Analytic vs. holistic approaches for the live search of sound presets using graphical interpolation

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ABSTRACT
The comparative study presented in this paper focuses on two approaches for the search of sound presets using a specific geometric touch app. The first approach is based on independent sliders on screen and is called analytic. The second is based on interpolation between presets represented by polygons on screen and is called holistic.

Participants had to listen to, memorize, and search for sound presets characterized by four parameters. Ten different configurations of sound synthesis and processing were presented to each participant, once for each approach. The performance scores of 28 participants (not including early testers) were computed using two measurements: the search duration, and the parametric distance between the reference and answered presets.

Compared to the analytic sliders-based interface, the holistic interpolation-based interface demonstrated a significant performance improvement for 60% of sound synthesizers. The other 40% led to equivalent results for the analytic and holistic interfaces. Using sliders, expert users performed nearly as well as they did with interpolation. Beginners and intermediate users struggled more with sliders, while the interpolation allowed them to get quite close to experts' results.

Author Keywords
Presets, interpolation, graphical, touch, polygons, holistic, analytic, sliders, mapping, working memory.

CCS Concepts
• **Applied computing → Arts and humanities →** Sound and music computing; • **Human-centered computing → Human computer interaction (HCI) → Interaction devices →** Touch screens; • **Human-centered computing → Human computer interaction (HCI) →** HCI theory, concepts and models

1. INTRODUCTION
In the domain of parameters mapping for sound synthesis and processing, the most basic method is the 'one-to-one' mapping [8]. It consists in the assignation of independent controls to parameters of sound processes; e.g. a large number of sliders or knobs can be one-to-one assigned to synthesis or filtering parameters. If each output depends on several inputs, the mapping can be called 'many-to-many'.

Other methods map fewer control parameters to the numerous synthesis parameters, because a reduced set of possible inputs can be more interesting for a performer [6]. To achieve this 'few-to-many' parameters mapping [8], it is possible to rely on graphical interpolation of presets. The basic principle is to internally assign presets – i.e. a set of defined values of all parameters of the controlled process – to geometric shapes on a screen. Later, when a user moves a cursor between these shapes, an interpolation is computed between the underlying presets. The interpolation engine outputs values of all parameters of the controlled synthesis process.

Many systems currently offer graphical presets interpolation features. A widespread one is the Nodes objects included in Max/MSP [3], which represents presets as disks. The system used for the present experiment is based on a specific controller app, running on an iPad, which allows free-form polygonal representations of presets. This is very useful to compare different preset-based interactions, e.g. using linear sliders or complex polygons from a unique app, on a unique touch screen.

The present work aims at measuring performances of users confronted to preset-search tasks, in order to compare two different geometric approaches. All presets are made of four various parameters. The first approach–called analytic [7]–let subjects directly control the synthesis parameters from four independent sliders. The second approach is based on graphical interpolation between four presets. It is called holistic [7] because subjects manipulate each preset (linked to a shape) as a whole.

Several experiments have already been conducted in the fields of graphical presets interpolation (subsection 2.1) and analytic vs. holistic mapping strategies (subsection 2.2). The first difference between this experiment and previous ones is the use of a unique touch app for all graphical representations (see subsection 3.1). This removes the risk of introducing bias when using several different physical interfaces.

Another contribution of this experiment is the nature of the preset-retrieving tasks. First, subjects had to listen and memorize melodic and rhythmic loops from widely used synths (see subsection 3.2). Secondly, they had to search for values of the synthesis parameters that give a similar result. Their performance scores depend on:

- The parametric distance between answered parameter values and reference parameter values
- The search duration (the shorter the better)

This process is similar to what an artist might be doing during an interactive music performance, a live DJ-set, etc. Recent research on Auditory Working Memory (AWM, see subsection 2.3) was taken into account for the conception and realization of the experiment. Results are presented in section 4 and discussed in section 5.

An additional contribution of this work is the search for correlations between subjects' expertise level in sound synthesis and processing, and their performance for the given tasks.

2. STATE-OF-THE-ART
2.1 Graphical presets interpolation
An extensive listing of graphical presets interpolators has been recently published by Gibson and Polfreman [4] and will not be detailed here. The geometric interpolation method used in the present experiment does not belong to that list, because it was

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initially used for sound spatialization [11] only. It was developed by the authors of this paper and has been recently repurposed as a generic controller app with OSC (Open Sound Control) output.

