FEELING THE FEAR: USING HAPTIC FEEDBACK TO MANIPULATE EFFICACY AND COGNITIVE PROCESSING OF A FEAR APPEAL ADVERTISEMENT IN VIRTUAL REALITY

By

Alexander David Lover

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ABSTRACT

With the rise of virtual reality technology, traditional media can be now consumed in a more immersive modality. Furthermore, the inclusion of haptic feedback (i.e., physical responses within the modality) brings a new sense to media that otherwise rely on visual/auditory senses. Traditional media (e.g., advertisements) need to be re-examined as our cognitive processing can potentially change within the new modality and accompanying technology. The present study investigates the role of haptic feedback on the efficacy and cognitive processing of fear appeal advertisements in virtual reality. Participants watched a short, low-threat safe-driving advertisement in virtual reality, feeling haptic feedback be played either at the beginning, middle, or end of the stimulus. Afterwards, participants answered questionnaire items pertaining to their self-reported fear, self-reported perceived threat, attitudes and behaviors/intentions towards safe driving, and their memory of the stimulus. Results provide support for perceived threat having a positive effect on attitudes and behaviors/intentions, but not for memory. There is no support for the positive influence of haptic feedback on perceived threat. Furthermore, there is only support for a significant difference in one section of memory between conditions, but no support for the other sections, potentially due to haptic manipulations or the chosen stimulus. In summary, this study suggests that haptic feedback might work better as an orienting eliciting structural feature for the perceptual resource pool rather than cognitive. Implications are provided as well as directions for future research studies.

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INTRODUCTION

Over the past decade, virtual reality development has skyrocketed. A headset that costs tens of thousands of dollars now can cost as low as $300 (numbers courtesy of vr.space). These headsets aim to provide the most immersive experience possible, and new consumer technologies have been designed to accomplish this. Haptic feedback equipment, for example, brings physical touch to virtual reality. The company bHaptics has designed a series of equipment that brings haptic feedback to various parts of the body (e.g., face, hands, and torso). This haptic feedback strengthens feelings of presence while in virtual reality (García-Valle et al., 2017). Virtual reality has traditionally been used for gaming, barring a few academic scholars that have pushed towards incorporating the tech into the classroom (e.g., Liou & Chang, 2018). However, companies such as Meta have pushed towards implementing the *Metaverse*. Coined by Stephenson (1992), the Metaverse describes a digital reality that mimics our own reality – a parallel universe of sorts, with new forms of media. This new reality has already created advertisements of all sorts, encouraging participants to spend real money on virtual designer clothing for their avatars (Mcdowell, 2023). Apple has now developed their version of a headset, releasing the *Vision Pro*. This headset is rather interesting, as it seems to mimic the functionality of a smartphone. Both cases seem to imply a push away from gaming contexts, now towards media consumption.

Media consumption has typically been viewed as a two-dimensional interaction, the salient example being advertisements. An individual would watch an advertisement on their television, for example, then either accept or reject the message. This becomes rather interesting in fear appeal advertisements, that is, advertisements that aim to elicit cognitive/physiological fear responses in order to gain message acceptance. Frameworks such as the Extended Parallel

Processes Model (Witte, 1992) describe a component of *perceived threat*. This construct is built upon *perceived severity and perceived susceptibility*, describing the perceived danger of the threat and the perceived likelihood of experiencing the threat, respectively. Haptic feedback, a physical response, can potentially strengthen these feelings by tying this strong, physical sensation to the danger described. A fear appeal advertisement that was originally designed for television might now be processed differently in virtual reality, which already is innately immersive. The inclusion of these consumer technologies such as haptic feedback could then potentially strengthen the ads further. This issue motivates the need to re-examine media consumption, now in the context of virtual reality and accompanying tech. The present study aims to shed light on media in virtual reality by incorporating new consumer technology (bringing physical sensations) to existing media artifacts. All of this is done to answer the guiding research question of how haptic feedback affects our cognitive processing of advertisements.

In this paper, I will overview the Limited Capacity Model of Motivated Mediated Message Processing (LC4MP; Lang, 2017; Fisher, 2020) and the Extended Parallel Processing Model (EPPM; Witte, 1992) to provide a theoretical framework. Alongside the EPPM, I will discuss haptic feedback research to supplement the accompanying hypotheses. I will then discuss existing research on fear appeals in virtual reality. Afterwards, I will summarize the hypotheses posited, and outline a series of hypotheses to build a model of the role of haptic feedback in cognitive processing. I conducted a quantitative experiment to test these hypotheses, in which participants watched a safe-driving fear appeal advertisement in virtual reality while feeling haptic feedback at a given time. I will finish by presenting the results found, provide a discussion for the theoretical importance of these results, and their implications for future research. Through this novel study and approach, I hope to expand our theoretical understanding of perceived threat and memory through haptic feedback.

LITERATURE REVIEW

In this section, I will review the Limited Capacity Model of Motivated Mediated Message Processing (LC4MP; Lang, 2017; Fisher, 2020) to explain the cognitive processing component of the study. I will also discuss the literature on fear appeals, using the Extended Parallel Processes Model (EPPM; Witte, 1992) as a framework. I will also describe research on haptic feedback alongside fear appeals to provide holistic justification for the accompanying hypotheses. Afterwards, I will also briefly discuss the relevant research on fear appeals (and more broadly, fear arousal) in virtual reality to provide a practical exigency for the present thesis. Finally, I will summarize the hypotheses posited, and will put forward a hypothesized mediated model that will be tested in the experiment proper.

THE LIMITED CAPACITY MODEL OF MOTIVATED MEDIATED MESSAGE PROCESSING

To best explain our cognitive processing, I will also be using the Limited Capacity Model of Motivated Mediated Message Processing (LC4MP; Lang, 2017; Fisher, 2020). This model assumes that humans have a limited capacity when it comes to processing a message, that we process information through natural motivation, cognitive resource allocation can be measured through psychophysiological reactions, and finally that all communication media is mediated (Lang, 2017; Fisher et al., 2018). Generally speaking, these resources are measured through cognitive measures such as memory, or physiological measures such as heart rate, attention, and secondary-task reaction times (Fisher, 2020). Furthermore, there has been research on the inclusion of a *perceptual* resource pool, a secondary pool of resources that drives perception

(Fisher et al., 2018). This perceptual pool drives visual and audio identification of unique components in the stimulus (Fisher, 2020).

