Haptic Logos: Insight into the Feasibility of Digital Haptic Branding

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Abstract. Companies design brands to invoke distinct perceptions in customers about their products. Currently digital consumers experience the identity of a brand subconsciously through only visual and aural logos. However, the sense of touch is a valuable conduit for establishing strong connections. Although haptic properties (e.g. engrossing textures) are part of a brand's identity in the physical world, the digital world lacks this presence. In this paper we present the concept of creating haptic logos for brands that can be digitally distributed to consumers. To achieve this task, we utilize vibrotactile haptic feedback. Haptic logos for brands were created by varying frequency, waveform and temporal properties resulting in distinct vibration patterns. We conducted two user studies: (1) assignment of appropriate haptic logos to brands by participants, and (2) judgment of the logos based on user experience and emotional response. Based on these studies, the applicability of haptic logos has been discussed.

Keywords: Vibrotactile · Haptic icons · Digital haptic logos
Haptic branding

1 Introduction

Successful companies have created iconic brand identities that capture the user's imagination, providing a unique and pervasive emotional connection [2]. Iconic designs such as the Apple logo, McDonald's golden arches and Intel's unique jingle have helped them become recognizable. To distinguish themselves in a saturated market, companies associate sensory cues to promote their brand. Visual and aural modalities are most commonly used in sensory branding. Visual logos include the combination of colors associated with a brand or other visual aspects [19]. Audio logos involve the distinctive sound made by a brand product or audio jingles associated with a brand [25]. The sense of touch utilizes haptic properties such as textures, hardness and weight to convey the brand message. In the digital world artists and designers only utilize the visual and auditory stimuli for branding. If we can digitize haptic branding, it can add more creative options. Engaging multiple senses always result in a stronger impact and helps

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to retain a brand's message [2]. In this paper, we outline the concept of creating digital haptic logos for brands. We have chosen the vibrotactile modality, as it can transmit emotions [24] and is easily incorporated into existing devices.

Current research is enabling high quality vibrotactile haptics in mobile and wearable devices [7,14,21]. This modality was first developed as a means of information transfer by Tan et al. using a multi-finger tactile pad [22]. Short tactile stimuli presented through vibration which can portray meaningful information are called tactile icons. They were introduced by Brewster et al. [3]. As the main application of these icons was information transfer, Enriquez et al. tested if users were able to uniquely discriminate, identify, and recall different tactile icons [9]. Further research was conducted by Ternes et al. to increase the amount of distinguishable icons by including rhythm [23]. Since then research has been conducted into exploring the effects of different parameters such as amplitude, frequency, and duration on the emotional perception of these icons [24]. The main difference between previous research and our work is that tactile icons are usually used for transferring discrete data. The user learns them consciously and associates each one with certain objective information, e.g., directions for navigation [8] or warning signals [6]. Our research focuses on creating haptic logos that can be associated positively with the perceptual image of a brand.

The world of touch has been extensively explored from a marketing design perspective [2]. Contemporary branding strategies engage this sense by providing rich haptic stimuli to the somatosensory system. Haptic properties of a product such as machined textures, weight, and thermodynamics [10] can be manipulated, resulting in an artifact with affective properties [5]. Researchers have also conducted studies to assess the impact of haptic information on product evaluations [17]. They stated that for certain type of products, if consumers can't use active touch they are inclined to feel frustration and rate the product adversely. The impact of haptic branding on the endowment effect is discussed by Peck et al. in [18]. They report that physically touching an object can enhance our perceived sense of ownership. Recently the Immersion Corporation [1,13] is promoting TouchSense Ads that introduce vibrotactile haptic effects into video advertisement. Although they only provide simple cues e.g., adding basic vibration feedback to footsteps or when an object is hit, they are reporting a huge impact of haptics in advertisement. A marketing report by IPG Media Labs, MAGNA, and immersion [11] stated that the inclusion of vibrotactile sensations has increased brand favorability by 50%.

