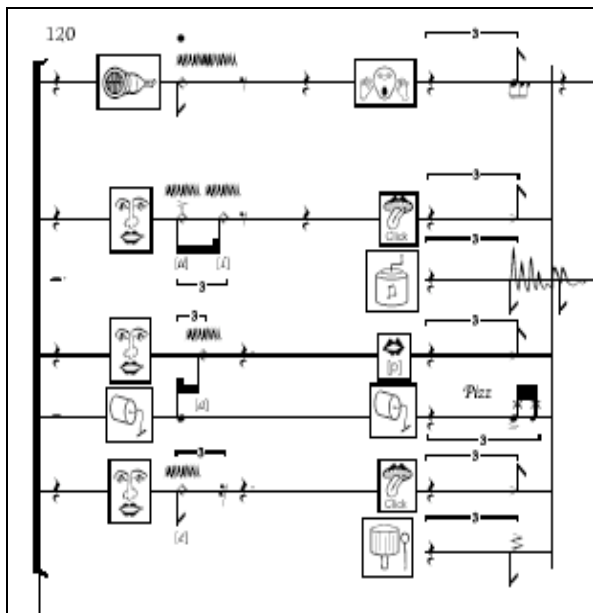
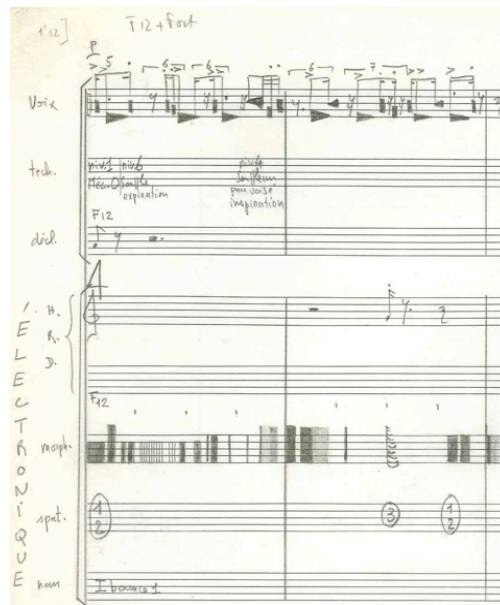


Fig. 6a: Score with added symbols to show actions to be performed by the choir.

Similarly, Fig. 7 shows a hand-written score with links to a variety of electronic documents and statements that trigger particular computer programs while the piece is being played. This hand-written paper score serves as the key reference point, with

links to the computer, but the final work is fundamentally located both on-line and on paper.



6b: ‘Electronic’ is written vertically, with links to various computer programs that are played in addition to the more traditional score to the right.

## DISCUSSION

We see that paper is the preferred medium at the two extremes of a sort of ‘temporality’ scale: Paper is excellent for quick sketches that express ideas as directly as possible: the composer does not have to fit the ideas to the particular software problem at hand, but rather simply records whatever makes most sense with respect to the idea. The composer can experiment freely with different ways of expressing the idea, and stay focused on the idea itself. At the other end of the spectrum, paper acts as the final, archival form of the finished score, except in particular cases in which the paper score is linked to on-line files to create a mixed archival document. In the interim design phase, composers shift back and forth between paper and computer, choosing the representation that makes most sense for the task at hand.

## DESIGN SCENARIO

We find that analyzing qualitative data into the form of a design scenario is a useful technique for extracting the key concepts that emerge from the data and transforming them into a form that helps us think about the design, situating it in the context of real use and obtaining feedback and additional ideas from users. The following is a design scenario that illustrates a musician in the process of using *Paperoles*, a technology probe (Hutchinson et al., 2003) based on Anoto technology that integrates paper and computer-based composition. We have created video prototypes of this and related design scenarios and are currently implementing the related software.

### Interacting with mixed scores

Pierre is writing a new symphony, inspired by multiple sources: He translated a poem by Verlaine into Morse code and used this as the initial pattern for the different rhythms in the piece and he selected the different timbres, based on models of musical instruments and voice. He uses a variety of different computer



tools to support the composition process, including the popular OpenMusic system, as well as MAX/MSP and AudioSculpt. When he opens his composition on the screen, he sees hypertext links to different zones corresponding to the appropriate software. When he interacts with a particular page of the score printed on Anoto paper, he can open the related software directly, following the same set of links.

