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A Sign of Things to Come: Behavioral Change through Dynamic Iconography

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We propose that features of static visuals can lead to perceived movement (via dynamic imagery) and prepare the observer for action. We operationalize our research within the context of warning sign icons and show how subtle differences in iconography can affect human behavioral response. Across five studies incorporating multiple methodologies and technologies (click-data heat maps, driving simulations, surveys, reaction time, and eye tracking), we show that warning sign icons that evoke more (vs. less) perceived movement lead to a quicker propensity to act because they suggest greater risk to oneself or others and increase attentional vigilance. Icons used in our studies include children crossing signs near schools, wet floor signs in store settings, and shopping cart crossings near malls. Our findings highlight the importance of incorporating dynamic elements into icon design to promote imagery and thereby elicit desired and responsible consumer behavior.

On a daily basis we consume countless public and private facilities, from swimming pools to beaches, neighborhood playgrounds to amusement parks, and parking lots to roads. While it is important to study what facilities we consume, it is also important to study how we consume them. Irresponsible consumption, such as ignoring warning signs and product labels, leads to costs that are incurred not only by the consumer and the company but also by society as a whole. For example, over 60,000 people each year require emergency room treatment for injuries sustained in swimming pool accidents in the

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United States (Kennerly 2014). Many of these accidents are due to negligent behavior and inadequate warning signs (Dworkin 2014). Responsible consumption, therefore, is not only desirable but also extremely important. One component of responsible consumption is following posted rules and signs. For example, if one is at the zoo, one should not get too close to the animals. When swimming at a beach, one should avoid areas that contain jellyfish. When working with products containing acid, one should be mindful of the possible consequences (see fig. 1).

Let us consider just one domain in which warning signs play an important role: driving a vehicle. Every day, throughout the world, there are 3,287 deaths due to car accidents. In the United States alone, 37,000 people die in road crashes each year, with an additional 2.35 million people being either injured or disabled (ASIRT 2014). These terrible consequences are not limited to just drivers or passengers in cars. Nearly one in every five children between the ages of 5 and 9 killed in traffic accidents was a pedestrian. In addition, of the 6.3 million car accidents recorded annually in the United States, 1.26 million occur in parking lots (AAC 2010).

In an effort to reduce the number of accidents, businesses and governments worldwide place traffic signs in areas of potential danger. Children are taught from a young age to abide by these traffic signs. Motorists learn about the signs, are tested for their comprehension of the signs, and are fined for any violations of the signal-suggested behavior. Interestingly, there is considerable variance both within and

FIGURE 1
 EXAMPLES OF REAL SIGNS IN A CONSUMER SETTING



across countries for traffic icons designed to elicit the very same behavior. Figure 2 shows the traffic icon for a school crossing where motorists are expected to slow down when they see the sign. We note differences in traffic icons across the United States, Poland, and Russia, while icons in other countries bring additional variations. We focus on one dimension of the icon—the perceived movement (or dynamic imagery) that the icon elicits. All three icons in figure 2 are static visuals (i.e., they have no animation). Yet, each of them has some element of “dynamism,” with the Russian icon appearing most dynamic, evoking the highest perceived movement of the children crossing. Can the way the traffic signs are designed impact desired behavior?

The design of warning signs and its effects on behavior have both substantive and theoretical implications. The substantive implications are particularly important given the implications warning signs have for human life as well as because of the significant costs that are likely to be incurred by companies and the government when they are not followed. A recent call for research on consumer and societal well-being (Mari 2008; Mick 2008; Mick et al. 2011) reflects the need for more research on how responsible consumption can be encouraged. In the context of warning signs, it is prudent to consider how best to design static warning signs to effect behavior change given that animation is typically expensive and not always doable. From a theoretical per-

spective, our research is important because it adds to the literature on image attributes that facilitate imagery (e.g., Adaval and Wyer 1998; MacInnis and Price 1987; Petrova and Cialdini 2005; Wang and Peracchio 2007) by highlighting the dynamic nature of imagery and exploring its consequences on behavior. To explore both these substantive and theoretical implications, we focus on driving and traffic signs. Surprisingly, despite consumers spending an average of over 2 hours per day in their cars (Arbitron, Edison Media Research 2013), very little research in consumer psychology has focused on the driving context or on driving behaviors (for an exception, see Wood, McInnes, and Norton 2011). This domain, therefore, provides a rich avenue within which to conduct our research.