The main contribution of our research is the introduction of haptic based logos, a novel concept that can enhance the digital perception of an entity e.g. brands, companies etc. To investigate the idea we conducted two user experiments. Binary levels of six different parameters (waveform, frequency, envelope, decay, duration and amplitude) were used to create a set of 64 unique haptic logos. Four different test brands (soft drink, hardware, sports car and fabric) were designed. In the first user experiment the participants rated the association of each haptic logo to the different brands. The best rated logos were then used in the second experiment, where a new group of participants judged them

based on their relevance and value to the test brand. We also provide an insight into how the emotional perceptions of the participants towards the test brands is changed after haptic logos are added. Finally based on the results of both user experiments, a comprehensive design guideline is provided that highlights which parameters to manipulate for a specific kind of brand.

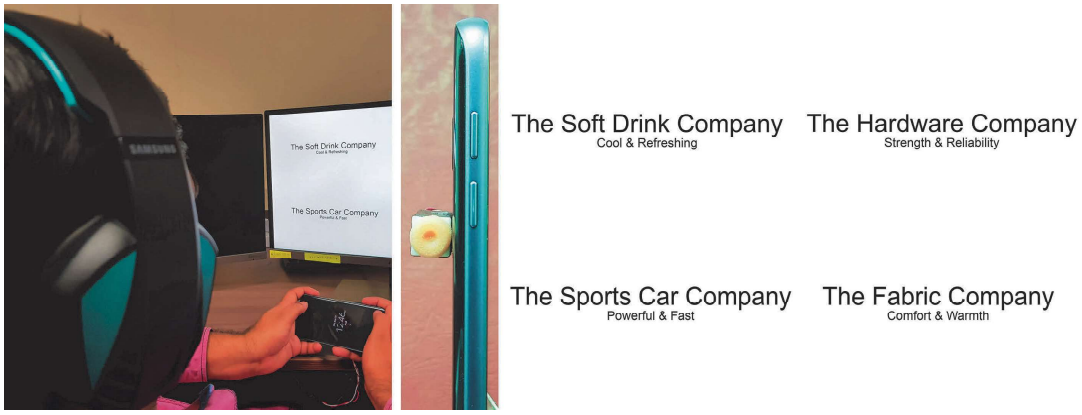

Fig. 1. The left side shows the experimental setup used for both the user studies. The Haptuator connected to the mobile phone is shown in the middle. The right side of the figure shows the collection of text logos (as seen by the participant) used for the test brands

2 User Studies

To validate the concept of haptic logos, two separate studies were carried out. In the first study, a variety of haptic stimuli, in the form of vibrotactile feedback, were produced and provided to participants. Furthermore, four different brands or companies were selected to be used in the study. The users were asked to rate the perceived associativity between the vibration patterns and a given visual logo of the selected brands. As a result of this study, three haptic logos which received the highest rating from the participants were shortlisted for every brand. These three logos were put to further testing in the next user study. The main focus of the second user study was to quantify the association of the haptic logos with the given brands, the emotional effect of the haptic logos, and the user response towards the haptic logos.

2.1 Experiment 1

Since the concept of using vibrotactile feedback as a haptic logo is new, it was required to check that what type of vibrations were acceptable by the users and if these vibrations could portray the identity of a brand to the user. Various kinds of vibrations patterns based on related research were used to find out the correct match for the myriad of brands that exist. In the current study, as a

proof of concept, four everyday brands were considered. Users evaluated all the haptic logos (vibration patterns) against these four brands. As a result, the top three logos for each brand were selected for further testing.

Hardware Setup. Vibration feedback to the users was provided using a haptuator (Mark 2, Tactile labs TL002-09-A [12]) mounted on the back of a cell-phone. This haptuator is widely used in haptics research as its frequency response covers the most sensitive frequency range for humans. Signal to the haptuator was provided through a computer. Figure 1 shows the overall setup of the hardware.

Table 1. The six independent variables used to generate 64 distinct haptic logos. Each variable has two levels

Parameters	Levels	
Waveform	Sine	Sawtooth
Carrier Frequency $\mathbf{F_c}$	100 Hz	300 Hz
Envelope Frequency $\mathbf{F_e}$	4 Hz	32 Hz
Decay	On	Off
Duration	1.5 s	3 s
Amplitude	High	Low

Participants and Stimuli. A total of 15 participants took part in this experiment. They were paid for their participation. Five participants were females and ten were males. They had no prior knowledge about the design of the experiment or haptics in general. They reported no disabilities.