An interesting component of the LC4MP is the *orienting response*, which is simply a physiological and cognitive shift in the viewer to start paying attention to the message. Haptic feedback is assumed to act as an orienting response driver–typically called an orienting eliciting structural feature (OESF)–which cues a viewer to start paying attention to the upcoming content (Fisher, 2020). Haptics could be a sort of dual-purposed OESF, potentially cueing the viewer either for the cognitive pool, perceptual pool, or both. Therefore, the goal with this experiment is to first investigate the cognitive resource pool by using a higher-order function like memory.

The research on the LC4MP has been applied to several different contexts. While this review won't be exhaustive, there are a few key studies to note as they have helped frame and design the general research protocol of the present study. A study found that the structure and content of a health communication message on cancer directly influences how effectively it is encoded, stored, and retrieved at a later time (Lang, 2006). Lang's study prompted the idea that haptic feedback can also act as an added structure to the content, potentially supplementing the narrative or message being shown. In a study pertaining to safe driving public service announcements, results suggested that message processing decreased as the intensity of the advertisement increased - presumably due to the limited capacity of resources we can allocate (Rhodes, 2017). This study has been helpful in two ways. First, it inspired the idea that a safe-driving advertisement, within the framework of the LC4MP, would work well with haptic feedback. If the participant watched a car crash on their television, they would imagine themself in that situation and narrative, similarly to how they would via the Extended Transportation-Imagery Model (Van Laer et al., 2014). However, with the inclusion of haptic feedback, I argue that there is less imagination as there is now a physical response directly tied to the crash, further supporting haptics as a new layer of structure to media. This claim will be further examined in the fear appeals section later in the paper. Rhodes (2017) study also suggests a sort of ceiling effect, where an intense advertisement decreased message processing. This finding is further supported by Plant et al. (2017), which suggests that graphic imagery leads to non-effects in outcomes. These studies help guide the choice for stimulus, as I hope to avoid any ceiling effect where message processing stops. Hence the decision to use a lower-threat advertisement on safe driving.

Using the LC4MP, a number of hypotheses can be made relating to general memory of the advertisement. The primary assumption in the present study is that haptic feedback can act as a forced orienting eliciting structural feature (OESF) of the stimulus. Therefore, the hypotheses relate to specific sections of memory of the advertisement, as I hope to first target the cognitive resource pool. For example, if haptic feedback is played in the middle of the ad, then we should see stronger memory of the *second half* of the advertisement rather than the first, as the haptics would elicit an orienting response for the remainder of the advertisement. This also illustrates the primary manipulation of the study, as participants will either feel haptic feedback at the beginning of the stimulus (an introductory OESF), in the middle right before the car crash of the stimulus (a threat-based OESF), or at the end of the stimulus (a concluding OESF). A general research question is also put forward, as there isn’t enough information to safely hypothesize that the memory of the *second half* of the advertisement will differ between two specific conditions.

Hypothesis 1a: When haptic feedback is used as an *introductory OESF*, memory of the advertisement will be stronger than when haptic feedback is used as a *concluding OESF*.

Hypothesis 1b: When haptic feedback is used as a *threat-based OESF (*i.e., haptics in the middle of the advertisement), memory of the second half of the advertisement (five recall questions on the last 30 seconds of the stimulus) will be stronger than the first half of the advertisement (five recall questions on the first 30 seconds of the stimulus).

RQ: When haptic feedback is used as an *introductory OESF*, how will the participant's memory of the second half of the stimulus compared to when haptic feedback is used as a *threat-based OESF*.

FEAR APPEALS & HAPTICS

I will be discussing both fear appeals and haptics in this section, overviewing the Extended Parallel Processes Model and salient research. The hypotheses view haptic feedback as a manipulation of perceived threat (a prominent component of fear appeals), so it serves well to discuss both simultaneously. While there is extensive research on both subjects individually, there is seemingly no research on the intersection of the two. After covering each topic, I will posit a few relevant hypotheses.

I will be utilizing the *Extended Parallel Processes Model* (EPPM; Witte 1992). The EPPM includes components such as perceived threat and perceived efficacy that ultimately lead to message acceptance or rejection. Perceived threat is the primary focus for the present study and is built upon perceived threat (i.e., how severe the individual perceives the threat to be) and perceived susceptibility (i.e., how likely the individual perceives they could be affected by the threat). In tandem with perceived threat, the model describes fear as an emotion, which acts as a feedback loop for perceived threat (Witte, 1992). Too much fear might lead to fear control processes, ultimately leading to message failure. The model does well to explain why a fear appeal might succeed or otherwise fail (Witte, 1996). Witte (1992) also puts forward the proposition that when the perceived threat of the stimulus is low, no message processing will occur. This proposition has traditionally been tested indirectly through message acceptance measures such as attitudes or behaviors/intentions (Popova, 2012; Lewis et al., 2007). The propositions of the EPPM have seen mixed empirical support (for review, see Popova, 2012), though testing the proposition via direct message processing outcomes like memory should prove to be beneficial. The LC4MP is a useful tool in adding more layers of message processing when testing the outcomes of perceived threat, rather than relying only on attitudinal or behavioral change, hence the inclusion in the present study.

Salient to this thesis, research involving safe driving campaigns are important to note. When attempting to reduce the number of risky driving behaviors, many advertising campaigns have utilized fear appeals as a way to scare viewers into the desired behavior. The EPPM is a beneficial framework to utilize in designing and evaluating these campaigns (Cismaru, 2014), studying contexts such as texting and driving (e.g., Cismaru & Nimegeers, 2017), speeding (e.g., Rhodes, 2017), or drunk driving (e.g., Ngene, 2023). While safe driving as a topic seems to work well with haptic feedback, which specific context to use becomes a focus in choosing the stimulus for this study. The stimulus chosen relates to driving over the speed limit, though this choice was more due to the requirements of the stimulus than the topic itself. For example, a car crash needed to be depicted halfway through the ad to create more even timings between the different haptic feedback for each condition, in which a specific public service announcement about speeding was executed well. Future research should investigate these extra topics as well to further define the boundaries of haptics in cognitive processing.

