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Technology Name and Celebrity Endorsement Effects of Autonomous Vehicle Promotional Messages: Mechanisms and Moderators

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Abstract

Autonomous vehicles represent an emerging technology with the potential to radically transform everyday life. Yet there is little understanding of how promotional tactics—easy-to-grasp technology labels or pairing the technology with well-known celebrities—influence public perceptions of risk, benefits, and intentions. Therefore, we experimentally tested (N = 721) the effects of technology name and celebrity presence on emotional, cognitive, and behavioral responses to promotional messages. Moreover, we examined how individual differences and attention to news about autonomous vehicles can moderate responses. Results of this exploratory study revealed the importance of affective and cognitive mediators and audience-related moderators in shaping responses.

Keywords

autonomous vehicles, emotion, subjective knowledge, technology, risk

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Autonomous or driverless vehicles (or cars) represent an emerging technology that has the potential to radically transform the everyday lives of people around the world. The Gartner consulting group placed autonomous vehicles at the apex of their 2017 "hype cycle" (Panetta, 2017). Experts estimate that these self-driving cars will be noticeable on U.S. roads by the year 2020 and that by the year 2040, 95% of new vehicles sold will be fully autonomous (Munster, 2017). Despite strong enthusiasm among automotive and technology companies, others argue that more thorough testing and government interventions are essential due to past fatalities and unknown safety issues (Crain, 2016). Journalists have also noted the complexity of safety issues and ethical concerns (Lin, 2014).

In the meantime, the companies working on autonomous vehicle hardware and software are promoting their products to consumers. In October 2017, Intel launched a digital campaign titled "Driving Trust," which featured basketball superstar LeBron James riding in an Intel-powered driverless car, with hopes of lessening the apprehension associated with autonomous vehicles (Jibrell, 2017). At the 2018 CES (formerly known as the Consumer Electronics Show) event, ride-sharing company Lyft, along with its partner Aptiv, debuted a fleet of self-driving BMWs (Etherington, 2018). Many of the featured Lyft riders at CES were celebrities, such as actor Neil Patrick Harris and entrepreneur/television star/NBA owner Mark Cuban (Abt, 2018).

Despite the world-changing predictions hovering around the technology, there has been little research into how this automotive technology is being communicated, or theorizing about the most effective ways to increase public acceptance of it. Much of the academic literature has focused, instead, on the legal and ethical aspects of the technology (Bonnefon, Shariff, & Rahwan, 2016; Collingwood, 2017; Eriksson, 2017; Schoonmaker, 2016). Currently, there is little understanding of how promotional tactics—using easy-to-grasp labels for the technology as well as pairing the technology with well-known celebrities—influence public perceptions and intentions related to autonomous vehicles.

Across events and messages promoting autonomous vehicles, a cacophony of terms are used to refer to autonomous vehicles, including driverless cars and self-driving cars. Others have noted that terminology around this technology often varies across media reports, and that the ambiguity with which the technology is described could affect public acceptance of it (Fraedrich & Lenz, 2016). Theoretically, previous research on public responses to emerging technologies suggests that it is a mix of affective and cognitive mechanisms that determine how audiences will respond to such messages (Lee, Scheufele, & Lewenstein, 2005). Furthermore, the literature on affect-as-risk (Slovic & Peters, 2006; Slovic, Peters, Finucane, & Macgregor, 2005) overlaps with industry research (Hedlund, 2017) suggesting

that emotional responses to autonomous vehicles—are they exciting or scary, or do they just make people curious?—are strongly tied to perceptions of this automotive technology as either beneficial or risky. As such, knowing which features of promotional messages produced by these companies shape emotional and cognitive responses is crucial for understanding public risk perceptions and intentions related to autonomous vehicles.

The purpose of the present investigation is to empirically test the effects of using different name frames (i.e., autonomous vehicles, self-driving cars, or driverless cars) and using celebrity endorsers on audience responses to promotional messages about autonomous vehicles. Furthermore, grounded in the differential susceptibility to media effects model (Valkenburg & Peter, 2013), we want to examine how these promotional messages are interpreted in light of personality differences in audience members, such as a tendency to enjoy novel consumer products or to trust machines over humans. Finally, we seek to assess how attention to previous news coverage of autonomous vehicles may also influence audience responses to promotional messages about these vehicles. There have been several notable accidents, including deaths, involving these technologies (Griggs & Wakabayashi, 2018), and individuals who have paid more attention to news coverage of these events may be more skeptical than others in rating the risks of autonomous vehicle technology. Below, we outline the relevant literature before detailing the methods used to test the role of message content and audience-related factors in shaping public responses to autonomous vehicles.

Mechanisms of Message Effects

Existing literature offers us some conceptual guidance for predicting the psychological mechanisms of the effects of promotional messages about autonomous vehicles. Broadly, the differential susceptibility to media effects model (Valkenburg & Peter, 2013) posits that individuals experience both emotional and cognitive responses to media messages, which in turn shape subsequent media effects. More specifically, in the context of assessing media effects on how risky or beneficial the public views autonomous vehicles, the affect heuristic model provides helpful guidance. This model argues that our affective states are typically the strongest predictors of subsequent risk perceptions (Slovic et al., 2005; Slovic & Peters, 2006). As argued by Slovic, Finucane, Peters, and MacGregor (2004), "People base their judgments of an activity or a technology not only on what they *think* about it but also on what they *feel* about it" (p. 315). Across multiple studies applying this model, Slovic and his colleagues have found that

information featuring high benefits or low risks typically leads to positive affect, which in turn leads to stronger benefit perceptions and weaker risk perceptions. Conversely, information about a lack of benefits or information about high risks typically leads to negative affect, which in turn predicts higher risk perceptions and lower benefit perceptions.

