





Yahp!: Yet Another Haptic Probe

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Abstract: Characterizing the relationship between vibratory stimuli and user responses is a complex challenge due to varying skin sensitivity across body areas and the onset of stimulus saturation. Achieving an optimal balance between body location, actuator types, and haptic cues is often a demanding and error-prone process. This paper presents Yahp! (Yet Another Haptic Probe), an open-source tool developed through a collaboration between the National University of La Plata and Stream S.A. to systematically design and execute user perception tests for industrial haptic alerts. Yahp! facilitates the evaluation of actuator settings and body locations through a modular architecture consisting of formal experiment definitions, a results database, a mobile trial director, and a generic haptic device utilizing a low-level messaging protocol. To demonstrate the tool’s utility, we present two experiments focusing on haptic bracelets and sleeves. Our preliminary results indicate that while 10% vibration intensity is consistently below the detection threshold, higher intensities are reliably perceived within an average of 3.5 seconds. Furthermore, the studies revealed significant detectability asymmetries during intensity transitions and confirmed the impact of sensory saturation on cue recognition. These findings suggest that Yahp! is an effective platform for defining the symbolic language of haptic interfaces in real-world applications. .

1 INTRODUCTION

The integration of haptic feedback is becoming indispensable in Human-Computer Interaction (HCI), particularly for systems requiring real-time, unobtrusive alerts. When a haptic device produces multiple stimuli, the interaction with the user creates a symbolic language (MacLean et al., 2015). The effectiveness of this language depends on the user’s ability to perceive and differentiate between individual symbols (Bassano, 2020).

A joint R&D project by the Universidad Nacional de La Plata and Stream S.A. aims to define specifications for a wearable industrial device that uses haptic cues for warnings and alerts. This project seeks to prototype a simple haptic device using affordable, off-the-shelf materials capable of communicating a defined set of scenarios. Before deciding on a specific device form factor (e.g., glove, bracelet, or sleeve),

a clear understanding of the available symbols is required. These symbols are dependent on both the haptic actuators used and the body part where the device is placed (Ott et al., 2005).


As the prototype was being developed following a User-Centered Design process, a tool for rapid prototyping was essential. The requirements for such a tool include:


- Rapid reconfiguration of actuator types and quantities.;
- Flexible specification of cue generation patterns.;
- Systematic gathering of experimental results.;


Finding no existing tool that met these specific needs for our actuators, we developed Yahp! (Yahp! Development Team, 2024), an open-source tool for designing systematic experiments to collect data on user perception of haptic interactions


1.1 Related Work

Our related work is organized following prior HCI systems and toolkit papers (Greenberg and Buxton,

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2008) (Schneider, 2016).

Psychophysics & Experimental Methods: the work of Jones & Tan (Jones and Tan, 2012) has established robust psychophysical methods for studying tactile sensitivity, thresholds, and saturation effects. It presents well-known methods (thresholds, JNDs, saturation) and explains why careful timing, randomization, and controlled exposure are critical. Tiest & Kappers (Tiest and Kappers, 2009) conducted experiments to investigate how humans perceive the hardness or softness of materials using two primary haptic cues: the force/displacement ratio (kinesthetic information) and surface deformation (tactile or cutaneous information). Our tool was designed to enable the application of the findings from those papers during the prototyping and design of a haptic device or stimulus.

Haptic Languages and Symbol Design: the work of MacLean et al. (MacLean et al., 2015) (MacLean et al., 2017) introduced the notion of a “haptic language” as a foundation for communication through touch in human–computer interaction. Rather than treating haptics as a direct simulation of physical forces, the authors frame it as a symbolic and expressive medium with its own grammar and design principles. Our tool was designed to enable the evaluation of the effectiveness of haptic languages through a systematic series of experiments and user evaluations.