It serves well to discuss haptic feedback here as well, given the initial claim of haptics influencing perceived threat. While research has been conducted in fear-appeal and fear-arousal fields, seemingly no research has been done investigating the role of physical sensations (i.e., haptic feedback) in fear appeals. This isn't terribly surprising, given traditional media consumption only relies on sight and hearing, not touch. Generally speaking, haptic feedback strongly influences virtual presence and immersion (Kreimeier et al., 2019; Lee & Kim, 2008; García-Valle et al., 2017). In a fear appeal advertisement, viewers typically have to imagine themselves in that situation with the depicted threat, relying on a cognitive effort to make a perception about the danger and likelihood of the threat. I argue that the added feelings of presence and immersion alongside external physical responses to the stimulus content acts as a *realized* threat, which would then elicit stronger senses of susceptibility to the danger, rather than relying on the viewer to imagine themselves in the situation. Given that haptic feedback will be more accessible by these VR companies (as they have control of those environments and accompanying tech), there are far reaching implications within advertising and media consumption.

Therefore, I hypothesize that depending on *when* the haptic feedback is played during the advertisement, there will be an influence on the perceived threat and fear of the stimulus, as haptic feedback could directly influence the perceived severity and perceived susceptibility of the threat.

Hypothesis 2: When haptic feedback is used as a *threat-based orienting eliciting structural feature (OESF)*, participants' perceived threat will be greater than when haptic feedback is used as an *introductory OESF* (H2a), and greater than when haptic feedback is used as *concluding OESF* (H2b).

Hypothesis 3: When haptic feedback is used as a *threat-based OESF*, participant's fear towards the advertisement will be greater than when haptic feedback is used as an *introductory OESF* (H3a), and greater than when haptic feedback is used as a *concluding OESF* (H3b).

I have also put forward a few hypotheses to examine the first proposition of the EPPM more closely. The hypotheses towards attitudes and behaviors/intentions aren't novel like the hypothesis towards memory, though all aim to expand the boundaries of said proposition.

Hypothesis 4: The perceived threat of the advertisement will positively influence the overall attitudes towards safe driving (H4a), behaviors/intentions towards safe driving (H4b), and memory of the advertisement (H4c).

VIRTUAL REALITY & FEAR APPEALS

Within the context of VR, little research has been done investigating fear appeals. One study had participants watch a safe driving ad – which was either a fear appeal or a positively-framed ad – on either a computer screen or in VR. This study suggests that positively framed ads decreased risky driving, which was further supported specifically in VR; however, they did find that when participants watched the fear appeal in VR, it actually *increased* their albeit self-reported risky driving behaviors (Cutello et al., 2021). As discussed previously, Rhodes (2017) study suggested a similar effect. Fear overload is certainly important to avoid in the present study to not rely on individual heuristics. Another study employed a more immersive experience, having participants work through a construction safety program. The experience aimed to elicit fear arousal within the participants, ultimately finding that it improved their attitudes towards workplace safety (Hoang et al., 2021). Using fear to lead viewers to message acceptance is definitely a salient finding, and as it helps support the practical goal of using fear for positive outcomes. The advent of virtual reality headsets designed for media consumption could elicit positive change but needs to be examined carefully.

SUMMARY OF HYPOTHESES AND OVERALL MODEL

Using the literature discussed, I have put forward a number of hypotheses that describe the different interactions of haptic feedback. In summary, I hypothesized that haptic timing (i.e., when in the stimulus haptic is used), there will be an influence on perceived threat, fear, and memory. Through these hypotheses, a general, mediated model detailing the relationship between haptics, perceived threat, attitudes, behaviors/intentions, and memory can be built.

Hypothesis 5: The relationship between haptic timing and attitudes (H5a), behaviors/intentions (H5b), and memory (H5c) will be mediated by the perceived threat of the advertisement.

These hypotheses work together to build a general model illustrating the role of haptic feedback in our cognitive processing of fear appeal advertisements. See figure 1 below for the full hypothesized model. The feedback loop between perceived threat and fear is described explicitly within the EPPM, and the interaction between perceived threat and message outcomes (attitudes, behaviors/intentions, and memory) is based on the first proposition of the EPPM. The present study intends to add another layer to this interaction by incorporating haptic feedback.

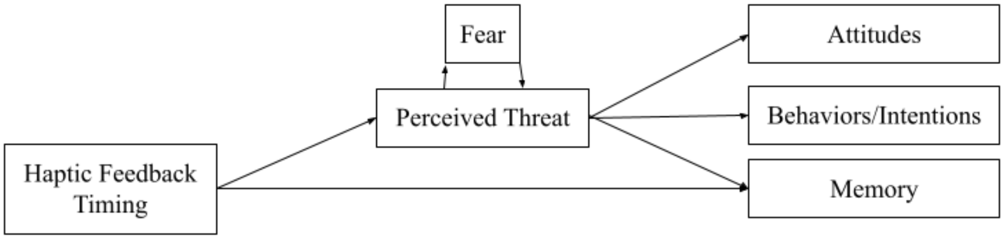

Figure 1 - Proposed model

METHOD

RESEARCH DESIGN AND PARTICIPANTS

Undergraduate students from Michigan State University (N = 101, 46 cisgender men, 53 cisgender women, 2 preferred not to disclose) participated in a between subjects experiment in which they viewed a safe-driving fear appeal advertisement in a virtual reality headset. Participants were randomly assigned to one of three conditions: haptic feedback was either played at the beginning (i.e., an introductory *OESF*), the middle (creating a threat-based *OESF*), or at the end (creating a concluding *OESF*). Afterwards, participants responded to survey items on a 2022 MacBook Pro. On average, the entire study lasted about 10 minutes. Participants ranged from 18 to 32 years old (8 freshmen, 18 sophomores, 52 juniors, 20 seniors, 3 senior+). Within the 101 participants, 71 are white, 10 are Asian and/or Asian American, 8 are black and/or African American, 5 are Hispanic/Latinx, 1 is Middle Eastern, and 6 reported dual ethnicities (3 Hispanic/white, 1 white/Asian, 1 black/white, 1 black/Hispanic). Students were recruited from the SONA participant pool on campus – undergraduates signed up in exchange for credit, which either was counted as a letter grade or as extra credit depending on different classes' syllabuses. 205 time slots were generated, 108 participated in the study for credit (7 students were excluded), around 50 students did not show up for the study, around 40 time slots were not assigned, and 10 participants had to be canceled due to technical issues (Meta servers being down stopped headsets from functioning for a day).