For the specific topic of comparing graphical presets interpolators, Gibson and Polfreman [4] proposed a framework including existing solutions. They concluded that it was usable for future formal experiments, without referring to previously published ones. This framework was not considered because the presented experiment began a few months before their publication. Moreover, our system brings free-form polygons and useful network-related configuration features.

Later, Gibson and Polfreman [5] published a study of mouse-traces records for various visualizations of presets, all based on simple shapes (blank screen, points, or disks on screen). Their experiment resembles the one presented in this paper but does not quantify user performances and relies on a preset-based, holistic approach only.

2.2 Analytic vs. holistic approaches

Humans can apprehend musical systems using analytic and/or holistic cognitive modes [7]. The analytic thinking tends to decompose input parameters and their effects. The holistic thinking is harder to describe; in the current context, it could mean that a system–from its inputs to its perceived outputs–is considered as a whole. These two cognitive modes are not activated in the same way in everyone's mind, e.g. Nisbett et al. [17] speculated that they are influenced by social systems.

The main experiments comparing the analytic and holistic cognitive modes for musical performances were conducted by Hunt and Kirk [7]. Subjects had to reproduce parametric trajectories using three different interfaces. The first and second interfaces were made of four sliders with a one-to-one mapping to synthesis parameters. The first relied on mouse-controlled on-screen sliders, the second relied on hardware sliders. Both incited subjects to think analytically. The third used a combination of physical sliders and movements and buttons of a mouse, with complex mappings to four sound parameters. Many users developed a 'feel' for this interface and the authors considered that users were thinking holistically.

Very briefly, the holistic interface gave better results only when reference parameters change simultaneously. Users also generally found it more 'fun' and engaging. When parameters changed sequentially, better performances were obtained using the analytic interfaces. Some subjects expressed a preference for the analytic thinking.

These results are very interesting and call for complementary experiments. They were obtained from different physical interfaces, whereas the presented work aims at providing new data about a modern touch interface, and about different geometric controllers on a unique interface.

2.3 Auditory Working Memory (AWM)

As our experiment involves human auditory memory processes, it is necessary to briefly focus on its organization even if it is very complex. In terms of duration, the auditory memory can be roughly divided into three categories:

- The long-term memory, in which information is encoded and stored [20]. This memory will not be involved much in the experiment, as subjects did not know the sounds before taking part in it.
- The short-term memory [2] (also called AWM), which stores information for a limited amount of time. It allows active mental manipulation of information and is the most involved in this experiment.
- The auditory sensory memory [2] (echoic memory), very brief and unconscious, which does not involve active mental manipulation of sensory traces.

AWM and echoic memory have been extensively studied, but their durations still cannot be precisely defined. The nonverbal echoic memory retention interval is considered to be in the range of a few seconds [15], but "possibly up to 60s". The AWM lasts longer but information deteriorates with time. Soemer and Saito [19] measured that the retention of auditory nonverbal information was slightly better for a 3s than for a 12s interval.

The number of items that can be manipulated simultaneously in the AWM is still being studied. A widely accepted figure is four, according to Cowan studies [2]. However, the AWM seems to be more complex and "flexibly distributed among all items in memory" according to a recent publication [14].

3. EXPERIMENT PROTOCOL

3.1 General organization

3.1.1 Population

Twenty-eight individuals (eight female) from 19 to 60 years old took part in the final experiment and were included in the results. One more person took part in it but was removed from the results due to a technical issue. Moreover, four individuals (one female) took part in the alpha and beta versions of the experiment to calibrate various parameters. Their performances were not included in the results.

One subject suffers from humeral agenesis (very short arms). However, he/she could normally perform the task–with good results–thanks to the touch interface on a rather small tablet screen. Thus, these results were fully integrated into final data.

Among the total of 33 participants, around 10 were colleagues or students of the authors. The population was made of professional and amateur musicians, sound designers, engineers, and people professionally unrelated to the domains of music or engineering.

To start the experiment, the subjects had to read and accept a consent form on the main computer. All results remain fully anonymous. Videos were recorded but focused only on the subjects' hands on the tablet.