The rest of the article is organized as follows. Next we discuss literature pertinent to our research and build our conceptual model. This is followed by a description of five studies and their findings. We conclude with implications, limitations, and possible extensions of our research.

LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

Literature relevant to our research is found in the areas of visual imagery, dynamic imagery, and completion of movement; perceived movement and attention; and per-

FIGURE 2
 SCHOOL CROSSING SIGN IN THE UNITED STATES, POLAND, AND RUSSIA



ceived movement and human behavior. We briefly discuss each in turn.

Dynamic Visual Imagery and the Completion of Movement

Visual imagery has been studied extensively within the psychology and consumer behavior literatures, providing a foundational framework for not only what facilitates image generation but also for the resulting content of these images (see Kosslyn, Thompson, and Ganis 2006; Petrova and Cialdini 2008). The elicitation of visual images occurs at both deliberate and spontaneous levels. At a deliberate level, visual images may be formed as a consequence of explicit instructions to imagine (e.g., Gregory, Cialdini, and Carpenter 1982; McGill and Anand 1989; Morewedge, Huh, and Vosgerau 2010). In addition, and importantly for our conceptual model, visual images can also be formed spontaneously. For instance, reading a concrete word or description can not only elicit an image (Paivio 1969) but also lead to automatic neural activity in corresponding sensory regions of the brain (González et al. 2006). Pictures alone can also lead to spontaneous generation of imagery, with vividness (Petrova and Cialdini 2005), stimulus orientation (Elder and Krishna 2012), and even stimulus type (e.g., hand tool vs. not; Chao and Martin 2000) affecting the amount of imagery generated. The content of these images, in addition to how the images are formed, plays a large role in affecting evaluations and behavior.

We explore how perception of motion from a static picture spontaneously facilitates dynamic imagery, with people mentally completing the movement of the action depicted in the picture. Images are not restricted to static pictures in the mind's eye but can also contain a visual representation of movement of the stimulus or even the self. In early research exploring the notion of kinematics (motion) and dynamics (motion and also the forces that produce motion), participants showed the ability to imagine the continuation of movement once movement of a stimulus stops, as well as the movement of shapes from a still line drawing (Anderson, Howe, and Tolmie 1996). These effects obtain as our minds draw upon past experiences in memory to continue the motion that we have perceived initially (McCloskey 1983). Such dynamic imagery has been studied most extensively within the rubric of "Representational Momentum" (RM; Freyd and Finke 1984). A typical study exploring this phenomenon has participants view objects that move on a computer screen and then disappear. Participants are then asked to identify where the object disappeared on the axis of motion. The common finding is that participants remember the object to have disappeared farther along the axis of motion than the actual vanishing point (e.g., Hubbard and Bharucha 1988).

The vast majority of RM studies utilize moving objects as described. However, some research investigates perceived motion using static images. Most commonly these are frozen-action images, in which a moving figure in the

midst of motion is captured (e.g., a still photograph of an individual jumping in mid-air or the trajectory of a ball in flight; Freyd 1983). In these snap shots, it has been shown that one can visualize movement—for example, the individual and the ball coming back to the ground in the actions cited earlier. Neuroscientific evidence also supports such dynamic imagery. The same brain regions (the medial temporal/medial superior temporal cortex; MT/MST) are active when observing action and when imagining motion (Goebel et al. 1998; O'Craven and Kanwisher 1997). Importantly, these brain regions are also active when viewing static images where motion is implied (Kourtzi and Kanwisher 2000), suggesting that even in the absence of actual motion, the brain is perceiving movement. While the bulk of the prior literature has focused on when dynamic imagery and perceived movement occur, recent research in consumer behavior has shown that perceived movement has consequences not only on memory but also on consumer evaluations. For example, using brand logos with lower and higher dynamic imagery, Cian, Krishna, and Elder (2014) show that more (vs. less) dynamic brand logos enhance brand evaluation.