Pierre likes to wear noise-reduction headphones and read the most recent version of his score, printed on paper, on the train going home. He hears the music in his head and makes a number of changes, modifying notes and deleting several chords. When he arrives home, he marks the "send" button (printed in the bottom corner of his score), which sends the revisions to his computer via Bluetooth. The changes are incorporated when he next opens OpenMusic. Pierre uses the history function to compare them to the previous version, moving backwards in time. Each set of editing changes is highlighted and marked with the date and time. Pierre can add additional annotations and notes, either on-line or on paper, depending upon which is most convenient at the time.

Like many contemporary music composers, Pierre creates new sounds for each individual piece. These sounds cannot be represented by traditional notes on a score, and require new symbols that define how to play the new sounds. Pierre sketches various ideas for different notations to represent these sounds and then marks his favorite on the printed score. His music assistant, George, has written a custom-made program to help Pierre express his ideas for the new composition. Pierre communicates with George by sending ideas for different notations via an annotation layer that sits on top of the relevant section of the particular version of the piece. Pierre decides to create a new sound by associating it with a particular frequency spectrum. He sketches several possibilities on sheets of paper, selects one, and creates an interactive annotation on the paper score with the appropriate information. When George later looks at the score on-line, he sees the modified notes highlighted, with a pop-up note that includes Pierre's explanation of the idea, a sketch of a symbol to represent it, and the sketch of the frequency spectrum (Fig.8). George transfers the sketch to a separate program, where he converts the curve into a playable algorithm, and creates a 'patch' that links the symbol and the spectrum to the original score. (This is an example of participatory programming (Letondal & Mackay, 2004).

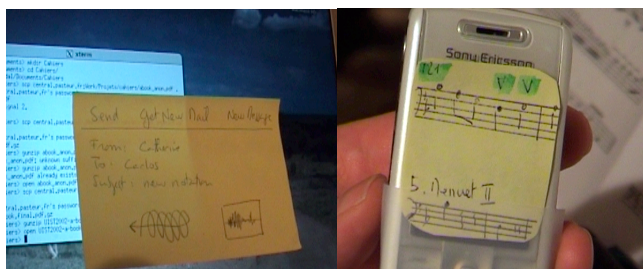


Fig. 8a : Videoprototype showing the annotation  
Fig. 8b: Message about bowing sent to violinist's PDAs

Pierre's composition is intended as a mixed piece, with human musicians and the computer playing together. Pierre inserts 'activate' commands into the paper score that Leonard, the 'chef de pupitre', uses to control when the computer plays. During rehearsals Leonard also makes changes to certain passages and communicates them to the musicians. These changes are captured on-line as well, and retained in the subsequent version of the

score. Fig. 8b shows the changes in bowing instructions, with the affected notes highlighted in green and sent to the violinists, via PDAs located on their music stands.

## CONCLUSIONS AND FUTURE WORK

Our studies of composers has demonstrated the important role that paper continues to play in the creative process, even when composers are adept computer users. Paper remains the optimal choice at the two extremes of the creative process: sketching initial ideas for the first time and creating an archival record of the finished work. Between these two extremes, composers mix paper and computers in a variety of ways, influenced by the particular input/output characteristics of each.

We are currently exploring the use of Anoto technology to expand the options available to composers in this interim stage of creation. We have implemented part of the above design scenario as a technology probe and are continuing to work with IRCAM composers to further explore this design space. Our goal is to create a system that supports the cycle of 'sketch – interact on the computer – print – annotate on paper – interact on the computer' in a more fluid and accessible way. This will allow composers seeking to add innovative notations to traditional music scores, a common theme in contemporary music, a framework in which paper, printouts and files can be linked together and support the process of co-adaptation (Mackay, 2000) in which users are encouraged to adapt technology to meet their own unique needs.

## ACKNOWLEDGMENTS

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