3.1.2 Graphical interpolation touch app

In order to study the analytic and holistic approaches, two different representations can be displayed on the tablet using the touch app. For a fair comparison, the analytic (Figure 1) and holistic (Figure 2) views must contain the same number of items, which is four, in coherence with Cowan's 'magical four' law [2].

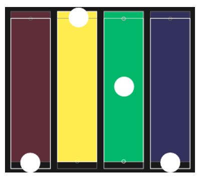

Figure 1. Analytic slider-based representation

The analytic, decomposed representation consists in a basic one-to-one mapping from four graphical sliders to four parameters. These parameters are described in subsection 3.2. In the example of Figure 1, the parameter assigned to the yellow slider has a 100% value and the one linked to the green slider has a 50% value. The two other parameters have a 0% value.

The holistic representation (Figure 2) assigns presets instead of parameters to the shapes on screen. Each preset is made of one parameter at a 100% value, all others at 0%.

When moving the cursor (white dot) from a shape to another overlapping shape, a smooth interpolation is computed between the underlying presets. The method for computing interpolation weights of polygons ensures the continuity of output values [19].

For example, on the left of Figure 2, interpolation weights are 50% for the 'green' preset, 50% for the 'purple' preset, 0% for the two others. On the right, the interpolation weight is 100% for the 'red' preset, 0% for the others. Each preset is made of one parameter at 100% value, all other parameters at 0% value.

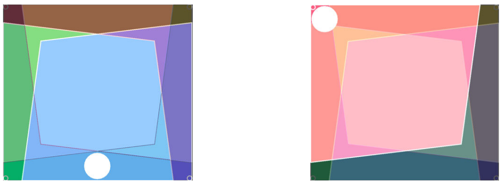

Figure 2. Two different preset interpolations obtained from the same holistic interface

Colors of all graphical items on screen are randomized during the experiment, and do not correspond to any particular parameter or preset. With the sliders, cursors are constrained to vertical lines. For the holistic view, the unique cursor can move freely inside the square area delimited by the four polygons.

For a given synthesizer, both search steps must begin from identical parameter values. To ensure this, the interpolation cursor is initially positioned at the center of the screen, and analytic sliders are initialized to a 25% value.

3.1.3 Twenty listening and search cycles

The main experiment contained 10 different synthesizers with their reference presets (see subsubsection 3.2.1). Each synthesizer was presented two times: once with the sliders-based interface, once with the interpolation. The core of the experiment then contains 20 cycles of listening and search, for an approximate duration of 20 minutes.

Durations of the different steps of a cycle are presented in Table 1. They were defined considering scientific literature on AWM and using observations and feedback from alpha and beta tests. We remarked that subjects lose auditory information of a reference sound when they refine their results too much. Thus, we tried several time limitations for the search step. We finally choose 35s, which gives enough time to explore the interface and refine the result if necessary. Subjects were incited to give their answer (by pushing a green physical button) quicker to improve their performance score.
The white noise might help erase sensory traces in memory [19], in order to improve independence of performances between cycles. Ordering was randomized, but at least 3 cycles separated the analytic and holistic presentations of a given synthesizer.

Table 1. Durations of the steps of a cycle (seconds)

Pause	Listening	Pause	Search	Pause	White Noise
8	20	5	35 max.	1.5	6

Prior to the 20 main experiment cycles, subjects had to test the whole setup. This test consisted in two trial cycles made of two different synthesizers. One cycle presented a sliders-based interface, the other presented an interpolation-based interface. At the end of the experiment, subjects were asked a few questions via a detailed form. The whole experiment lasted 30 minutes maximum.

3.2 Sound parameters

3.2.1 Nature of sound loops and parameters

The controllable parameters were usual but very diverse, e.g. gains, waveforms, dry/wet ratios, cut-off frequencies, etc. They were parameters of synthesizers and effects (low- or high-pass filters, mixers, delays, reverbs, choruses, etc.) from Arturia Analog Lab [1] and built-in Reaper [18] plug-ins. Subjects were only informed about the possible nature of parameters, but not about their specific names.

Each synthesizer was played from its own MIDI loop (maximum duration 5s), at its own tempo, in its own Reaper track. All reference presets could be reached from both analytic and holistic interfaces. The preset search tasks were tried and criticized by alpha and beta testers, in order to obtain pleasant sounds and reasonable levels of difficulty. To prevent extreme unmusical variations, a rescaling of parameters' values could be applied inside the touch app.