Toolkits and Platforms for Haptic Prototyping: the work of Schneider (Schneider, 2016) argues for standardized tools to accelerate the development of haptic interactions. Bordegoni et al. (Bordegoni and Cugini, 2006) presented a system for modeling industrial products based on haptic technology. It exemplifies haptic prototyping in design, which often requires custom hardware and lab-specific systems. Our tool was designed as an open-source project with the hope of handling different haptic actuators, making it possible to systematically test each before it can be integrated on a given prototype.

Wearable and Multimodal Experimental Frameworks: the work of Janaka et al. (Janaka et al., 2024) presents TOM (The Other Me). It is an architecture developed to facilitate the rapid creation and analysis of wearable intelligent assistive applications, employing a client-server model to manage the limited computational resources of wearable devices. TOM is explicitly designed to support multimodal interactions (visual, auditory, and haptic). It focuses on applications rather than controlled psychophysics experiments. Hirao (Hirao and Yoshida, 2024) studied

the vibration sensitivity of body areas that come into contact with the seat in the automobile industry. This research provides a crucial starting point by mapping perceptual thresholds. Our tool is a complement to TOM, as its main value is in the evaluation of specific haptic actuators, and it is closely related to the tool presented by Hirao, but it is intended to support different kinds of haptic actuators and to be used with devices that can rest on top of different parts of the body.

2 YAHP! (YET ANOTHER HAPTIC PROBE)

Yahp! is an open-source tool for designing systematic experiments to collect user perception data on haptic cues. This process requires defining experiments and user trials, supported by a dedicated haptic device

2.1 Architecture

Yahp! is composed of four elements: Experiment Definitions, Trial Results, Trial Director, and the Actuator’s Platform. Figure 1 shows the overall architecture of Yahp!.

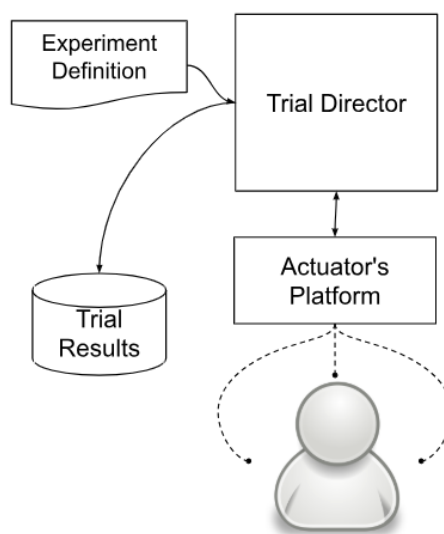


Figure 1: Overall Architecture

One Experiment Definition is used by the Trial Director to proceed with each Trial. The Trial Director configures and commands the Actuator’s Platform to initiate and terminate each haptic cue in the trial. A concrete setting of the Actuator’s Platform is a device; for example, a simple experiment can use only a coin vibrator actuator (Eccentric Rotating Mass), while another experiment can combine a coin vibrator and an

LRA (Linear Resonant Actuator). The Trial Director is a mobile application that is intended to be used by the subject or an assistant conducting the Trial. The Trial Director gets feedback by its user (the subject or the assistant) and stores the results on a Trial Results database.

2.2 Experiments & Trials

Yahp! defines an Experiment by a finite set of stages and the transitions among those transitions. Each Experiment has only one initial stage and one final stage, as mentioned before, the Trial Director takes one Experiment Definition to run a user Trial so that at any given time, exactly one Stage will be active. Table 1 shows the available Stages. The set of Stages and Transitions can be combined to create adaptive experiments (Bakshy et al., 2018), although such cases are outside the scope of this paper.

Table 1: Available stages.

Confirm	It remains until the user acknowledges, at which point it triggers the next fixed transition.
Delay	It holds for a given period and triggers the next transition.
Wait	It awaits the user’s simple feedback. It has a deadline after which it triggers a transition to the next Stage.
Feedback	It awaits the user’s non-trivial feedback. Different transitions can be set for each expected condition.

Although the definition of Stage is simple, the combination of haptic cues and stages produces a wide range of possibilities. For example, presenting a user with an increasing level of vibration while displaying a Wait widget enables the device to register the vibration level.