To summarize, findings from existing research suggest that (a) people can spontaneously generate mental images and (b) static visual stimuli can lead to perceived movement, with dynamic imagery on the part of the observer leading to mental completion of the movement in one's mind. In this research, we operationalize dynamic imagery within the context of warning sign icons and explore if dynamism within these icons can stimulate people to imagine how objects move. This perception of movement should also lead to behavioral consequences, which were not explored in the prior literature. Previous research has shown that the completion of movement in the mind corresponds to a more vivid image of the event depicted (Callow, Roberts, and Fawkes 2006; Smallwood et al. 2004). Thus, increases in dynamism to a sign icon depicting a dangerous situation should lead to a more vivid image of the action depicted. A vivid representation of a dangerous situation (e.g., a rock falling on the road) should then lead to heightened levels of perceived risk as imagining oneself in a scenario increases its perceived likelihood of occurring (Carroll 1978; MacInnis and Price 1987).

Perceived Movement, Risk Perception, and Attentional Vigilance

As humans have evolved, they have learned to be vigilant to threat. Motion plays a large role in determining what people attend to and how vigilant they are in their attentional response. In an article on the effects of *animacy* (the life and motion perceived in an object) on attentional capture, Pratt et al. (2010) highlighted how animacy affects prioritization in visual processing. Indeed, humans have developed systems to maximize the chances of detecting potential predators and other dangers, one of these systems being animacy detection (Barrett 2005). Animacy signals something unpredictable that one might have

to react to; thus, our attention system evolved to detect animacy automatically and quickly (New, Cosmides, and Tooby 2007), with attentional prioritization given to animate objects before the stimulus is fully identified (Ptak and Fellrath 2013). Evolutionary psychology further shows that the increased attentional vigilance triggered by animacy is domain specific, so that such perceptual “tunings” work to foster survival (Nairne et al. 2009). Higher perceived risk, or an increase in vigilance, leads to greater detection of possible dangers. Consequently, when scanning a scene containing potential risk, animacy gets attentional priority and increases vigilance.

Given the considerable overlap in neural activity between actual movement and perceived movement (Kourtzi and Kanwisher 2000), we predict that perceived movement should have similar consequences on behavior as actual movement. In this research, we examine the ability of dynamic iconography to create alertness and vigilance when it comes to processing warning signs. Specifically, in an alert state (e.g., when driving), icons that evoke greater perceived movement (dynamic imagery), being more vivid and evoking more perceived risk, are likely to attract earlier attention and lead to greater attentional vigilance within the environment. This attentional vigilance should be exhibited by participants shifting attention to the surrounding area upon viewing a warning sign icon with more (vs. less) perceived movement. The warning sign icon, which will appear to convey movement, will then be revisited, leading to additional shifting of attention back and forth between the warning sign icon and the surrounding area. We operationalize this within our eye tracking study by examining the number of visits to the areas surrounding, but not including, the warning sign following initial exposure to the warning sign icon.

Specifically, we predict that:

- H1a:** A warning sign icon (e.g., a yield sign) with more (vs. less) perceived movement will attract earlier attention.
- H1b:** A warning sign icon with more (vs. less) perceived movement will evoke greater attentional vigilance.