For data analysis, it was determined a priori to exclude any incomplete responses from analysis, low standard deviation of responses (evidence of straight lining), or any *unverifiable* manipulation. The emphasis on *unverifiable* is placed as 23 participants failed the manipulation check, either reporting that they felt the haptic feedback at an unassigned time, *or that they didn't feel any haptic feedback.* The researcher had listened for the haptic feedback during each experiment, so the manipulation for the remaining sample is confirmed and will be tested as if they subconsciously recognized the haptic. However, this does introduce a new data point, which will be called ‘manipulation awareness’, given the interesting interactions with memory and physiological responses. Of the 108 final participants, six were excluded from analysis due to unverified manipulation because of the lack of cross checking with the data sheet, and one participant was excluded for low standard deviation (*SD* < .50 was the cutoff for exclusion), leaving 101 participants for analysis (N = 101).

For data cleaning, prior VR experience included an open-ended question asking how many hours the participant has used VR within the past year, which included response types such as “2 hours”, “2 hours and 30 minutes”, or “7-8 hours”. These responses were changed to “2”, “2.5”, and “7.5” respectively. The median of the range of hours should act as a better representation of the range, rather than relying on either end of the spectrum. In total, there were 15 cases that converted text and minutes to hours, and three cases that converted a range to a median. Participants who self-described as man or woman were grouped with cisgender man or cisgender woman (two instances of this case), respectively, and the individuals who preferred not to disclose their gender was excluded from any gender-based analysis. The sample also was predominantly white, so analysis categorized race/ethnicity by white versus non-white for statistical power.

EQUIPMENT AND STIMULUS

Participants used a Meta Quest 2 headset for the study. This was a factory default headset, using a third-party backstrap for comfort. The stimulus experience was programmed in Unity version 2022.1.23f1. The haptic feedback was administered via the bHaptics TactVisor, a third-party cover that covers the cushion around the user’s eyes. There are four motors evenly placed around the top of the rim of the visor and would play the haptic feedback for 1.5 seconds at the appropriate time (depending on the condition). No controllers were needed from the study, and the researcher controlled the transitions of scenes in the headset on their end. Participants completed the post-test survey on a 2022 Macbook Pro with a 2018 Apple mouse.

Participants viewed an eye test within the headset to determine if the lens were placed respective to the participants' inter-pupillary distance. The main stimulus included a floating movie theater overhanging a simple road. See figure 2 below for a screenshot of the experience. Participants stood at the side of the road, looking across towards the video. The video itself was a minute-long safe-driving public service announcement in which a narrator describes the difference between a car crash at 60 km/hour and 65 km/hour. This stimulus was used in a previous study (Rhodes, 2017) and was deemed low threat. A low-threat stimulus was chosen to avoid a ceiling effect in the interaction.

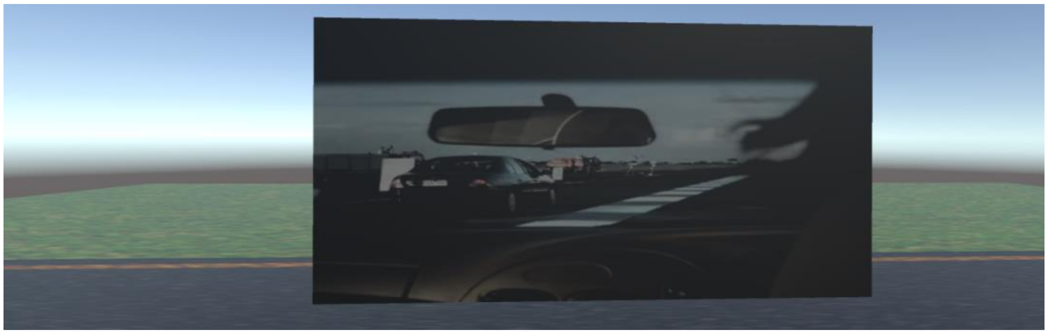

Figure 2 - A screenshot of the primary stimulus

MANIPULATIONS

There are three potential conditions for participants: either haptic feedback was played at the beginning (condition A; n = 34), the middle (condition B; n = 33), or the end (condition C; n = 34), all for 1.5 seconds. The stimulus is exactly 60 seconds long, so this haptic feedback played at the 0 seconds, 30 seconds, or 58.5 seconds marks. 58.5 seconds was chosen as no further information in the stimulus is provided and the haptic feedback bookmarks the end of the stimulus perfectly.

Haptic feedback being played at the beginning is assumed to represent a traditional orienting eliciting structural feature (OESF*)* in which the rumbling cues the participant in to start paying attention (which is labeled as an introductory OESF). Haptic feedback being played in the middle happens right before the car crash scene in the stimulus, which was hypothesized to further increase perceived threat and fear of the stimulus, becoming a structural component of the advertisement alongside the general manipulations of timing. Due to this added structural component, condition B was labeled as a threat-based OESF. Haptic feedback being played at the end (labeled as a concluding OESF) was hypothesized to not have any effect on the measures but was included to provide a comparison to the other conditions.

PROCEDURE

After participants arrived, their anonymous ID was confirmed so course credit was given to the correct individual. After this confirmation, they were instructed to sit at the computer and read through the consent form after silencing their phone. After the consent process, the researcher helped participants put on the headset and adjusted as needed. Participants first viewed an eye test to see if the lens were adjusted properly respective to their inter-pupillary distance. Adjustments were made as needed, followed by a quick tutorial of the haptic feedback. This haptic feedback was played for 1.5 seconds to prepare the participant; this was also chosen so that the self-reported fear item of the survey wasn't exacerbated by the shock and/or surprise of the haptic feedback. The participant was then taken to the side of a virtual road, where they watched the video play above the road. After the stimulus finished playing, the researcher instructed participants to take off their headset, and return to the computer to finish the survey. After completing the survey, participants received their credit.