The affect heuristic paradigm is a good fit, conceptually, in the context of studying vehicle communication because vehicles and vehicle use are emotional subjects for many people (Sheller, 2004). Since the 1900s, cars have been associated with the exhilaration of going fast, "joy rides," a sense of discovery and independence, not to mention being a status symbol and indicator of having reached a positive station in life (McCarthy, 2007). Human-computer interaction research has also demonstrated that drivers often experience strong emotions while driving, and that vehicles equipped with the interactive technology to help regulate driver emotions and adequately explain challenging driving situations can improve drivers' experiences with their cars (Harris & Nass, 2011; Nass et al., 2005), including in cars with automated functionalities (Koo et al., 2015).

In a report commissioned by the Governors Highway Safety Association, Hedlund (2017) compiled results from several large surveys on public opinions in the United States and Canada of autonomous vehicles and found emotions to be a common theme: 34% of respondents said the prospect of autonomous vehicles becoming widely used makes them excited, while the majority, 57%, said this prospect makes them worried. Additionally, 32% reported feeling unconcerned about riding in an autonomous vehicle, but two thirds (68%) said they do feel concerned about potentially riding in one. This connection between cars, including autonomous vehicles, and the emotional states of those who use them makes it crucial to analyze emotional responses to automotive messages, too.

When studying how affect and emotion shape risk perceptions, Druckman and McDermott (2008) argued that when studying how affect and emotion shape risk perceptions, it is important to look at specific, discrete emotions even if they are of the same valence because discrete emotions are associated with different core relational themes, associated cognitive appraisals, and action tendencies (Lazarus, 1991; C. A. Smith & Lazarus, 1993). Below, we discuss three discrete emotions that might help explain how promotional materials about autonomous vehicles can influence audiences.

Anxiety is a negatively valenced emotion similar to fear but more existential in nature, whereas fear is associated with an imminent threat (Lazarus, 1991). So (2013) argues that while fear is linked with perceived severity of a negative outcome, anxiety is more closely aligned with uncertainty perceptions. In the context of autonomous vehicles, which many individuals have

yet to see or experience in real life, uncertainty and anxiety responses to messages may be key in shaping risk perceptions and behavioral intentions.

Excitement is a positively valenced emotion that is, in essence, a high-arousal form of future-oriented happiness (Seginer, 2008). Research suggests that future-focused positive emotions help motivate individuals to pursue their goals (Winterich & Haws, 2011). Unlike negative emotions that often motivate avoidance, positive emotions motivate individuals to approach the situation causing them (Fredrickson, 1998). As such, a high-intensity positive emotion like excitement might motivate consumers to want to ride in autonomous vehicles.

Curiosity is a positively valenced emotion that belongs to the so-called knowledge family of emotions because it is associated with the desire to think and learn (Kashdan, 2004). This emotion arises when people appraise a situation as novel and are motivated to learn, explore, and immerse themselves in the topic (Kashdan & Silvia, 2009). Curiosity has also been linked to a desire for science-related information. A January 2018 poll by the Pew Research Center found that 81% of U.S. adults say that curiosity is a reason why they follow news about science, the most cited reason for following science news in the poll (Shearer, 2018). Given that autonomous vehicles are novel to many Americans, promotional messages about the science behind the technology could evoke this emotion, as well. And because curiosity is a positive emotion, like excitement, and promotes exploration, it may lead to enhanced benefit perceptions.

After reviewing the literature on affect-as-risk as well as emotion-specific considerations, we offer two hypotheses:

Hypothesis 1 (H1): Participants who experience stronger anxiety-related emotional reactions will report (a) higher risk perceptions and (b) lower benefit perceptions.

H2: Participants who experience stronger excitement-related and curiosity-related emotional reactions will report (a) lower risk perceptions and (b) higher benefit perceptions.

While emotional responses to messages about emerging technologies are likely crucial for understanding public risk and benefit perceptions, cognitive responses to messages about new technology are also important in determining risk and benefit perceptions. Lee et al. (2005) proposed and tested a model of interactive affective-cognitive effects on public attitudes toward nanotechnology and found that objective knowledge, the cognitive variable in their model, had a weaker effect on attitudes for people who reported strong emotional reactions to the topic of nanotechnology. Across two studies

on public opinion of emerging technologies (carbon nanotubes and genetically modified foods), Druckman and Bolsen (2011) found that factual information about these technologies had no greater influence on opinions than other variables like values and did not make fact-based arguments more persuasive than arguments lacking facts.

As such, it may be more advantageous to assess levels of individual perceived, or subjective, knowledge as compared to their actual knowledge in order to measure the role of cognitive message responses in shaping persuasive outcomes. In an experiment testing the role of subjective knowledge in shaping responses to fear appeals about cancer, Nabi, Roskos-Ewoldsen, and Carpentier (2008) found that participants who reported higher subjective knowledge about cancer were less emotionally affected by the fear appeals (i.e., they reported lower levels of fear). In this study, high levels of subjective knowledge were also associated with lower negative responses to the messages, suggesting an important role for subjective knowledge in shaping both emotional responses and message judgments.

Together, these findings are in line with previous work asserting that objective knowledge gains will not automatically improve attitudes toward science (Sturgis & Allum, 2004). Instead, context and additional factors are also important for shaping perceptions of science-related topics. Specifically, perceptions of both knowledge and emotional motivations are likely strong drivers of subsequent responses to messages, including risk perceptions. Risk theorists argue that risk is a feeling with a cognitive component (Loewenstein, Weber, Hsee, & Welch, 2001), supporting the fact that emotions are central to risk perceptions but that cognitions also matter for risk perceptions and other downstream message evaluations, too. Correspondingly, the above literature on the interplay of affect and cognition in response to messages about emerging technologies leads us to the following hypothesis:

> **H3:** Emotional responses and subjective knowledge will mediate the relationships between frame type and risk/benefit perceptions and outcomes of riding intentions and support for stronger regulations.