3.2.2 Subjects' performances measurements

A subject's performance depended only on the validated final result, not on trajectories on the touch screen. The formula for computing performances does not include psychoacoustic differences between the result and reference sounds but relies on parametric differences. We make the assumption that plugins' controls are calibrated such that a linear-scale control has an equivalent psycho-acoustic effect, e.g. a frequency slider from 0 to 1 controls a physical frequency on a logarithmic scale.

The total error e is the normalized sum of the four parametric errors (differences between target and user values of parameters). Given the search duration d, the performance s is:

$$s = max\left(\left(1 - \frac{e}{0.55}\right)\left(1 - \frac{d}{87s}\right), 0\right) \in [0; 1]$$

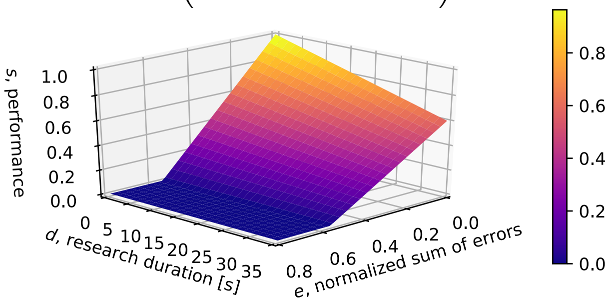

Figure 3. Performance evaluation function (surface plot)

By considering both the speed and error, this performance function evaluates a live situation, with a linear decrease on both axes. It has been calibrated using data from alpha and beta experiments. To prevent good scores for very fast but quite wrong answers, an average error of 0.55 gives a 0% score. Nonetheless, to incite subjects to search as fast as possible, the maximum performance decreases with time. The 87s factor was chosen after the 0.55, to obtain an average score around 50%.

3.3 Hardware setup

3.3.1 General hardware setup

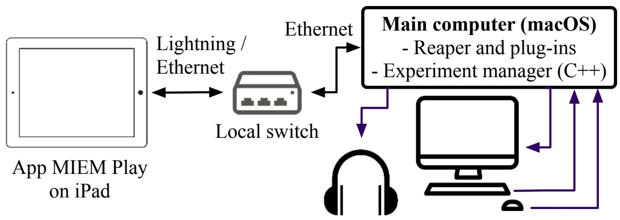

Figure 4. Connections between computers and peripherals

While subjects performed the preset search tasks on the tablet, Reaper ran synthesizers and filters on the main computer. To play and stop loops, the manager app (also running on the main computer) controlled Reaper from local OSC messages. The main screen's UI was dynamic and depended on the cycle step: it displayed initial and final forms, countdowns, progress bars, scores, etc.

Once launched, the system was autonomous. Besides the OSC connection from the iPad app to Reaper, the experiment manager kept a TCP/IP connection opened to the iPad to control the touch app and monitor its status. The experiment manager also opened a local OSC connection to Reaper to control it.

Participants could always see the main computer's screen and the tablet. They were seated in an adjustable office chair, inside a cabin covered with acoustic foam, covered itself by black curtains in order to minimize visual stimuli. They were wearing Sennheiser PXC 480 noise-cancelling headphones connected to a Focusrite USB audio interface.

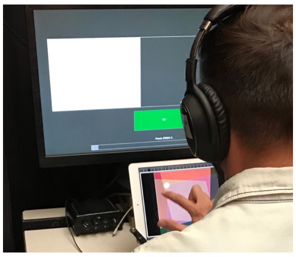

Figure 5. Subject during a search phase

The tablet screen was black during all steps but the search one. During this step, a large white bar (Figure 5) displayed the remaining time. The small bar (screen bottom) is the global progress bar. In other cases, the main screen displayed various information such as a countdown or the last performance score.

3.3.2 System latencies

High latencies might impair user performances and must be estimated for such an experiment. Values from 20 to 30ms are considered acceptable for instrumental musical application [10]. Commercial touch screens present high latencies (dozens of milliseconds) and 15% of subjects notice visual latencies of 40ms for touch pointing tasks [9].

Using a custom latency measurement system (not published yet) based on a microcontroller, LEDs and fast photodiodes, the 'touch drag' latency was estimated for visual and audio feedbacks. For this experiment, the drag latency is more relevant than the 'touch tap' audio latency (which is nonetheless easier to measure e.g. using a single microphone [12]).