MEASURES

Participants answered a number of survey items relating to their self-reported fear, perceived threat of risky driving, attitudes towards safe driving, their self-reported behaviors and intentions towards driving safely, their overall memory of the first half and second half of the stimulus, their prior VR experience and their demographic information. Measures will be reported in order of the study procedure.

Self-Reported Fear. A 7-point Likert scale measuring the participant's self-reported fear was adapted from an existing study on fear appeals (Carey & Sarma, 2016; $\alpha = .88$). Participants reported their level of agreement to feeling various emotions such as afraid, panicked, worried, nervous, etc. See Appendix A for all seven items.

Perceived Threat. This measure employed a previous study's 7-point Likert scale (Shi & Smith, 2016) to gauge the participants perceived threat of the stimulus ($\alpha = .62$). This scale includes three items for perceived severity ($\alpha = .60$) and three items for perceived susceptibility ($\alpha = .59$), as per the EPPM. Participants reported their level of agreement on items such as "Getting into a car crash could be fatal for me" for severity and "I'm at risk for getting in a car crash while I'm on the road" for susceptibility. See Appendix B for all six items.

Attitudes. Attitudes towards safe driving were also measured. The scale was adapted from Roskos-Ewoldsen et al. (2004) and included six 7-point semantic differential items. Participants reported their attitudes on spectrums such as negative/positive, unsafe/safe, and boring/exciting ($\alpha = .68$). See Appendix C for a full list of all 6 items.

Behaviors & Intentions. The behaviors/intentions scale from Roskos-Ewoldsen et al. (2004) was also adapted to fit the present study. Participants reported their level of agreement on five items, including "I plan to encourage my friends or family to drive the speed limit" and "I do not intend to drive the speed limit in the near future" (reverse coded; α = .73). See Appendix D for the full list of five items.

Memory. Ten memory recall questions were created for the stimulus. This included a mix of purely visual, purely audial, or both visual/audio questions. Given that the stimulus is exactly 60 seconds, five questions asked about the first 30 seconds of the stimulus, and five questions asked about the last 30 seconds. The goal in splitting the stimulus in half is to test if haptic feedback is strong enough as an *OESF* to target memory of a specific section. For example, I hypothesized that the second half memory will be stronger than the first half if the orienting response happens in the middle. These responses were graded, which created three new variables: first half score (*skewness* = -.54, *kurtosis* = -.17, *mean* = 3.59, *SD* = 1.05), second half score (*skewness* = -.44, *kurtosis* = -.79, *mean* = 3.52, *SD* = 1.20), and total score (*skewness* = -.52, *kurtosis* = -.31, *mean* = 7.12, *SD* = 1.81). See Appendix E for the full list of ten items used in the present study.

Novelty & Demographic Information. Participants ended the survey by reporting their prior VR experience (both in number of times used and a total hour count), and their demographic information. Participants were asked about their gender identity, age, race/ethnicity, and academic year (e.g., freshmen vs. sophomore). The manipulation check of the study was placed here as to not clue the participants into the exact manipulations of the study immediately. This item asked participants when they felt the haptic feedback, which included each of the three conditions, and a '*no haptic felt'* option as well. Gender, race/ethnicity, prior VR experience, their glasses being on or off (if applicable) will all act as potential control variables. For a full list of items, see Appendix F.

RESULTS

In order to test the hypotheses and the research question, a number of statistical tests were conducted. Simple independent samples t-tests were conducted to compare specific sections of memory between the three conditions. Analysis of variance (ANOVA), alongside a Tukey post-hoc test comparing means, was used to compare the means of each condition to the dependent variables. An analysis of covariance (ANCOVA) was also used to better control for gender, race, age, and prior VR experience. Haye's PROCESS Model (2012) helped test the mediation model built from the hypotheses as well. These tests were conducted on SPSS version 29 on a 2022 MacBook Pro.

Of the 101 responses, 23 individuals failed the manipulation check (22.8% of sample). This, of course, prompts the question *why did so many of them fail?* Feeling the haptic, but at the wrong time (n_a = 6 cases, n_b = 5 cases, n_c = 3 cases) is another data point for memory. However, *not feeling any haptic at all* (n_a = 6 cases, n_b = 1 cases, n_c = 2 cases), can act as a data point for physiological measures alongside cognitive memory. The haptic feedback was hypothesized to be a tool to elicit stronger perceived threat (directly relating to fear, per the EPPM). A tutorial was played before the experience proper so as to not affect fear responses due to shock or surprise. The haptic manipulation for each final participant was confirmed, so it serves well to investigate if their awareness of the haptic feedback influenced these cognitive and pseudo-physiological variables in any way. Alongside the test for each hypothesis regarding perceived threat, fear, and memory, I will also be analyzing the relationship using manipulation awareness to further examine this anomaly. For analysis, this variable was broken into three levels – they either felt the haptic at the correct time, felt the haptic at the 'wrong' time, or felt 'no' haptic.

Hypothesis 1a stated that when haptic feedback is played at the beginning of the stimulus (condition A), memory will be stronger than when haptic feedback is played at the end (condition C). The memory recall questionnaire wasn't pre-tested, so each section of memory will be compared here to roughly gauge if the items were too easy or too challenging to complete. There were no significant differences found between the total scores and first half scores, but there was a significant difference in the second half scores ($t(66) = 2.24$, $p < .05$). I confirmed this finding by running an ANCOVA, using haptic timing as the fixed factor, glasses being off or not applicable as a nominal covariate, and second half scores as the dependent variable ($F(2, 65) = 3.94$, $p < .05$, $\eta_p^2 = .11$). The memory recall items are a mix of visual/audio information, so incorporating glasses being taken off for select students is necessary. While this result should be viewed cautiously, there are some potential implications about the nature of haptic feedback in the context of safe driving. However, such implications should be viewed as conjecture until a more thorough pre-test of the items can be conducted. See figure 3 below for differences in second half score memory.