Celebrities and Persuasion

When considering potential audience responses to promotional messages about autonomous vehicles, understanding how companies promote these products and testing the effects of those real-world messaging strategies are important too. Research examining the use of celebrity endorsements found that stock values tend to rise when publicly traded companies announce celebrity endorsements, but the costs of securing the endorsements are about

equal to the increased stock value (Ding, Molchanov, & Stork, 2011). However, this analysis by Ding et al. (2011) also found that celebrity endorsements of technology industry products were more profitable than those of other industries, suggesting that stars who back certain products may be an effective marketing strategy for this broad sector. Indeed, technology companies have started using celebrities in their promotion of autonomous vehicles with the explicit intent of trying to ease consumer worries about this technology (Jibrell, 2017).

The literature on the effects of celebrity endorsements in an advertising context finds these strategic messages, on the whole, to be effective marketing tools (Erdogan, 1999). A meta-analysis of celebrity endorsement effects suggests that advertisements and public service announcements featuring celebrities can change audience attitudes but are less likely to change target behavior (Knoll & Matthes, 2017). The audiences' affective and cognitive responses to celebrity endorsements have both been cited as causal explanations of the persuasive effects of endorsements. Fleck, Korchia, and Le Roy (2012) argue that both affective/emotional and cognitive factors are important mechanisms of celebrity endorsement effects on audiences, and as such, both should be studied in this context. These mechanisms of audience responses to celebrity endorsements include immediate emotional responses to messages and cognitive evaluations of the celebrity's expertise or motives (Eisend & Langner, 2010).

A meta-analysis found that celebrity endorsements routinely evoke positive emotions in audiences (Knoll & Matthes, 2017). Brain imaging research has also found that the parts of the brain that process emotional stimuli become more active when individuals see appeals featuring celebrities than when they see appeals featuring equally attractive nonfamous individuals (Stallen et al., 2010). Moreover, these researchers found that the neurological processes associated with implicit memory and attention were *not* central to explaining the persuasive advantage of celebrity appeals, suggesting that the positive emotion associated with celebrities can transfer to the target of a message.

While more research is needed to examine the exact nature of the dynamic interplay of between affect and cognition in determining message effects in general, the weight of the evidence in the celebrity appeals literature suggests that celebrities are particularly good at sparking positive emotional responses, leading to the following hypothesis:

H4: Promotional messages that include celebrities will be associated with (a) greater excitement and (b) greater curiosity, as well as (c) less anxiety than messages without celebrities.

Additionally, it is possible that the use of celebrities will shape subjective knowledge perceptions, too. The meta-analysis of celebrity endorsement effects also found that celebrity endorsements less consistently predict changes in audience cognitions—sometimes they do, sometimes they do not (Knoll & Matthes, 2017). This finding suggests that additional research is needed to understand when and why celebrity endorsements shift cognitive perceptions. If celebrities are familiar entities for audiences (i.e., people feel they are knowledgeable about celebrities), then, this subjective knowledge about the celebrity could cross over to perceptions of the vehicles themselves and lead participants to believe they know more about the vehicles than they really do. This carryover effect, or the transfer of meaning from the celebrity to the product, has been theorized previously in the celebrity endorsement literature and is often cited as one reason why celebrity endorsements can potentially shift product-related cognitions (McCracken, 1989). This line of thinking leads to an additional hypothesis:

H5: Promotional messages that include celebrities will be associated with higher levels of subjective knowledge.

Communication About Autonomous Vehicles

A central issue for communication research about this emerging technology is what to call it. While previous research has found that the language used to describe novel computer software technologies can influence the psychological importance attached by technology adopters to specific beliefs about the technology (Vishwanath, 2009), there has been very little research into the framing of driverless vehicles and associated media effects.

The Senate and House bills related to the technology are a case in point. The House bill (H.R. 3388, which passed by voice vote in September 2017) is titled the "Safely Ensuring Lives Future Deployment and Research in Vehicle Evolution Act." The Senate bill (S. 1885, which passed out of the Committee on Commerce, Science, and Transportation in September 2017 but is now stalled in Senate) is called the "American Vision for Safer Transportation Through Advancement of Revolutionary Technologies Act." So the House went with SELF DRIVE and the Senate with AV START. Self-driving and autonomous have emerged as the leading terms to describe the next generation of vehicle technology, but they are by no means the only labels used.

The major associations supporting development of the technology have also chosen a variety of different naming conventions: Association for *Unmanned* Vehicle Systems International, *Intelligent* Transportation Society

of America, *Self-Driving* Coalition for Safer Streets (italics added). The Society of Automotive Engineers International (2018) identifies six levels of automation: No Automation, Driver Assistance, Partial Automation, High Automation, and Full Automation. Other manufacturers and investors have chosen different euphemisms. Tesla refers only to "auto pilot" driving modes. Uber has its "advanced technologies group." Ford has launched the "Autonomous 2021" program as a main pillar of its "Ford Smart Mobility" plan. General Motors has dubbed its vehicle the "Cruise AV."

Conceptually, the name used to describe autonomous vehicles is important because words like "self" or "driverless" are related to people, and anthropomorphizing vehicles has been associated with greater trust in them (Waytz, Heafner, & Epley, 2014). However, communication research to date has not yet investigated the effects of labeling vehicles, specifically, on subsequent psychological mechanisms of eventual media effects, leading to an initial question:

> **Research Question 1 (RQ1):** What is the relationship between the name frame (autonomous vehicle, driverless, self-driving) and emotional responses as well as subjective knowledge about autonomous vehicles?