2.3 Trial Director

The Trial Director is a mobile application that runs a given Experiment Definition. The application defines a set of widgets corresponding to each possible stage of the experiment. It displays the appropriate widget, sends commands to a connected Actuator’s Platform (the device), and stores the results in a database. Table 2 shows the structure of a Trial result.

The Director connects to the device via PoMA (Balaguer and Gutierrez, 2026), a lowlevel messaging protocol that enables device configuration and the transmission of haptic commands. For example, the Director must specify to the device which ports

Table 2: Trial Event Structure.

name	“EXPERIMENT_ABORT” “EXPERIMENT_ADVANCE” “EXPERIMENT_FINISH” “EXPERIMENT_RESET” “EXPERIMENT_START” “POMA_COMMAND” “STAGE_RESULT” “TRIAL_ENV”
timestamp	DATETIME
extra.result	“FEEDBACK_YES” “TIMEOUT”
extra.stageId	stage_id
extra.comd	POMA_COMMAND

are used in a given trial and, for each stage, the required vibration intensities. The Director keeps a log of events generated during a Trial, stored in a non-relational database. Table 2 shows the structure of the entries. The entry’s name describes the type of event, except for those related to a given experiment (starting, aborting, resetting, etc), there are also entries for setting the parameters for a trial (“TRIAL_ENV”), and also registering the commands sent to the device (“POMA_COMMAND”). PoMA implementation details are presented in Section 3.3.

2.4 Actuator’s Platform

The Actuator’s Platform is the device that receives commands from the Director and produces the corresponding haptic cue to communicate with the user. Figure 2 shows the prototype. It is based on an ESP32-C6 microcontroller, which features a wide range of components, including WiFi, BLE, a PWM signal generator, I2C, and ADC, among others.

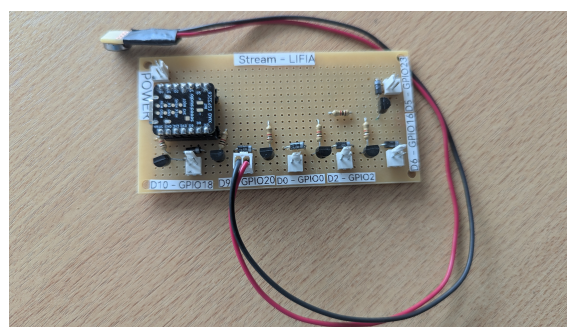


Figure 2: Example JPG figure

Currently, the firmware is based on ESP-IDF, a FreeRTOS port, but it can also run on other platforms. This microcontroller was selected because it offers a balanced combination of computing power, connectivity, and signal-processing capabilities, making it

suitable for developing prototypes of various haptic devices and sensors. Connecting new actuators requires having a corresponding driver; the first version of the Actuator’s Platform supports PWM based actuators. It is possible to extend the firmware to add drivers for actuators that support common protocols such as one-wire, serial, I2C, SPI, or Modbus.

The current design draws power from the USB connector; battery power will be an option in the near future, once the system’s overall power requirements are evaluated. Ultimately, the device’s goal is to be sufficiently flexible to evaluate different configurations rather than to serve as a final product. The current device firmware version includes the open-source version of PoMA. This protocol could be included on the firmware of other devices to be connected with the Trial Director. In the proposed schema the Trial Director connects to the device which has a register of topics. For each topic, there are two callbacks: one for querying and the other for setting values. PoMA’s API publishes three commands:

- List: it returns a list of available “topics”;
- Read *topic* returns the value obtained by activating the query callback for the given topic.;
- Write *topic* ;value; activates the setting callback for the specified topic and value. It returns the command execution status: ACK or ERROR;