The latency from a movement on the touch screen to audio feedback was estimated to 49ms (SD=10ms, n=1073). Considering the number of interfaces involved, it remains quite low thanks to the highly reactive iPad touch screen, the efficient C++ implementation and the reliable cable network. The latency from a touch move to visual feedback was estimated to 78ms (SD=5ms, n=1073). This quite high figure comes from improvable internal management of graphic buffers.

Although these latencies might slightly decrease users' performances, they were not considered as an issue by subjects (see subsubsection 4.3.1).

3.4 Gamification

A literature review by Lumsden et al. [13] states that introducing game elements in user tasks improves their motivation and enjoyment, reduces test anxiety and increases long-term engagement. Ninaus et al. [16] concluded that "game elements facilitated the individuals' performances closer to their maximum working memory capacity".

Thus, the user interfaces and general organization of this experiment have been conceived respecting some basic principles of gamification. According to the theory of the 'state of flow' [16], a gamified experiment should provide clear goals, feedback, playability and a sense of control.

4. RESULTS

4.1 Sliders vs. interpolation comparison

In general, the interpolation-based interface allows a significant performance improvement over sliders (Figure 7). The overall average performance is 47%.

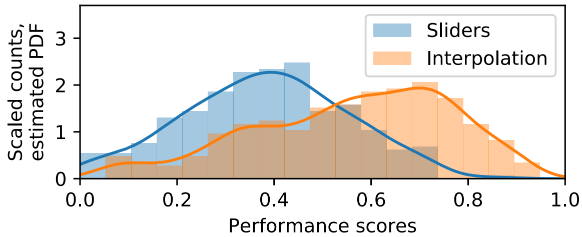

Figure 7. Histograms (and kernel density estimates) of all measured performances, sorted by control interface

However, Figure 6 shows that results actually vary depending on the synthesizer and its associated reference preset. For six of them (IDs 3, 4, 5, 6, 7, 8), performances obtained from the interpolation-based interface are significantly higher (p-values < 0.001, Wilcoxon signed-rank test). Median performance values are around two times higher than values obtained from the sliders-based interface. For three synthesizers (IDs 0, 2, 9), the interpolation seems to slightly improve performances, but results are not significant (p-values are 0.221, 0.055 and 0.122, respectively). Synthesizer 1 presents quite similar results for both interfaces (p-value = 0.923).

4.2 Effect of subjects' expertise level

Figure 8 represents average performances, sorted by their estimated level of expertise on digital sound synthesis and processing. This level was estimated by the subjects themselves during final questions, thanks to extensive descriptions of all levels (from 1 to 4). This figure contains the 28 average user performances obtained from the sliders-based interface, compared to the 28 average performances from interpolation. It also shows the best polynomial fits for these sets of points: a 2nd order fit for sliders data, a 1st order fit for interpolation data. The 2nd order fit for sliders data minimizes the root mean square error and maximizes the R^2 coefficient of determination.

Average performances using the interpolation interface are quite consistent across all expertise levels, while they seem to be slowly rising as the level increases. Experts present the smallest performance difference between the two approaches. Results from the sliders interface show a pronounced performance increase between levels 3 and 4, but also a slight decrease from level 1 to level 2. This is unexpected and will be discussed in subsection 5.4.

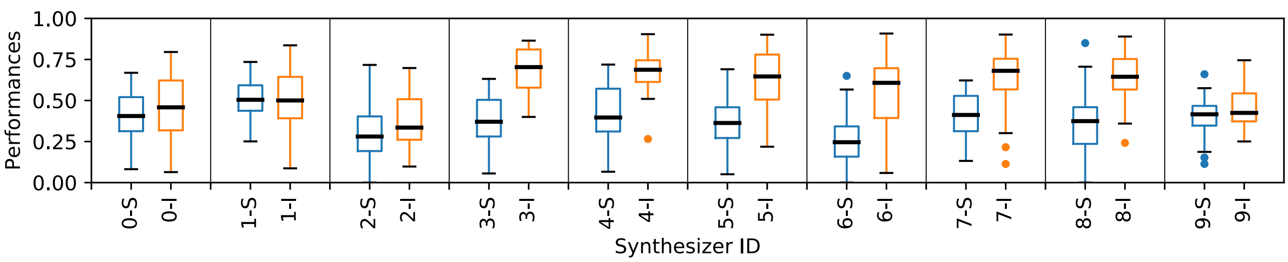

Figure 6. Measured performances of all subjects, sorted by synthesizer ID and interface (S=Sliders, I=Interpolation)