Potential Moderators of Message Effects

Message effects researchers generally agree that there are many contextual and individual differences to consider in examining how a message will affect any particular audience member (e.g., Bennett & Iyengar, 2008; Oliver, 2002). When examining the potential effects of promotional messages about autonomous vehicles, both context factors and individual differences will likely shape audiences' emotional responses, subjective knowledge, risk/benefit perceptions, and behavioral intentions. For instance, in describing the affect heuristic, Slovic et al. (2004) argued that "the feelings that become salient in a judgment or decision-making process depend on characteristics of the individual and the task" (p. 315).

This supposition that individual differences and contextual factors could affect audience responses to promotional messages about autonomous vehicles is also supported by the differential susceptibility to media effects model (Valkenburg & Peter, 2013). In this model, dispositional factors, such as personality traits, as well as the larger social context in which the individual is currently situated will affect how they respond to a message.

First, the social context of the message matters. Outside of any promotional advertising messages individuals may see about autonomous vehicles, information about these products can also appear in news media coverage.

The nature of news reporting on autonomous vehicles could very well influence public opinions of it and make it more or less difficult for promotional messages to shape audience attitudes. Recently, Americans have reported hearing "a lot" (35%) or "a little" (59%) about the development of driverless vehicles through national public opinion polls (A. Smith & Anderson, 2017). A majority of these respondents (66%) indicated hearing a mixture of positive and negative reports, which might suggest balanced levels of information being disseminated and contestation related to eventual benefits (A. Smith & Anderson, 2017).

Recently, news coverage of autonomous vehicles has focused on risks of the products. On March 18, 2018, a self-driving Uber, with a human safety driver sitting in the driver's seat, struck and killed a pedestrian in Tempe, Arizona (Griggs & Wakabayashi, 2018). The incident was the first pedestrian death in the United States caused by a self-driving car. After the incident, Uber suspended its testing of self-driving cars in Tempe as well as in its other test city of Pittsburgh, Pennsylvania (Linder, 2018). Incidents like these, when reported in the news and attended to by audiences, could shift how they respond emotionally and cognitively to promotional messages.

Apart from news coverage, audience members bring their own personalities and background views to any message, which in turn shape how they respond to it (Valkenburg & Peter, 2013). Two individual differences to consider in understanding audience responses to messages about autonomous vehicles are consumer novelty seeking and trust in machines.

Consumer novelty seeking has been defined as an individual's desire to seek out novel stimuli (Chau & Lung Hui, 1998). Novelty seeking is thought to be the antecedent of an adoptive attitude, information seeking, and use of new consumer products. Tests of this personality trait have shown that consumer novelty seeking is positively related to the early stages of the adoption process (Chau & Lung Hui, 1998; Manning, Bearden, & Madden, 2008). In the case of autonomous vehicles, audiences who are higher on levels of consumer novelty seeking may be less risk averse and more excited to ride in them.

The concept of trust in machines stems from research on media technology, and extends the concept of trustworthiness from interpersonal relationships to technological artifacts. According to Jian, Bisantz, and Drury (2000), trust in the human-machine relationship is similar to human-human trust, with trust in technological artifacts predicting adoption intentions and behavior (Wang & Benbasat, 2005). Trust in machines has been defined as an individual's general assessment of trustworthiness toward an agent's ability, benevolence, and integrity (Jarvenpaa, Tractinsky, &

Saarinen, 1999; Mayer, Davis, & Schoorman, 1995; McKnight, Choudhury, & Kacmar, 2002).

Considering the role of attention to news about autonomous vehicles as well as individual differences related to technology adoption leads us to propose two final research questions:

RQ2: Will attention to news about a recent autonomous vehicle–related death moderate the relationship between frame type and emotional responses as well as subjective knowledge about autonomous vehicles?

RQ3: Will individual difference variables (trust in machines, consumer novelty seeking) moderate the relationship between frame type and emotional responses as well as subjective knowledge about autonomous vehicles?

Overarching Conceptual Model

To provide an overview of the interrelationships suggested by the above hypotheses and research questions, we created on overarching conceptual model (see Figure 1). First, we predict that name frame and the use of celebrities in promotional messages will predict emotional responses and perceived knowledge about autonomous vehicles. Next, both affect (emotional responses to the messages) and cognition (perceived knowledge about the product) should predict perceptions of autonomous vehicles as risky and/or beneficial, with risk and benefit perceptions predicting intentions to ride in autonomous vehicles as well as intentions to support stricter regulations on them. In line with the differential susceptibility to media effects model (Valkenburg & Peter, 2013), our model examines how message factors (name of the technology, use of celebrity endorsers) and audience factors (individual differences as well attention to other relevant media) work to predict affective and cognitive mediators of audience risk/benefit perceptions and responses to messages about emerging vehicle technologies. This model presents an overview of the potential effects of these messages on different types of audiences.

Method

To address the above hypotheses and research questions, we conducted a 3 (name frame: autonomous vehicle, driverless car, self-driving car) $\times$ 2 (celebrities: present, absent) between-subjects fully factorial online experiment using a nationwide sample.

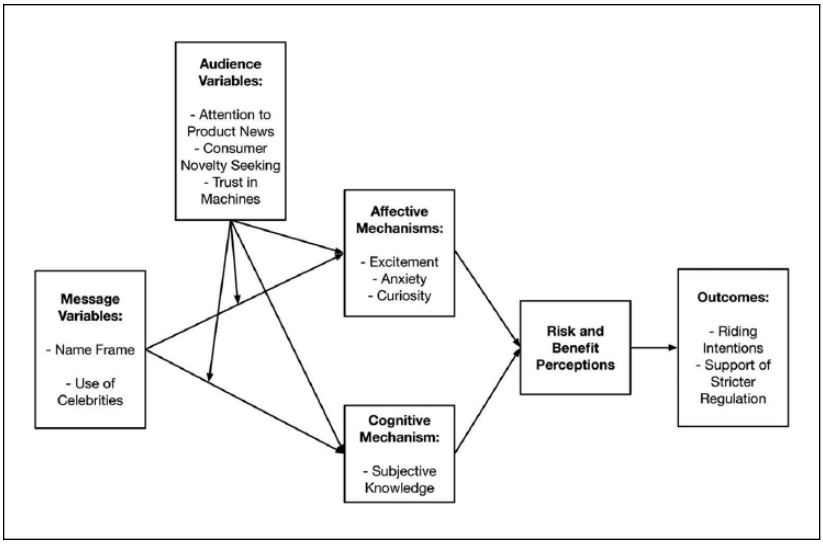

Figure 1. Conceptual model.