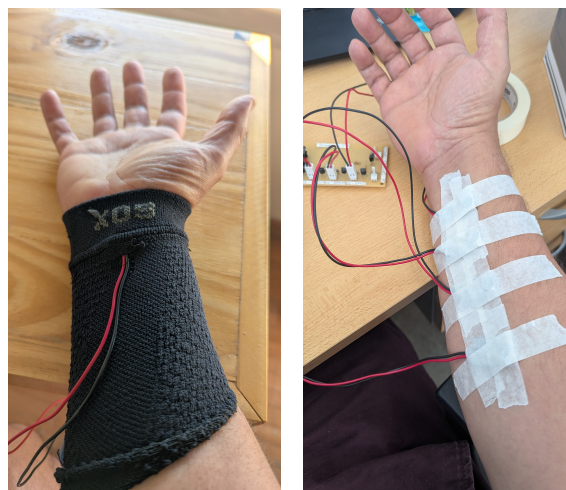
In the case of the Actuator’s Platform there are two registered topics: “enable_motors” and “Intensity” The write command of the “enable_motors” topic sets the ports to be used in the experiment, while the read command returns the current configuration. The write command of the “intensity” topic sets the percentage of vibration of each enabled motor, the list of parameters should match the number of enabled motors. The read command of the “intensity” topic. Although adding new topics requires changes to the firmware, we found that any student or junior C developer can complete the task in less than 4hs.

3 ILLUSTRATIVE EXAMPLES

As noted previously, we began a project to develop the simplest possible haptic device for use in industrial environments. Before we can decide on the type of device (glove, bracelet, sleeve, etc.), we need a clear understanding of the set of symbols available for constructing the working language. We conducted two relatively simple studies to evaluate Yahp! with a small number of subjects. Ultimately, we wanted to understand how to use Yahp! effectively and to gather new requirements for improvements.

3.1 Wearable Prototypes

Yahp! was designed around the idea of quick turn around from conception to prototype. Figure 3 shows a simple wrist prototype with one coin vibration (3a) and an early sleeve prototype with four vibrators that was used to validate a composed cue idea (3b).



(a) Wrist Prototype (b) Sleeve Prototype
Figure 3: Two Prototypes

The studies presented in this paper use the wrist prototype presented in Figure 3a with a outoftheshelf elastic sleeve and one coin vibrator .

3.2 First Study

Given the bracelet with a coin vibration engine located on the inner wrist, the study tried to answer:

RQ 1.1. What vibration intensities are more effective?

RQ 1.2. How much time does a subject require to feel the haptic cue?

PARTICIPANTS . The experiment included five individuals (two females and three males). One male participant was aged 40–50, while the remaining four were aged 20-30. All subjects held college degrees and were proficient in using digital technology.

MECHANICS . The sequence of intensities was fixed: 40-60-10-20-70; each lasted 5 seconds or until the person indicated they felt the vibration. After the designated time (5 seconds), if a subject did not recognize the vibration, the Director records the result as Timeout in the Trial Result database and transitions to the next Stage. Between each intensity step, there were pauses of random duration in the range of 10-15

seconds. The mechanics were put together considering:

- The goal was to evaluate single vibration cues separately.;
- Long sequences of cues stress the subject and degrade her sensitivity.;
- Two consecutive cues must be separated by a reasonable period of silence.;
- Subjects tend to anticipate the next cue; therefore, it is advisable to break patterns and randomize waiting times.

Table 3: First Experiment’s Results.

Vibration %	RQ1.1		RQ1.2
	Success	Fail	Average Time (S)
10	0	5	Timeout
20	5	0	2.36
40	5	0	3.04
60	5	0	3.15
70	5	0	2.54

RESULTS . Table 3 summarizes the answers for RQ1.1 and RQ1.2. The lower vibration (10%) was not recognized, while the other cues took, on average, less than 3.5 seconds. The pause between two consecutive cues was appropriate. An additional silent period would be equally effective but shorter.

3.3 Second Study

Given the bracelet with a coin vibration engine located on the inner wrist, the study tried to answer:

RQ 2.1. Are changes in consecutive vibration intensities recognizable? *RQ 2.2.* Do increasing changes work and decreasing changes?