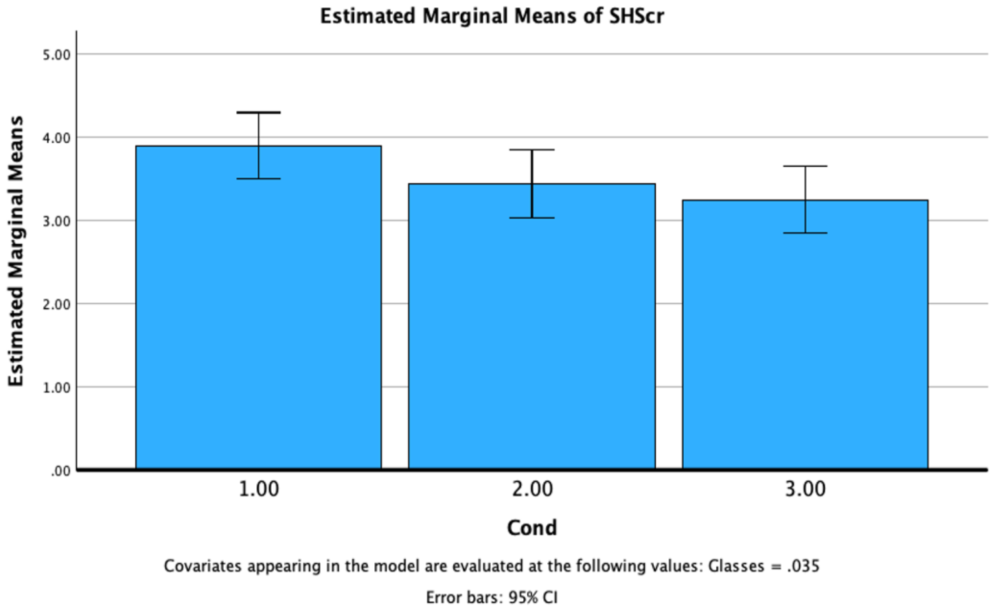

Figure 3 - Differences in Second Half Scores Between Conditions

Hypothesis 1b stated that when haptic feedback is played in the middle, memory of the second half of the stimulus will be stronger than the first half of the stimulus. This hypothesis was made as haptic feedback is generally hypothesized to act as an OESF, which would in turn positively affect memory of the stimulus following the haptic feedback. This relationship is non-significant, *but trends in the opposite direction* – the first half scores (*mean* = 3.71, *SD* = 1.03) are stronger than the second half scores (*mean* = 3.47, *SD* = 1.16) when haptic is played in the middle.

The research question asked how the memory of the second half of the stimulus when haptic feedback is played at an *introductory OESF* (condition A) compared to haptic feedback as a *threat-based OESF* (condition B). This was posed as a research question due to the lack of understanding in *how long* an *OESF* occurs (i.e., if the introductory *OESF* is still in effect when the other hypothetical *OESF* starts). The second half scores for the *introductory OESF* (*mean* = 3.88, *SD* = 1.07) are stronger than the second half scores for the *threat-based OESF* (*mean* = 3.47, *SD* = 1.16), but there was no significant difference found.

Hypothesis 2 detailed that when haptic feedback is used as a *threat-based OESF* (condition B), perceived threat will be greater than when haptic feedback is used as an *introductory OESF* (condition A; H2a) and concluding *OESF* (condition C; H2b). Hypotheses 2a/2b are not supported, as an ANOVA test suggests the differences between condition B (*mean* = 4.33, *SD* = .55), condition A (*mean* = 4.33, *SD* = .47), and condition C (*mean* = 4.20, *SD* = .46) are non-significant ($F(2, 98) = .639$, $p = .53$, $\eta_p^2 = .01$) using haptic timing as a fixed factor and perceived threat as a dependent variable. An ANCOVA test also suggests that when manipulation awareness as a covariate is added to the previous test, no significant differences were found ($F(2, 98) = 1.095$, $p = .36$, $\eta_p^2 = .03$).

Hypothesis 3 detailed that when haptic feedback is used as a threat-based *OESF* (condition B), self-reported fear will be greater than when haptic feedback is used as an introductory *OESF* (condition A; H3a) and concluding *OESF* (condition C; H3b). Hypotheses 3a/3b are not supported, as the ANOVA test suggests that the differences between condition B (*mean* = 2.97, *SD* = .75), condition A (*mean* = 2.90, *SD* = .79), and condition C (*mean* = 2.61, *SD* = .88) are non-significant ($F(2, 98) = 1.68$, $p = .191$, $\eta_p^2 = .03$) using haptic timing as a fixed factor and self-reported fear as a dependent variable. However, an ANCOVA test, when adding manipulation awareness as a covariate, shows results much closer to significance ($F(2, 98) = 2.422$, $p = .07$, $\eta_p^2 = .07$). This approach to significance should be taken with caution, as it might not become significant with better sample size power. These results trend in the hypothesized direction implying that the manipulation awareness is affecting this particular measure.

Hypothesis 4 stated that the perceived threat of the stimulus will positively influence attitudes (H4a), behaviors/intentions (H4b), and memory (H4c). These are broad tests of the first proposition of the EPPM. I further hypothesized that perceived threat acts as a mediating variable between haptic timing and attitudes (H5a), behaviors/intentions (H5b), and memory (H5c). To test all these hypotheses, I used the PROCESS model to conduct a regression analysis for each part of the mediated relationship at once. This hypothesized model was tested as model #4 in SPSS. In this test, haptic timing was used as the independent variable, perceived threat was used at the mediator variable, and the dependent variable was attitudes, behaviors/intentions, and memory, respective to each hypothesis. Hypothesis 4a is supported ($\beta = .196$, $SE = .085$, $p < .05$), alongside hypothesis 4b ($\beta = .23$, $SE = .10$, $p < .05$), providing support for the impact of perceived threat on message outcomes. However, hypothesis 4c is not supported ($\beta = -.03$, $SE = .37$, $p = .93$), suggesting that perceived threat does not influence memory of the advertisement.

An ANCOVA adding manipulation awareness as a covariate further confirms this lack of support. Hypotheses 5a, 5b, and 5c are all unsupported, as there was no significant relationship found between haptic timing and perceived threat, breaking the first part of the mediated relationship ($\beta = .07$, $SE = .10$, $p = .49$).