The main stimuli in this experiment were a set of 64 distinct vibrotactile patterns. A wide range of vibrotactile stimuli were created by varying six different parameters/independent variables, namely, the waveform [15], carrier frequency (F_c) [16], envelop frequency (F_e) [16], decay rate [4], duration [4], and amplitude [15]. All these parameters were varied on two levels, which were significantly different from one another, as shown in Table 1. These values were based on related research as cited with each parameter. Another approach for selecting the number of parameters and their levels could be to select fewer parameters and create a higher number of levels for each one of them, but as mentioned earlier, the main aim of the current study was to search and distill out the vibrotactile sensations suited for haptic branding or logos. Therefore, it was decided to widen our search radius so as to cover as wide a range of parameters as possible. For instance, if we vary all the parameters on three levels, the resulting number of vibration patterns would be 729, which is not feasible for such studies.

Furthermore, four characteristically distinct and easily relatable companies or brands were selected to which the haptic logos were to be assigned by the users.

These were *The Soft Drink Company*, *The Hardware Company*, *The Sports Car Company*, and *The Fabric Company*. Their visual logos can be seen in Fig. 1. The visual logos designed for these brands were text-based to keep them neutral and avoid bias due to visual design. These companies were selected because most people have a general perception about such companies, and therefore, assigning logos based on those perceptions would be natural. Furthermore, these perceptions were reinforced by providing the users with a general description of the product and services associated with the brands. For example the fabric company makes clothing while the hardware company makes power-tools etc.

Procedure. One user took part in the experiment at a time. The user was seated on a chair while holding the cell phone in hand. The haptuator was attached to the back of the cell phone. The users wore headphones playing white noise and were instructed not to touch the haptuator directly. All the visual logos were displayed together on a screen in front of the user. The 64 haptic logos were played one by one in a random order using Latin-squares. The participants scored each haptic logo four times i.e. once for each brand. The experimental setup can be seen in Fig. 1.

In this experiment the users were asked to rate the association of each of the 64 haptic logos against each of the four companies. The experiment was designed to get the perceived associativity without modulus. A haptic logo which was perceived to be related to a given company received a higher score, while the