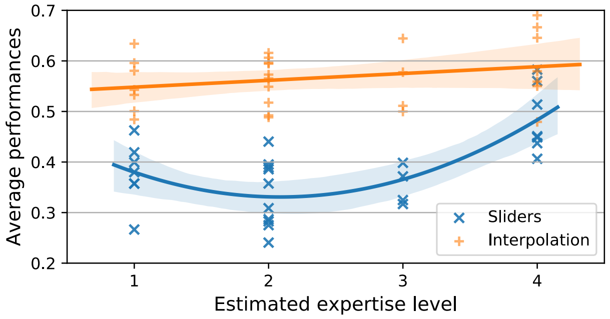

Figure 8. Average user performances, sorted by their self-estimated expertise level about sound synthesis and effects

4.3 Subjects' opinion

4.3.1 General opinion on the experiment

All participants gave a positive feedback on the experiment and described the sounds and interfaces as 'fun' or 'enjoyable'. When asked, many expressed a feeling of being in the 'state of flow' [16]: they felt immersed in their tasks. None of them noticed the audio latency, and the whole system was described as 'reactive'. Thus, their performances should be close to the best they could do.

Some participants were nonetheless a bit frustrated by bad performances displayed on the screen, when they forgot or did not find the preset. Some also reported being a bit stressed by the bar displaying the remaining time. These two elements seem to be downsides of gamification and might have lowered performance results. A few people felt some fatigue at the end.

4.3.2 Sliders vs. interpolation interfaces

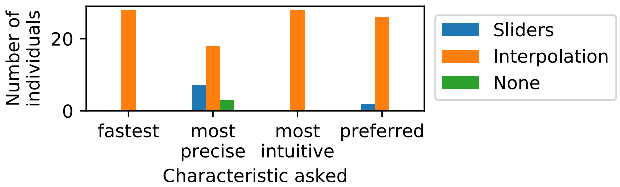

Figure 9. Answers to the questions: Which interface is the […]?

At the end of the experiment, subjects were asked to select their preferred interface depending on four criteria (Figure 9). Their interface of choice was generally the interpolation, but a few users expressed a better feeling for sliders. Seven participants considered the sliders to be the most precise.

5. DISCUSSION

5.1 Performance evaluation function

The function described in subsection 3.2.2 relies on the $(0.55, 87s)$ couple of values, and many others were tried during post-processing. For instance, $(0.50, 140s)$ and $(0.70, 60s)$ give the same 47% overall average performance, but do not significantly change comparative results from section 4.2.

The $(0.41, +\infty)$ couple of values evaluates only the error, with the same 47% overall average score. It does not significantly change results either. The $(+\infty, 36s)$ couple of values evaluates only the speed, with a 47% average score as well. This evaluation leads to differences for synthesizers 0 and 9 only: the interpolation method shows a significant improvement.

However, these two last couples of values do not properly evaluate the task because participants were explicitly told to give an accurate and fast answer. For detailed results about all the different evaluations, please refer to the provided data and Python scripts (section 10).

5.2 True holistic/analytic representations?

One might rightfully ask whether the sliders- and interpolation-based interfaces are truly analytic and holistic, respectively. About the sliders, all subjects easily understood during the trials that each slider has its own effect, independent from the others. This corresponds to an analytic situation.

The question is more complex about the interpolation. Thanks to the complexity of presented sounds, most people did not realize that each preset consisted in one parameter at a 100% value, and three parameters at 0%. They were then navigating between sound presets, which is a holistic cognitive mode.

However, several experts reported understanding a link between presets and some parameters (about some synths, not all of them). Some of them were then trying to think analytically about the holistic interpolation, maybe because it was more usual and natural to them. This might explain why performances with both methods are quite similar for experts (Figure 8) and indicates that the polygon-based interface was not 100% holistic for all participants. Nonetheless, all subjects (experts included) had to navigate in-between the shapes of the interpolation view at some point. Thus, a pure analytical thinking was probably not possible. The interpolation is therefore considered more holistic than analytic, even for level-4 participants.