Sample

The sample included 721 participants. Gender and age quotas were used to ensure the sample was representative of the U.S. adult population on those two factors. Participants ranged in age from 18 to 85 years, with the average being about 40 ($M = 39.82$, $SD = 17.96$). Nearly half (50.2%) of participants were women, 46.3% identified as men, and another 3.5% either preferred not to answer or reported that neither category represented their gender well. About three quarters (73.0%) of the sample reported they were White, 14.4% were Black, 7.1% were Hispanic/Latino(a), 5.3% were Asian/Pacific Islander, 2.5% were American Indian/Native American, and another 2.8% identified as "other" (participants could choose more than one race/ethnicity with which to identify). When asked if they held a valid driver's license, 77.8% responded that they did, 19.8% said they did not, and another 2.4% said they were not sure. About a third (33.2%) of participants had a high school degree or less education, 25.5% had some college but no degree, 9.6% had a 2-year degree, 17.3% had a 4-year degree, 4.7% had some graduate school, and 9.7% had a graduate degree. Participants resided in 48 of the 50 U.S. states as well as from the District of Columbia.

Stimuli

The stimuli were chosen after the researchers conducted an extensive online search for marketing and promotional materials associated with autonomous vehicles. Actual images found online from companies working on autonomous vehicles were used in order to ensure ecological validity. However, captions were created by the researchers in order to both operationalize the name frame manipulation and control as much of the information not related to the independent variables (i.e., name frame and celebrity presence) as possible. Participants in each condition viewed a total of six images and their accompanying captions. The images were produced by the following companies, with some images containing logos of multiple companies: Lyft/BMW/Aptiv, General Motors, Uber/Volvo, Toyota, and Intel/Waymo/Chrysler. By using multiple images from multiple companies, we were able to control for brand biases such as familiarity and preference and help to be sure our results were not related to one particular brand or promotional campaign. We chose to show participants six images (instead of a single image) to more accurately reflected how brands promote their products in the digital era by posting multiple pictures of various users and types of vehicles on their websites and social media pages. As such, this methodological choice supported ecological validity.

The name frame manipulation took place in the instructions for viewing and in each of the captions. The particular frame (autonomous vehicles, driverless cars, or self-driving cars) was inserted in the instructions and within every caption. In the instructions, the name was bolded to increase the chances of being viewed. The celebrity presence manipulation occurred in both the images and the captions. The companies remained the same across celebrity versus no-celebrity conditions. However, actual images of celebrities engaging with actual autonomous vehicles at the 2018 CES show were used in three of the six images for the celebrity condition. These celebrities included actor Neil Patrick Harris, NBA player LeBron James, former NBA player Baron Davis, and businessman/television personality Mark Cuban. Real product images featuring actual celebrity promoters were used to support ecological validity. Multiple celebrities (instead of just one) also helped control for the unique influence of any one celebrity (Slater, Peter, & Valkenburg, 2015).

For an example of the stimuli, in the no-celebrity/self-driving frame condition, one of the images was of a Lyft-Aptiv car and the caption stated, "Lyft demonstrated its self-driving cars at the 2018 Consumer Electronics Show (CES)." In the celebrity/self-driving frame condition, though, the corresponding image included two celebrities as well as the Lyft-Aptiv car and the

caption stated, "Tech entrepreneur, *Shark Tank* star, and owner of the Dallas Mavericks Mark Cuban stands outside of one of Lyft's self-driving cars alongside former NBA player Baron Davis at the 2018 Consumer Electronics Show (CES)."

Procedures

The company Qualtrics was employed to secure a national sample of participants for the experiment. It recruits participants for its panels from various online sources, including website intercept recruitment, member referrals, targeted e-mail lists, gaming sites, customer loyalty Web portals, permission-based networks, and social media. Qualified potential participants received an e-mail invitation with a link to the questionnaire and information about the incentive they would receive if they participated (typically worth $4-$5). The online experiment launched on March 26, 2018 and closed on March 28, 2018. Settings in Qualtrics did not allow participants to use a back button when progressing through the study. Additionally, the questionnaire was set such that only one response could be completed by a single IP address.

After consenting to participate, individuals provided background and demographic information before completing the items to measure individual differences in consumer novelty seeking and trust in machines. Next, Qualtrics software randomly assigned participants to see images from one of six conditions (described below). Participants were told that the images were part of promotional and marketing materials companies were using and that they would be asked questions about the images and their captions after viewing them. After viewing the images and their captions, participants rated their emotional responses to the content. Next, they responded to items about perceived knowledge of the products, perceived risks of the products, and perceived benefits. Finally, they were asked about their intentions to ride in the products and to support stricter regulations on them. All questionnaire items avoided language that would overlap with the name frame manipulation and instead referenced the "product" or "type of product" featured in the messages. The questionnaire took most participants less than 10 minutes to complete. All procedures were approved by a university institutional review board.

Measures

All items were assessed on 7-point Likert-type scales and were presented to participants in the order they are described below.