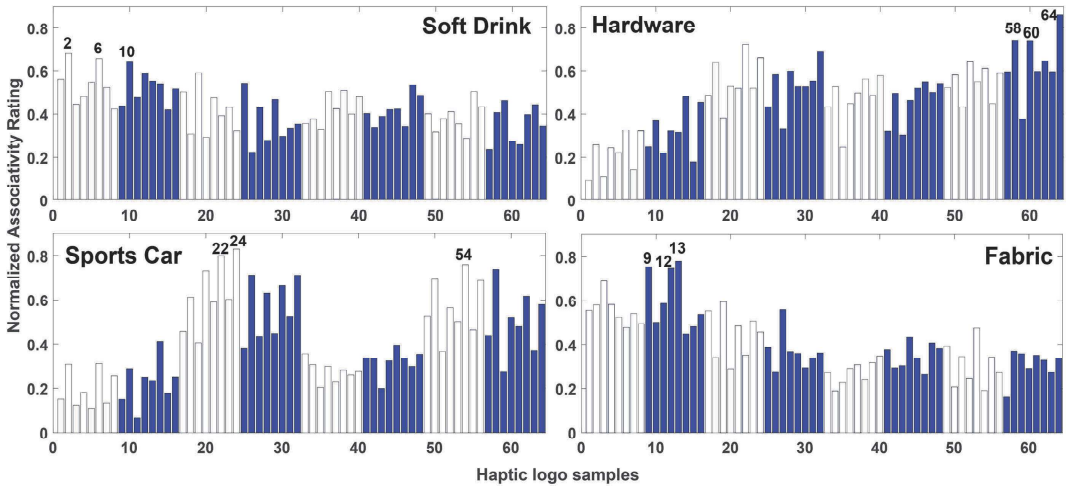

Fig. 2. The results from the associativity rating in experiment one. The independent variables repeat in the following manner: waveform - sine is 1–32, sawtooth is 33–64; F_c - repeats every 16 samples, 1–16 is 100 Hz and 17–32 is 300 Hz and so on; F_e - repeats every 8 samples, 1–8 is 4 Hz and 9–16 is 32 Hz and so on; Decay repeats every 4 samples, 1–4 is on, and 5–8 is off and so on; Duration repeats every two samples, 1–2 is 1.5 s and 3–4 is 3 s and so on; Amplitude repeats after every sample, 1 is low and 2 is high and so on. The color alternates every 8 samples to help in distinguishing the variables. The top three most associated logos for each brand are numerically highlighted

haptic logos which were perceived to be dissociated were assigned a score of zero. There was no upper limit on the associativity score, however, the users were asked to keep the rating scale consistent throughout the experiment. The users were given short breaks during experiment to avoid bias due to fatigue. On average the experiment took 60 min per participant.

Results. The associativity scores for all participants were averaged together after normalizing them from zero to one as shown in Fig. 2. It can be seen that there exist some haptic logos for each of the companies which received high associativity ratings. To find out the specific parameters which mattered the most for each of the brands, multi-way anova tests were carried out for all brands. Table 2 shows the results for the anova tests where some interesting trends can be seen.

In case of the soft drink company, the levels of waveform and carrier frequency showed statistically significantly different means ($p\text{-}value \leqslant 0.01$). This indicates that the users were able to judge the logos on the levels of these parameters easily. On the other hand, if we look at Fig. 2 (Soft Drink), the haptic logos with sine waveform, carrier frequency of 100 Hz, and high amplitude have received high scores. Thus it can be argued that the users associated the vibrations having sine wave and 100 Hz carrier frequency as the most associated with the soft drink brand. The nature of these logos can be described as slow (100 Hz carrier) and smoothly (sine wave) varying vibrations [16].

For the hardware company, waveform, carrier frequency, decay, and amplitude showed significantly different means ($p\text{-}value \leqslant 0.01$). Additionally, from Fig. 2 (Hardware) it is evident that the vibrations having sawtooth wave, 300 Hz carrier frequency, a positive decay, and high amplitude received higher association scores. All these parameters characterize a bumpy and abrupt (sawtooth), rapidly changing (300 Hz carrier) heavy (high amplitude) vibrations [15]. Such a choice of vibrations can be accredited to the general perception of a hardware company in users' minds, which usually is related to heavy machinery and tools.

Users readily associated the logos for sports car company using the carrier frequency and amplitude ($p\text{-}value \leqslant 0.01$). Furthermore, most of the highly rated vibrations for this company carried a carrier frequency of 300 Hz, a high amplitude, and a sine waveform [15,16]. Such vibrations generally characterize smooth (sine wave) rapidly (300 Hz carrier) varying heavy (high amplitude) vibrations, such as usually exuded by a sports car.

The logos for fabric company were associated based on the waveform, carrier frequency, and amplitude of the vibrations. Figure 2 (Fabric) shows that the haptic logos with high association scores for the fabric company contained sine waveform, 100 Hz carrier frequency, and a low amplitude. Generally, fabrics carry a smooth and calm perception, and this characteristic is readily available in the smoothly varying (sine and 100 Hz carrier) and calming (low amplitude) vibrations which received high association scores for the fabric company [24].

The top three logos for each brand which received the highest associativity ratings were selected to be used in the second experiment. These logos were {2, 6, 10} for soft drink, {58, 60, 64} for hardware, {22, 24, 54} for sports car, and {9, 12, 13} for fabric.