PARTICIPANTS . The experiment included four individuals (two females and two males). One male participant was aged 40–50, while the remaining three were aged 20–30. All subjects held college degrees and were proficient in using digital technology.

MECHANICS . The intensities were in increments of 10%, from 0% to 100%, and from 100% to 0%. Each increment lasted 10 seconds or until the participant indicated that they perceived the change. After the designated time (10 seconds), if a subject did not

recognize the vibration, the Director records the result as Fail in the Trial Result database and transitions to the next Stage.

The mechanics were put together considering:

- The goal was to evaluate transitions that increase and decrease.;
- Each vibration-cue level was set to a duration sufficient to detect the change. ;
- The exact duration of each cue will be determined in another study.

Table 4: Second Experiment’s Results.

↑	Ok	T	↓	Ok	T
0 → 10	0	Fail	100 → 90	0	Fail
10 → 20	3	3.0	90 → 80	1	5.63
20 → 30	4	2.2	80 → 70	0	Fail
30 → 40	4	1.8	70 → 60	1	5.34
40 → 50	4	1.8	60 → 50	0	Fail
50 → 60	4	1.9	50 → 40	0	Fail
60 → 70	4	2.1	40 → 30	0	Fail
70 → 80	2	2.96	30 → 20	1	5.4
80 → 90	2	2.86	20 → 10	4	2.0
90 → 100	2	3.0	10 → 0	0	Fail

RESULTS. Table 4 summarizes the answers for RQ2.1 and RQ2.2. The first and fourth columns show the transitions in vibration intensity levels. The first column shows ascending transitions, while the fourth column shows descending transitions. The third and sixth columns show the average time required to perceive those transitions; Fail indicates that the transition was not detected. The second and fifth columns show the number of positive detections of the transition. For example, the transition from 0% to 10% failed (Fail) in all cases. The transition from 10% to 20% took an average of 3.05 seconds. The transition from 20% to 10% took an average of 2.02 seconds, and the transition from 60% to 50% failed (Fail) in all cases. One consideration for future studies is the timing of subjects’ exposure to the cues. This time may be detrimental to their ability to perceive vibration.

Considering that a failing result is produced after 10 seconds and taking the average times, a subject presented with the 100% to 90% transition was already exposed to 27.9 seconds, and by the end of the study, that time is 101.4 seconds. This could mean that a haptic device would need to account for the intensity and duration of the generated vibration before it saturates the skin [Bergmann2009].

4 CONCLUSIONS AND FUTURE WORK

This paper presented Yahp!, an open-source tool designed to facilitate the systematic evaluation of haptic stimuli through configurable user trials. Developed to support rapid experimentation with diverse actuator configurations and interaction scenarios, Yahp! serves as a specialized research probe rather than a framework for end-user applications.

The preliminary studies presented demonstrate that Yahp! effectively captures user responses and perception thresholds. The first study confirmed that vibration intensity is a critical factor in detectability: while low-intensity signals (10%) fell consistently below the detection threshold, higher-intensity signals were reliably identified with minimal latency. The second study further explored subtle intensity transitions, revealing significant detectability asymmetries between ascending and descending changes, as well as the impact of prolonged exposure on sensory saturation. While these findings are contextualized within our specific industrial alert project, they serve as a proof-of-concept for Yahp!'s capability to generate reproducible haptic data.

While Yahp! has proven to be a practical and flexible tool for haptic research, several avenues for future work remain. We have identified two primary trajectories:

System Enhancement: We aim to expand support for diverse actuator types and enable integration with third-party haptic devices. In the spirit of open-source development, we hope to foster a community ("innovation happens elsewhere") that will help Yahp! to evolve through collective contribution (Goldman and Gabriel, 2005).

Experimental Expansion: We plan to use Yahp! to map high-sensitivity regions of the arm, profile complex combined vibration cues, and incorporate multimodal tactile stimuli.

These efforts align with our ongoing industrial collaboration and several emerging academic projects at the Universidad Nacional de La Plata, aiming to bridge the gap between haptic hardware and human perception.

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