Consumer novelty seeking was measured with eight items adopted from Manning et al. (2008). Sample items included "I frequently look for new products and services;" "I am continually seeking new product experiences;" and "I like magazines that introduce new brands" ($\alpha = .88$, $M = 4.11$, $SD = 1.31$)

Trust in machines was measured with six items adopted from Song and Zahedi (2003). Participants were asked to rate their agreements with the statements in terms of ability, benevolence, and integrity trust. Sample items included "I believe that machines are better at making good faith agreements than humans" and "I believe that machines are better at fulfilling promises than humans" ($\alpha = .88$, $M = 3.30$, $SD = 1.55$)

Emotional responses were measured with 13 items (displayed in a random order). Participants were asked to respond to the following prompt: "Thinking about the product featured in the materials you just viewed, how do you currently feel about the product?" Items of excited, eager, delighted, and enthusiastic formed the excitement index ($\alpha = .95$, $M = 3.79$, $SD = 1.94$). Items of anxious, nervous, apprehensive, worried, and cautious formed the anxiety index ($\alpha = .89$, $M = 4.69$, $SD = 1.66$). And, items of curious, intrigued, inquisitive, and interested formed the curiosity index ($\alpha = .93$, $M = 4.29$, $SD = 1.89$).

Perceived knowledge was measured with three items: "I am already very knowledgeable about this type of product"; "I know a lot about this type of product"; and, "I have read a lot about this type of product before" ($\alpha = .93$, $M = 3.34$, $SD = 1.78$).

Risk and benefit perceptions were measured with 12 items (6 apiece, all 12 displayed on the same page but in a random order) drawn from industry reports and news coverage. For the risk items, participants were asked to rate their agreement with statements such as "The product may cause injuries to passengers;" "The product may cause injuries to pedestrians;" and "The product may be susceptible to hacking." For the benefit items, participants were asked to rate their agreement with statements such as "The product may prevent accidents due to distracted driving;" "The product may decrease energy use and fuel emissions;" and "The product may lead to less road congestion." Both the risk ($\alpha = .89$, $M = 4.82$, $SD = 1.45$) and benefit ($\alpha = .89$, $M = 4.36$, $SD = 1.48$) items combined to form reliable indices, respectively.

Riding intentions were measured by asking for responses to two questions: "If given the opportunity, how likely are you to ride in the type of product featured in the materials you just viewed?" and "If given the opportunity, would you prefer riding in the backseat of the type of product featured in the materials you just viewed over riding in the backseat of a traditional vehicle

driven by a human?" Together, they formed a reliable index ($r = .75$, $p < .001$; $M = 3.68$, $SD = 1.95$).

Support for stricter regulation was measured by asking for responses to two questions: "How supportive would you be of legislation that requires there to be a human in the driver's seat who could take control of the type of product featured in the materials in the event of an emergency?" and "How supportive would you be of legislation restricting the type of product featured in the materials to dedicated lanes on the road?" Together, they formed a reliable index ($r = .64$, $p < .001$; $M = 4.80$, $SD = 1.72$).

Attention to news about autonomous vehicles was measured with a single item on a 1 to 7 scale asking "Within the past week, how much attention did you pay to the news stories related to the type of product featured in the materials you viewed for this study?" This item was presented only to participants who had reported having recalled any news stories related to the type of product featured in the messages within the past week. Individuals who responded "no" to that first question were coded as 0, giving this variable a range of 0 to 7 ($M = 1.63$, $SD = 2.51$).

Results

An initial model was constructed in Mplus8 Version 1.5 software in order to address the hypotheses and research questions. First, frame condition was recoded into two dummy variables (number of dummy variables being one less than the number of levels of the original variable). One represented the driverless car condition (coded as 1, all other name frame conditions coded as 0), and the other represented the self-driving car condition (coded as 1, all other name frame conditions coded as 0). These two name frame condition variables, the celebrity condition variable, the three moderator variables (attention to news, consumer novelty seeking, and trust in machines) as well as the nine interactions between the three moderator variables and the three message manipulation variables were entered as exogenous variables in the model. Next, they each were allowed to predict emotional responses (excitement, anxiety, and curiosity) as well as subjective knowledge. These mediators (emotions and subjective knowledge) were allowed to correlate with each other given the intertwined nature of affect and cognition. Next, each emotion and the subjective knowledge variable then predicted both intentions to ride and support for stricter regulations. Finally, intentions to ride and support for stricter regulations were allowed to correlate with each other. The initial model did not demonstrate good fit based on typical guidelines (Kline, 2011): χ^2(degrees of freedom [df] = 68) = 530.15, $p < .001$; root mean square error of approximation

(RMSEA) = .097 (90% confidence interval [CI; .089, .105], p-CLOSE < .001); comparative fit index (CFI) = .88; standardized root mean square residual (SRMR) = .035.

Because the data did not initially demonstrate good fit, we examined the model for potential modifications. Notably, RQ2 and RQ3 asked how attention to news about autonomous vehicles and how individual differences might moderate the relationships between the use of celebrities in promotional content as well as different name frames and subsequent emotional and cognitive responses. None of the interactions between attention to news about autonomous vehicles and trust in machines with the three exogenous variables (celebrity condition, self-driving condition, and driverless condition) were significant. Additionally, modification indices suggested the data would fit the model better if emotions and perceived knowledge were allowed to directly predict the outcomes of riding intentions and support for stricter regulation. Given the theoretical support for the importance of these variables in predicting public opinion on other science-related topics (e.g., Feldman & Hart, 2017), including emerging technologies (Lee et al., 2005), the model was revised to allow these eight additional paths (from the three emotions and perceived knowledge to each of the two outcome variables) as well as to remove the nonsignificant six interactions terms noted above. Other nonsignificant paths were allowed to remain in the model.