Table 2. The result of multi-way anova analysis for the six independent variables against the four test brands. The p-values less then 0.01 are considered as significant. These are highlighted as bold face numbers

	Soft drink	Hardware	Sports Car	Fabric
Waveform	**0.004**	**0**	0.512	**0**
Carrier frequency	**0**	**0**	**0**	**0.0005**
Envelope frequency	0.233	0.029	0.504	0.63
Decay	0.553	**0.0001**	0.02	0.51
Duration	0.832	0.105	0.017	0.256
Amplitude	0.301	**0**	**0**	**0.006**

2.2 Experiment 2

The three best logos selected from the experiment 1 were put to further testing in this experiment. One of the main aims of this experiment was to evaluate the user's perception of the selected logos and check if they are appropriate from a design perspective. For this purpose the users evaluated their excitement, relevance, and the value added by the given logos to the associated brands. They also evaluated how annoying the logos felt. Another aspect of this study was to calculate the change in the emotional response of users due to the haptic logos. Based on these studies the best logos for the given brands were highlighted. The same hardware setup was used in this experiment also.

Participants and Stimuli. A new group of 15 participants, three females and 12 males, took part in this experiment. They were paid for their participation and reported no disabilities. The stimuli for this experiment were a set of 12 haptic logos, the best three for each brand.

Procedure. The physical setup used in the first experiment was used here. This experiment was divided into two parts. In the first part, the user was provided with a questionnaire comprising of four questions, which are generally asked in brand design studies to assess the quality of a logo [11]. The questions were to rate: the relevance of the logo, the value it added to the brand, their level of excitement, and how annoying it felt. The users answered the above questions for each of the three best logos. The process was repeated for all four test brands. The user response was recorded on a seven-point Likert scale. The users were

also asked if they would like to experience haptic logos in case they became a part of mainstream designs. Lastly, they were asked to give candid attributes and comments about the associated haptic logos for each brand. These attributes and comments are considered at their relevant points in the discussion section.

In the second part, the users were asked to provide their emotional response to the given haptic logos. The emotional response was recorded on circumplex of affect which is also known as the valence-arousal (V-A) space [20], a two dimensional space with valence (x-axis) and arousal (y-axis) as the two independent axes. The main aim of this exercise was to examine the effect of haptic logos on the users' pre-conceived emotional perception about the brands. Initially, the users recorded their emotional response on the V-A space for the visual logos of a given test brand. Afterwards, the three best haptic logos for that brand were presented alongside the visual logos, and the users mapped them onto the same V-A space. This process was repeated for all four test brands.

Results. The scores assigned by the participants to the questionnaire answers were averaged out and these are shown in Fig. 3. Based on these scores, the top logo for each of the test brands is highlighted. In case of the soft drink logo 6 was assigned high scores in all questions. However, it was also rated as the most annoying logo. A logo is a representation of a companies perception and thus it should not be annoying. Therefore, logo 6 was discarded. The two other logos (Logo 2, 10) were rated almost equally by the participants across all the questions. Therefore, at this stage we selected both of them to be equally representative of the soft drink brand. Selecting the top logos for hardware (logo 60), fabric (logo 9), and sports car (logo 24) was straightforward as they were rated highly across all the questions by the users.

The emotional response for the 12 haptic logos and the visual logos for the four test brands is provided in Fig. 4. The emotional response for the visual logos of the test brands are located at different positions in the V-A space. This signifies that users had different pre-conceived notions about the given brands.

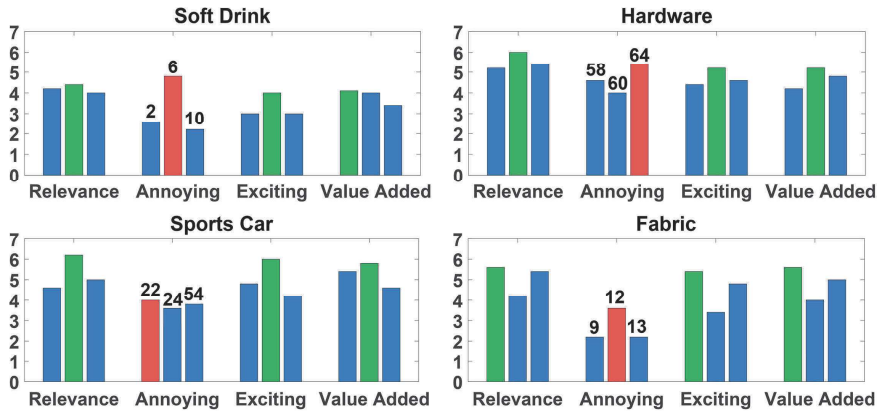

Fig. 3. The results obtained from the questionnaire in the second user experiment

Furthermore, it is also evident that the emotional response for all the best logos shifted positively with the inclusion of haptic logos.