5.3 Holistic vs. analytic comparison

Results from Figure 7 and Figure 6 show a general performance improvement for the holistic approach. The analytic method showed no clear improvement over the other one, which confirms earlier studies [8]. It is also coherent with Cowan's "magical 4" [2] law: the task of manipulating four independent sliders tends to saturate our AWM capacity, while the interpolation cursor might be a complex but single item. This reasoning is true as long as participants actually use a holistic cognitive mode when playing with the interpolation cursor.

This general improvement was nonetheless not obvious. For example, in a very general context, Nisbett et al. [17] mention that Western societies tend to be more analytical while east-Asian societies adopt a more holistic approach. Not all people are prone to a more holistic thinking.

From the participants' point of view, the holistic control was clearly perceived as the fastest and the most intuitive. It was in general considered more precise and was preferred by a large majority of individuals. However, this preference was certainly influenced by better performances: people tend to like more what they succeed at. In a different experiment, the analytic approach might be preferred if it would give better scores.

A major downside of the holistic approach is the time needed to prepare presets. Because this task had been fulfilled by the authors, this inconvenience does not influence opinion results.

5.4 Expertise-performance relations

On Figure 8, the general and progressive increase of performance seems quite natural. The more experienced an individual is, the more likely he or she is to identify sound characteristics, differences and similarities. That said, it is very interesting to observe that the holistic interface allows non-experts participants to perform almost as well as experts.

The slider-based performance rise between levels 2 and 4 is not surprising either, because amateurs and professionals are used to this common kind of analytic interfaces. The unforeseen result is the rather good performance of level-1 subjects using sliders. Thanks to the performance evaluation function – which gives a 0.0 score for a 0.55 error, see subsubsection 3.2.2 – this cannot come from random answers (the "beginner's luck").

This interesting phenomenon might come from their total lack of analytic training about sound and music. By combining measured data to remarks of participants, we speculate that it forces these individuals into some kind of intuitive exploration of sound spaces, which eventually gives better results than a pure analytic exploration. The lower performance of level-2 subjects might come from a desire to fully analyze all sound characteristics, without having the training to do so. Their AWM might reach its maximum capacity, which causes a loss of auditory traces of the reference sound and leads to incorrect answered presets.

This speculation of course needs further research to be confirmed. The fit curves presented on Figure 8 requires more data to become really meaningful and usable, because the orders of the best polynomial fits could change.

6. CONCLUSION

This comparative study presented measurements of user performances for preset search tasks. Twenty-eight individuals had to listen to sound loops played from synthesizers and effects, memorize them, then search for the values of four parameters of the sound synthesis process. The search tasks were carried out on two different controllers, based on usual sliders (analytic) or based on graphical interpolations between polygon shapes (holistic). These two representations were presented on the same low-latency touch app MIEM Play, developed by the authors.

User performances were computed from the time they needed to finish the search task, and from the parametric distance between the reference and answered values. Results show that the holistic approach led to much better performances for 60% of the ten sounds presented, and similar performances for the remaining 40%. Links to anonymous recorded data and the OSC-controller touch app are available in section 10.

Moreover, average performances were sorted by participants' expertise in sound synthesis and processing. As expected, the more experienced users generally got better scores. However, the holistic approach allowed neophytes to get results very close to experts' performances. An interesting variation was observed about the least experienced users using analytic interfaces: they did not get the lowest scores. These observed trends, however, require a larger set of data to be confirmed.

This experiment was entirely based on presets made of four parameters. This figure is widely accepted as the approximative number of items simultaneously actively manipulated in our AWM, but it is currently being questioned. Thus, some other analytic-holistic comparative studies are planned in order to obtain data about higher numbers of parameters. The touch app used here allows free-form representation of presets, so it can also be employed to formally compare different holistic interpolation-based graphical approaches.

7. ACKNOWLEDGMENTS

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8. COMPLIANCE WITH ETHICAL STANDARDS

This research was funded by IRISIB, a public research institute. All participants read and validated a digital consent form, informing them of the anonymous usage of stored data for scientific purposes only.

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10. DATA AND TOUCH APP

The MIEM Play app is open-source and freely available on app stores (https://miem.laras.be). Anonymous experiment data and Python processing scripts are available at:
https://github.com/gwendal-le-vaillant/MIEM_Experiments