The revised model fit the data better: $\chi^2(df = 36) = 83.83$, $p < .001$; RMSEA = .04 (90% CI [.031, .055], p-CLOSE = .825); CFI = .99; SRMR = .017. Figure 2 displays the path estimates and their significance levels for the model. RQ1 asked how the name frame might affect emotional responses and subjective knowledge. The path analysis revealed that participants who read descriptions of the vehicles as self-driving cars were less excited than others, but no other significant paths emerged between the name frames and emotions or subjective knowledge.

As mentioned above, RQ2 asked if attention to news about autonomous vehicles, and RQ3 asked if individual difference variables (trust of computers, consumer novelty seeking) would moderate the effects of the message manipulations on audiences. While attention to news did not moderate any effects, it did have a significant negative direct effect on excitement and a significant direct positive effect on anxiety. Moreover, attention to news was a positive predictor of subjective knowledge about autonomous vehicles. Like attention to news, trust in machines had no interactive effects but did have significant main effects. Trust in machines predicted higher levels of excitement, curiosity, and subjective knowledge.

Additionally, consumer novelty seeking had main effects on affective and cognitive mechanisms. Participants with higher levels of dispositional

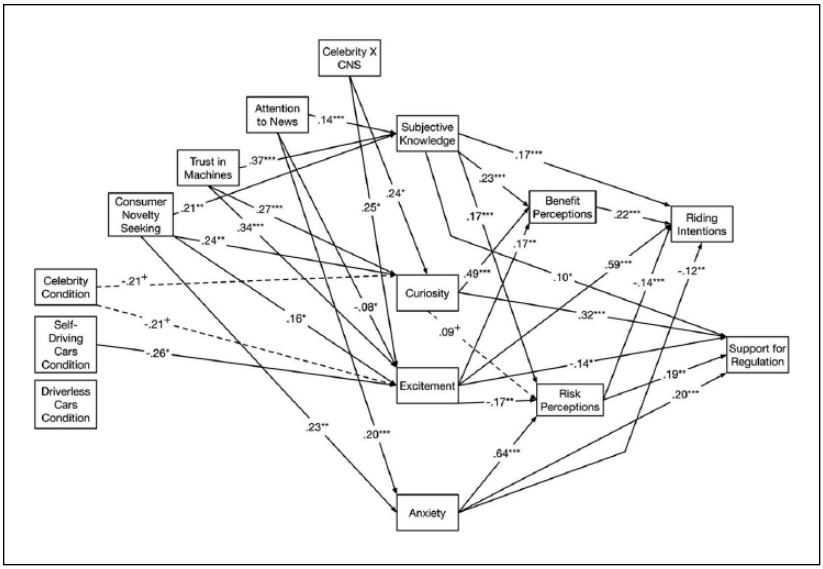

Figure 2. Path model results.
$^{+}p < .10$. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

consumer novelty seeking reported stronger emotional responses across the board, as well as higher levels of subjective knowledge. Additionally, there were two significant and positive interactions between consumer novelty seeking and the celebrity condition. Participants high in consumer novelty seeking who also viewed celebrities experienced significantly higher levels of the two positive emotions of curiosity and excitement.

Moving from left to right in the model, the next set of hypotheses to consider are H4 and H5. H4 predicted that promotional messages that include celebrities would be associated with greater excitement and greater curiosity, as well as less anxiety than messages without celebrities. Excitement was predicted by the celebrity condition but through a negative relationship (meaning participants who received the celebrity stimuli or read descriptions of the vehicles as self-driving cars were actually less excited than others). There were no other significant paths between name frame conditions and emotions, and therefore H4's prediction that use of a celebrity would have main effects on emotions was not supported. H5 predicted that individuals who viewed celebrities would express higher levels of subjective knowledge, but the path model did not support this prediction as the path was not significant.

Moving toward the middle of the model, H1 and H2 are the next relevant hypotheses to asses. H1 predicted that participants who experienced stronger anxiety-related emotional reactions would report higher risk perceptions and lower benefit perceptions. The results revealed there was not a significant relationship between anxiety and benefit perceptions; however, anxiety was a positive and significant predictor of risk perceptions, lending partial support of H5. Furthermore, anxiety was a positive predictor of support for stricter regulations on autonomous vehicles as well as a negative predictor of intentions to ride in these vehicles. The only additional direct predictor of riding intentions was subjective knowledge, which displayed a positive direct path with this outcome. Subjective knowledge was also a direct positive predictor of support for regulations.

H2 predicted that participants who experienced higher levels of excitement and curiosity would report lower risk perceptions and higher benefit perceptions. In partial support of this hypothesis, excitement and curiosity were both positive and significant predictors of benefit perceptions. However, only excitement was a negative predictor of risk perceptions, meaning H2 was only partially supported. In addition to its positive effect on risk perceptions, curiosity was a positive direct predictor of support for regulation while excitement was a negative predictor of regulation support. Also, excitement was a positive predictor of riding intentions, but curiosity did not have a significant direct path with riding intentions.

To test for indirect effects, as suggested by H3's prediction that emotions and subjective knowledge would mediate any message effects on outcomes, 5,000 95% bias-corrected bootstrap samples were run (see Table 1 for a list of indirect effects). These analyses revealed that the message manipulations had little indirect impacts on the main outcomes; however, the celebrity condition had marginally significant but negative indirect effects on ride intentions and support for stricter regulations via its effect on curiosity. As such, H3 was not supported.

Discussion

Futurists are having a field day with the autonomous vehicle technology; it potentially affects most aspects of individual and social existence. It is easy to imagine how the world of automated vehicles will change what it means to live in a city, what it means to commute, what it means to live in rural areas, what it means to be connected to others, what it means to be free, and how many drinks or other substances are socially acceptable to have at a party, among other dramatic social transformations. The potential for significant social change is why it is crucial to understand the effects that messages

Table 1. Significant Specific Indirect Effects.