DISCUSSION

The present study examined the role of haptic feedback in cognitive processing by using the context of fear appeals in virtual reality. To do so, both the Limited Capacity Model of Motivated Mediated Message Processing (LC4MP; Lang, 2017, Fisher, 2020) and the Extended Parallel Processes Model (EPPM; Witte, 1992) were used to provide a theoretical framework. The study had participants view a short safe-driving advertisement in virtual reality, and felt haptic feedback at the beginning, middle, or end of the video. Afterwards, they responded to items measuring their fear, perceived threat, attitudes towards safe driving, behaviors/intentions towards safe driving, and memory of the stimulus. Consistent with previous research, perceived threat was found to affect attitudes, behaviors, and intentions towards safe driving (Popova 2012; Lewis et al., 2007). However, the timing of haptic feedback was not found to have any significant effect on the perceived threat of the advertisement. Haptic timing only showed significant differences in memory of the second half of the stimulus, not the first half, nor the entire stimulus together.

An interesting finding of this study was the variable *manipulation awareness*. This new data point was created as 23 of the 101 participants had reported feeling haptic at an otherwise unassigned time. For example, some participants reported that they felt the haptic feedback play during the middle of the advertisement, when their random condition assignment has haptic feedback playing at the end of the advertisement. The researcher verified the manipulation during each experiment, so the data was treated as the manipulations being correct and subconscious, while 'manipulation awareness' became another variable to explore in the data. While manipulation awareness didn't have a significant effect on memory, it drastically increased the differences in self-reported fear ($p = .07$ rather than the initial $p = .191$). The tutorial sequence exists to get the participant used to the haptic feedback, rather than the shock or surprise affecting their levels of fear. However, this shift might suggest that the tutorial did not achieve the desired effect. Therefore, future iterations of the experiment should refine the tutorial further, potentially adding repeated exposures, or a longer break between the tutorial and the experience proper. Failing to remember the manipulation timing is indicative of both memory and physical feelings, which is salient to the nature of this study, so it is worth exploring further.

The research question was placed in lieu of a hypothesis as there is not a strong understanding in how long an orienting response occurs. The second half scores being stronger in the first condition (haptic being used as an introductory OESF) compared to the second condition (haptics being used as a threat-based OESF) isn't terribly surprising, as both conditions aim to elicit an orienting response to the remainder of the stimulus. However, the first hypothesis (H1b) becomes a rather interesting comparison to the research question. Hypothesis 1b states that when haptic feedback is used in the middle of the advertisement (condition B; threat-based OESF), memory of the second half of the ad would be stronger than memory of the first half of the ad. This hypothesis was an outcome of haptic feedback being viewed as a stronger OESF, which would in turn cue the participant to pay attention to the remainder of the stimulus. Not only was this hypothesis not supported, but data trended in the opposite direction (i.e., first half scores being stronger than second half). This finding is presumably due to the innate OESF that is present within the stimulus already, excluding any presence of haptic feedback. Repeated exposure to OESFs were found to diminish any effects (Fisher, 2020), so although haptic feedback is seen as a stronger OESF, that could explain the results seen here.

There are a few explanations for the unsupported hypotheses. The first proposition of the EPPM states that when perceived threat is low, no message processing will occur. This was traditionally measured through message acceptance measures like attitudes and behaviors/intentions (Popova, 2012). While perceived threat was found to positively affect attitudes and behaviors/intentions, it is plausible that perceived threat was still low enough to halt all forms of direct message processing like memory storage and recall. This indicates a potential floor effect to avoid in future research. It is also possible that the current study isn't using an optimal configuration of haptic feedback. A longer duration of haptic feedback (e.g., 3 seconds instead of 1.5 seconds), a different location of haptic feedback (e.g., on chest rather than face), or repeated exposure to haptic feedback (e.g., played consistently through the ad rather than once) all might have different effects on perceived severity and perceived susceptibility. While repeated OESFs diminish effects of processing (Fisher, 2020), the potential increases to perceived threat could mitigate this. Given that the stimulus was low threat innately, it seems that we have hit a floor effect with the hypotheses regarding haptic timing, perceived threat, and direct message processing outcomes. While haptic feedback is viewed as a tool for eliciting orienting responses, it's entirely plausible that haptic feedback *consumes available resources*, which would then run into the same issue in halting message processing. A secondary-task reaction time would help illustrate the consumption and distribution of available resources to examine this claim (Fisher, 2020).

Haptic feedback might also work better as the type of orienting eliciting structural feature (OESF) that would prime attention and secondary-task reaction times, rather than memory. The perceptual resource pool of the LC4MP is fairly subconscious (Fisher et al., 2018), further suggesting that haptic feedback might be better aligned with that pool of resources given the differences in manipulation awareness. However, that claim will remain conjectured until a full study including physiological measures, measures of attention, and secondary-task reaction times is conducted. While some support was found in significant differences in sections of memory, other sections trended in the *opposite* direction from the hypotheses. This could be attributed to poor memory recall items, as the entire quiz was fairly left skewed.

LIMITATIONS

There are limitations in this study that should be addressed. A power analysis indicated that 120 participants were needed for the sample size (per the effect size of the LC4MP). Therefore, the final sample size of N = 101 was insufficient for proper analysis. The participant recruitment issues posed to be a challenge, so the hypotheses that approached significance could have potentially been swayed. The decision to group participants into white versus non-white in race-based analyses is not ideal either, as it is rather reductionist in identifying differences.

The lack of physiological measures such as heart rate, and more physical measures such as attention or secondary-task reaction times also is a prominent limitation of the present thesis. The unsupported hypotheses regarding memory suggest that haptic feedback might work as a manipulation for the perceptual resource pool, influencing measures like secondary-task reaction times more than cognitive memory. Physiological measures like heart rate would determine if haptic feedback is eliciting an orienting response *at all* (Fisher, 2020). The low reliability of the perceived threat also is a limitation, as the general hypothesized model relies on perceived threat as a mediation between haptic timing and message processing outcomes.

FUTURE WORK

Future iterations of this research should aim to include a number of extra measures. Measuring attention to the content and secondary-task reaction times would help illuminate the perceptual resource pool of the LC4MP (Fisher et al., 2018; Fisher et al., 2019). It is possible that haptic feedback works better to prepare these types of responses rather than purely cognitive measures. Furthermore, measuring physiological responses such as heart rate and skin conductance will help determine if haptic feedback is eliciting an orienting response *at all* (Fisher, 2020). These added measures should better gauge the cognitive resource pool capacity, allocation, and distribution.