The visual logo for soft drink is located in the high valence, low arousal region. The two best haptic logos for soft drink occupy different locations. The overall valence value is considerably decreased for logo 10. However, logo 2 maintains the valence value and enhances the arousal (more exciting) value considerably. Therefore, it was selected as the best logo for the soft drink brand. The initial perception about the hardware company based on the visual logo occupies a low negative arousal and low negative valence (sad) location in the V-A space. However, all three haptic logos shift the emotional response towards positive valence and high arousal. The emotional response for the visual logo of sports car already lied in the high arousal and high valence state. With the inclusion of the best haptic logo it moved higher on the arousal scale while maintaining its valence value. The visual logo for the fabric company is present in the low negative arousal and positive valence region. The inclusion of haptic logos shifted the emotional state of the users towards low arousal (calmness). The location of best logo is a combination of reasonable arousal and valence values which can represent a fabric brand.

When asked if the participants would like to experience the haptic logos again, twelve out of fifteen participants answered yes and showed high interest. The other three participants mentioned that the repeated logos were somewhat annoying.

3 Discussion

Based on observations from the first study, we can infer some guidelines for designing haptic logos so that they can be easily associated with specific brands. It is evident from Table 2 that Envelope Frequency (F_e), Decay, and Duration,

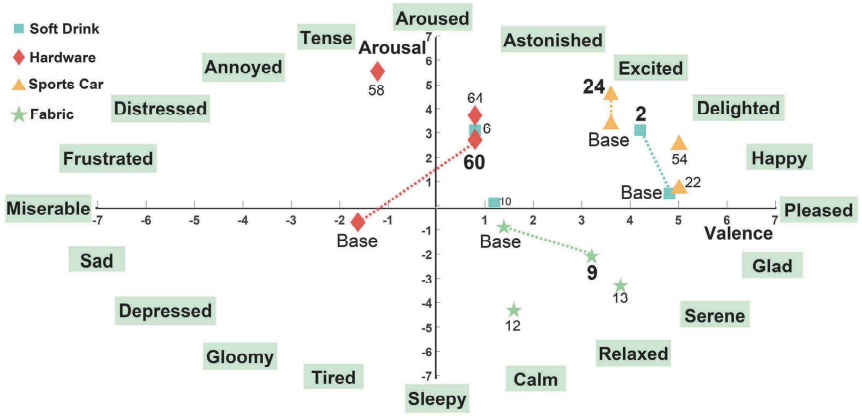

Fig. 4. The Valence-Arousal space showing the emotional rating of the top three logos for each brand. The base indicates visual logo (without haptic feedback) of the given test brands. The best logo for each brand is indicated in boldface numbers. The dotted lines indicate the shift in emotion after experiencing the best haptic logo for that given brand

did not have any clear effect, while the Carrier frequency (F_c), Waveform, and Amplitude parameters appears significant across all or most of the different brands, meaning that the users were easily able to discriminate and associate the different brands with haptic logos based on these parameters. The vibrations having F_c at 100 Hz significantly achieved high associativity ratings with the soft drink and fabric brand, while those having 300 Hz F_c were strongly associated with sports car and hardware brands. Such a behavior shows that the logos for former brands (and other such brands) can be considered as having a calming effect and the latter as more energetic.

Similarly, the waveform parameter appeared to be significant for three out of four brands. The fabric and soft drink brands are perceived to be relaxing and were readily related to the smoothly varying sine wave. The hardware brand which is perceived as harsh was more associated with the abruptly changing sawtooth wave. Some participants attributed the term "disruptive" to the logos associated with the hardware brand. For the sports car brand the effect of waveform was found insignificant. This can be attributed to the fact that each participant had a different perception about sport cars. Some people might relate to the relatively contained sine wave, while others may have preferred the more jarring sawtooth waveform. It can be inferred from the comments of two participants, as one thought that a good car is not "noisy and shaky" while the other mentioned "raw uncontrolled power".