Path	Indirect effect (β)	*p*
Celebrity Condition → Curiosity → Benefit Perceptions → Ride Intentions	−.02	.09
Self-Driving Condition → Excited → Riding Intentions	−.15	.05
Celebrity Condition → Curiosity → Support for Stricter Regulations	−.07	.10

about this technology, including strategic messages and news reports, may have on consumers and pedestrians, not to mention all citizens. That backdrop motivated the present study, and the results of the study provide a starting point for additional work to replicate and expand upon in order to foster necessary conversations about the risks and benefits of autonomous vehicles in a changing society.

First, the results revealed that most of the message factors had little impact on subsequent outcomes, with the exceptions being the impact of the celebrity condition and the celebrity × consumer novelty seeking interactions. Contrary to predictions, use of a celebrity had a negative main effect on curiosity and excitement (though the significance levels were slightly above the typical .05 threshold). However, participants high in consumer novelty seeking responded with higher amounts of curiosity and excitement, demonstrating that celebrity endorsements can evoke emotions that also promote downstream behaviors. The only name frame variable that had any effect on subsequent variables in the model was the self-driving car name, which actually decreased excitement. Of the three names, "self-driving" also seems to indicate that the vehicle drives itself. "Autonomous vehicle" could take on a range of benefits or drawbacks, and "driverless vehicle" suggests there is no driver in the car but not necessarily that the car drives itself. This suggests that for companies hoping to excite customers, they might want to choose a different name, but for journalists or safety advocates wanting to be sure consumers balance excitement about new technology with attention to risks, this moniker may be helpful.

The results did confirm the importance of emotional responses to messages in shaping risk/benefit perceptions as well as behavioral intentions. In fact, excitement had the strongest effect on intentions to ride in an autonomous vehicle while curiosity had the strongest effect on intentions to support stricter regulations. Curiosity has not been studied frequently in media effects contexts or in science-related media effects, despite public polling suggesting it motivates news consumption (Shearer, 2018) and

psychological evidence that it motivates learning and action (Kashdan & Silvia, 2009). The data presented here could spur future investigations into which message features spark curiosity and how curiosity fosters knowledge gain and additional cognitive mediators of behavioral outcomes. For instance, it could be that the use of surprising but not too terrifying statistics in messages about emerging technology sparks curiosity, but additional research is needed to test this supposition.

Furthermore, anxiety reduced intentions to ride but increased support for stricter regulations. While it is not always wise to stoke public fears, the results suggest that a healthy level of concern about new emerging technologies may help consumers and policy makers avoid making decisions they later regret with regard to autonomous vehicles. Together, the findings that emotions play a strong role, but that different emotions play different roles, in shaping risk/benefit perceptions and behavioral intentions regarding autonomous vehicles should encourage scholars to continue investigating their effects in this messaging context. By paying attention to consumer sentiment, be it via public opinion polls or through sentiment analysis of social media conversations about autonomous vehicles, researchers, policy makers, and technology companies could be better able to predict how citizens will respond to future messages about autonomous vehicles.

Subjective knowledge, a cognitive variable, was also an important factor in shaping risk/benefit perceptions and intentions to ride in vehicles. The more people think they know about autonomous vehicles, the more benefits they perceive and the more likely they are to ride in autonomous vehicles. This may be a problematic finding if perceived knowledge is incorrect or biased and leads consumers to take more risks than they would have with greater factual information. Studies comparing objective with subjective knowledge levels could help advance this line of work and assess any gaps between the two. Notably, subjective knowledge was predicted by greater attention to news, demonstrating another important role for media in shaping how the public responds to the growing use of autonomous vehicles in our society.

In fact, all of the individual difference variables (consumer novelty seeking and trust in machines) as well as attention paid to news about autonomous vehicles had notable impacts on emotions and subjective knowledge. For strategic messages—be they from companies or from public agencies hoping to inform the public about this new technology—these findings point to the importance of tailoring messages to specific audiences and conducting formative research prior to launching campaigns related to autonomous vehicles. Furthermore, the celebrity message condition interacted with the consumer novelty seeking individual difference

variable to influence both excitement and curiosity levels, suggesting that messages using celebrities could be more effective for individuals who typically enjoy and seek out novel experiences. Future research could build off of these findings to assess how "influencers," that is, opinion leaders who influence others' thoughts and behaviors, respond to promotional messages about autonomous vehicles and subsequent shape public opinion and intentions (Keller & Berry, 2003).

Furthermore, the conceptual model employed by the authors is not necessarily the only potentially useful model for exploratory analysis of relevant variables. As autonomous vehicles become more widely available, diffusions of innovations (Rogers, 2003) will become a key conceptual framework for understanding how messages might shape who becomes an early adopter and who waits before buying or riding in these vehicles.

As with any scientific endeavor, the present findings come with their limitations. Only three types of name frames were tested for autonomous vehicles, and additional ones (like "robot car") may emerge and shift how audiences perceive these vehicles. Furthermore, only four different celebrities were featured, and we did not assess how familiar audiences were with these celebrities or how much they liked them, or how credible they were as promotors of autonomous vehicles. Because we used actual images, it just happened that most of the well-known celebrities were men and linked to sports. For audiences who identify more with women celebrities and/or who are not fans of sports, these individuals may not have had the same responses as other participants had. Furthermore, our message manipulation focused on short, highly visual strategic promotional messages, and additional work is needed to test how people respond to news coverage (alongside promotional messages) as we measured only self-reported and general exposure to news about autonomous vehicles in the present study.

Despite these limitations, the data presented here offer a starting point for additional exploration of the effects of autonomous vehicle communications on audiences. This emerging area of science communication research needs to consider both strategic marketing messages and news information as parts of the messaging environment, as well as both affective and cognitive psychological mechanisms in addition to individual difference variables, when trying to understand public perceptions of autonomous vehicles. As these powerful, technologically advanced vehicles become more common, more popular, and more affordable, the need for research in this area will only grow.

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