A pre-test of the stimulus, perceived threat, and memory recall questionnaire should also be conducted. Such a pre-test would provide a potential comparison group of no haptic, no virtual reality to see if the *presence* of haptic feedback is influencing perceived threat or memory in the next study proper. A pre-test can also help refine the memory recall questionnaire to create a normal distribution in the scores, rather than the current left skewed data, and help create a higher reliability scale for measuring perceived threat. A higher threat stimulus, with similar criteria to the current video, should also be chosen to avoid the floor effect of the first EPPM proposition.

With these added measures, a pre-test conducted to refine memory and perceived threat items, and a higher threat stimulus, a study of similar design could create a more holistic picture to better determine the cause for the manipulation awareness issue of the present thesis. These limitations addressed and implemented can also better test the hypotheses put forward in this thesis, as they will examine both the cognitive and perceptual resource pools.

CONCLUSION

The present study provided more support for the interaction between perceived threat and attitudes/behaviors. While there was no support found for the interaction between the timing of haptic feedback and perceived threat, the anomaly of manipulation awareness begs future research to investigate further as there seems to be some form of manipulation within the perceptual resource pool of the LC4MP. Haptic feedback has promise in influencing perceived threat and cognitive resources but requires more data to answer the question more holistically. This study acts as a preliminary report to inform my future program of research during my doctoral journey.

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APPENDIX A: SELF-REPORT FEAR ITEMS

I found the advertisement to be scary (Carey & Sarma, 2016):

-3 - Strongly Disagree -> 3 Strongly Agree

Please rate the extent to which you felt the following emotions while watching the advertisement (-3 strongly disagree -> 3 strongly agree; Carey & Sarma, 2016):

Afraid
Panicked
Scared
Worried
Nervous
Tense

APPENDIX B: PERCEIVED THREAT ITEMS

Please rate the following beliefs towards safe driving (-3 strongly disagree -> 3 strongly agree; Shi & Smith, 2016)

Car crashes are severely dangerous.
Getting into a car crash could be fatal for me.
Car crashes are harmful to everyone involved.
I am more likely to get into a car crash while speeding.
I’m at risk for getting in a car crash while I’m on the road.
Car crashes are a threat whenever I am driving.

APPENDIX C: ATTITUDES TOWARDS SAFE DRIVING ITEMS

Please rate your views on safe driving in the following scales (Roskos-Ewoldsen et al., 2004):

-3 Negative -> 0 Neutral -> +3 Positive
-3 Worthless -> 0 Neutral -> +3 Valuable
-3 Dislike -> 0 Neutral -> +3 Like
-3 Bad -> 0 Neutral -> +3 Good
-3 Safe -> 0 Neutral -> +3 Unsafe (Reverse Coded)
-3 Boring -> 0 Neutral -> +3 Exciting

APPENDIX D: BEHAVIORS & INTENTIONS TOWARDS SAFE DRIVING ITEMS

Please rate the following statements (-3 strongly disagree -> 3 strongly agree; Roskos-Ewoldsen et al., 2004)

In the next two weeks, I will drive the speed limit while on the road.
I do not intend to drive the speed limit in the near future.
I plan to encourage my friends or family to drive the speed limit.
I am now more motivated to be safe and drive the speed limit.
I will make safe driving decisions a habit of mine.

APPENDIX E: MEMORY RECALL ITEMS

1. What is the name of the professor that narrated the video?
    - *A. Ian Johnston
    - B. Daniel Smith
    - C. Isaac Brahm
    - D. Oliver Jones
2. What was the difference in speed between the two cars?
    - A. 2 km/hr
    - *B. 5 km/hr
    - C. 8 km/hr
    - D. 10 km/hr
3. What was the color of the two cars shown in the video?
    - A. Red/Gold
    - B. Blue/Silver
    - C. Blue/Black
    - *D. Silver/Black
4. What was the speed of the *black* car initially?
    - A. 55 km/hr
    - B. 50 km/hr
    - C. 70 km/hr
    - *D. 60 km/hr
5. What was in the road ahead of the two cars?
    - *A. A semi-truck passing through
    - B. Pedestrians crossing the street
    - C. A parked car
    - D. A tree fell onto the road

6. In the last 5 meters of breaking, how much speed do you wipe off?
    - *A. Half
    - B. A quarter
    - C. Two thirds
    - D. All of your speed
7. What was the speed of the *silver* car upon collision?
    - A. 0 km/hr
    - B. 10 km/hr
    - *C. 32 km/hr
    - D. 5 km/hr
8. What was the speed of the *black* car upon collision?
    - A. 0 km/hr
    - B. 10 km/hr
    - C. 8 km/hr
    - *D. 5 km/hr
9. What was the difference in speed between the two cars upon collision?
    - *A. 27 km/hr
    - B. 15 km/hr
    - C. 8 km/hr

D. 2 km/hr

10. What was the motto shown at the end of the video?
    - A. Shave off 10
    - B. Don’t speed
    - *C. Wipe off 5
    - D. Texting can wait

APPENDIX F: GENERAL INFORMATION ITEMS

When did you feel the haptic feedback play?

- At the beginning of the ad
- During the middle of the ad
- At the end of the ad
- I didn't feel any haptic feedback

How many times have you used virtual reality in total?

- Never (0 times)
- A few times (1-10)
- More than a few times (11-25)
- A handful of times (25-50)
- Many times (50+)

How many hours have you spent using virtual reality in the past year?

____

What year are you in school?

- Freshman
- Sophomore
- Junior
- Senior
- Senior+
- Graduate Student

What is your gender?

- Cisgender Man
- Cisgender Woman
- Non-binary, Genderqueer, and/or Gender Fluid
- Transgender Man
- Transgender Woman
- Prefer to self describe: _________
- Prefer not to say

What is your ethnicity and racial background?

- Asian and/or Asian American
- Black and/or African American
- Hispanic, Latino, Latina, and/or Latinx
- Indigenous/Native American, Alaska Native, and/or First Nations
- Middle Eastern or Northern African
- Native Hawaiian and/or Other Pacific Islander
- White
- Prefer to self-describe: _________
- Prefer not to say

How old are you?

____