Lastly, the amplitude parameter was also significant across three brands. As expected, the hardware and sports car brands were considered high power brands thus their haptic logos were predominantly high amplitude. On the other hand, fabric received low amplitude rating as it is perceived as a more serene brand. For the soft drink brand the amplitude parameter was rated as insignificant. The reason could be that soft drink provides a nice blend of energy and relaxation. This duality can also be found in the attributes assigned by the users to the soft drink logos, i.e., "relaxing", "fizzy", "popping", etc.

3.1 Design Guidelines

In the current study we tested four brands. We selected hardware and sports car as representatives from the high energy/power brands. To represent the other side of the spectrum we chose the soft drink and fabric brands. When designing logos for high power brands two major parameters, the F_c (around 300 Hz) and amplitude should be kept high. If we wish to increase this perception further, the sawtooth waveform should be specifically employed. The reason is that the sawtooth waveform, due to its abrupt changes, can be more readily associated with this perception. For brands such as fabric and soft drink the sine waveform and a low F_c (around 100 Hz) should be considered. In order to design logos for brands that can be associated to an even more relaxing/calming perception, the amplitude should be kept low.

For the decay parameter, results from the experiments did not establish any significance. However, a question in the second experiment asked the participants to rate how annoying each haptic logo felt. From Fig. 3 it was seen that three

out of the four most annoying logos contained no decay factor. Generally, decay is considered an important aesthetic factor in visual and audio logo designs. In case of haptic logos this design parameter may also play a more vital role. Thus the inclusion of decay should be considered for designing pleasant logos.

In the field of haptics a duration of two seconds is considered effective for haptic icons. However, the duration values of 1.5 and 3 s were adopted from audio logo designs. This limit, according to the anova tests, did not cause any significant effect in our study. The reason could be that haptic icons are for information transfer while we are dealing with perceptual brand identities. Thus, a longer range of duration can be exploited for designing haptic logos.

The aim of this study is to provide high level guidelines for designing haptic logos. These generic guidelines can be manipulated to cover a wider range of brand identities. Brands such as extreme sports, motorcycles, fitness, and construction can emulate the guidelines provided for the sports car and hardware brands. Whereas, brands that wish to exude a calm and relaxed impression can follow the guidelines similar to those provided for fabric and soft drink brands. A few examples of such brands include I.T., perfumes, airlines, furniture, etc. Some brands (such as energy drink, or electronics) may want to utilize the space in between the given test brands. These can extrapolate the given guidelines to achieve their specific requirements. A number of options (rhythms, melody, etc.) still remain unexplored which can be used creatively by artists and designers to craft relevant digital haptic logos.

3.2 Limitation and Future Works

For this research we used an external actuator for providing the haptic logos. The frequency response of this actuator covers the most sensitive frequency region in the human vibrotactile perceptual spectrum. Although, it would be preferred to have such an actuator in off-the-shelf consumer devices, it may take some time for the current technology to catch up.

Another caveat is the relatively limited capacity of vibrotactile haptics as compared to audio and visual. Nevertheless, it still affords additional creative options and can add novelty to a brand. In the future, these logos may be able to utilize other haptic modalities when the technology matures sufficiently.

In the current study, we examined 64 haptic logos across six independent variables with binary levels against four test brands. For a more in depth research the independent variables, their levels, or the number of test brands can be increased.

4 Conclusion

In this research, we introduced the idea of haptic logos, where the identity of a brand can be associated with a digital haptic pattern. The result of two separate user studies provided us with a set of guidelines to design logos in accordance with the perceptual image of a brand. User perception and logo design values

were also taken into consideration while providing the design guidelines. These studies showed that the addition of an associated haptic logo positively influences the emotional response of a user towards a given brand. This also proves that there is scope for the inclusion of haptic logos into mainstream branding design practices. The outcome of this research can play a major role in the world of digital design and will increase the creative options available to the design team. Inclusion of these logos will give a novel edge to early adopting brands. Most visual logos alone cannot completely define the brands' image in the digital domain and adding haptic logos can further clarify their perceptual identity.

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