Perceived Movement and Human Behavior

Much recent research in situated cognition suggests that thinking is for doing and facilitating action in a manner that considers the current situation (Smith and Semin 2004, 2007). Because thinking is for doing and is influenced by the settings of the immediate context, the particular actions or thoughts that are activated are a function of what is psychologically relevant and salient in the context, together with situational action potentials (Oyserman 2009). In particular, the mental representation of a concept prepares the individual for action in the context the concept is placed in. This includes the setting, actions, and introspections that go along with the concept, creating the experience of “being there”

(Barsalou 2008; Niedenthal et al. 2005). Consequently, perceived movement from static images can not only activate the neural structures involved in motor planning and execution for the corresponding movement but also lead to a more general “preparation to act” in the given context. Because perception of movement prepares one for actual movement and a warning sign icon with more (vs. less) perceived movement should result in earlier attention and increased attentional vigilance (hypothesis 1), we propose this:

- H2:** A warning sign icon with more (vs. less) perceived movement will result in faster reaction time.

Hypothesis 2 suggests that the desired behavior in a sign (e.g., stopping) will occur faster with a warning sign icon that conveys greater perceived movement. Furthermore, warning sign icons able to evoke greater perceived movement should lead to heightened levels of perceived risk. Based on these two assumptions:

- H3:** A warning sign icon with more (vs. less) perceived movement will result in earlier stopping behavior (i.e., the stopping will occur farther back from the sign).

An overview of our conceptual framework is depicted in figure 3. It is important to note that while perceived movement evoked by icons may impact behavior across multiple domains, we operationalize our research to icons that are within the domain of warning signs, with a particular emphasis on traffic sign icons, due to their important downstream behavioral consequences and their static visual nature.

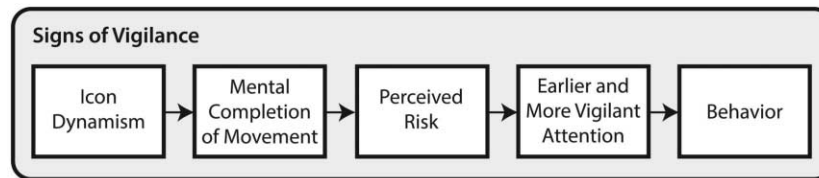
Because the context of driving behavior is particularly prone to demand effects stemming from learned compliant behavior, we design our studies so that there is no “correct” answer (e.g., the question “Would you stop your car if you saw a ‘Stop’ sign?” would be prone to demand effects since there is only one correct answer). In addition, in two of our studies, we design car driving scenarios that allow us to test simulated driving behavior and reactions. We use multiple methodologies and technologies—time to first fixation and area of interest visits using an eye tracker (study 1), reaction times measured in a driving simulation (study 2), and behavioral intentions captured through click-data heat maps (studies 3A, 3B, and 4). Next we discuss our studies.

STUDY 1: (EYE TRACKING) PERCEIVED MOVEMENT, VIGILANCE, AND EARLY ATTENTION

In study 1, we examine how perceived movement affects attention. We have hypothesized that a higher dynamism icon will attract earlier attention than a lower dynamism icon (hypothesis 1a). We use eye tracking technology to measure the time to first fixation on our area of interest, which is the time in milliseconds from when the scene is shown to a participant until the participant’s eyes fixate on the traffic sign. We also hypothesized that a higher dynamism icon will evoke greater attentional vigilance than a

FIGURE 3

THE CONCEPTUAL FRAMEWORK



lower dynamism icon (hypothesis 1b). We measured attentional vigilance by the number of visits outside the traffic sign after the initial visit to the traffic sign. Shifting one's focus from the sign to the surroundings would count as one visit. Subsequent visits to the surrounding areas would accumulate after refocusing on the traffic sign. Therefore, attentional vigilance is a measurement of darting one's eyes across the scene and coming back to the sign. (Note that in viewing a scene with a target object, one tends to fixate on the target object at some time, and then one leaves it and fixates on something else, and then reverts back and fixates on the target object or fixates on another part of the scene; this goes on repeatedly.)

Stimuli and Pretests

We created eight road signs—four of lower dynamism and four of higher dynamism. In designing the stimuli, we tried to ensure that the lower and higher dynamism sign icons contained the same information to minimize any other visual confounds. All signs were manipulations (but not

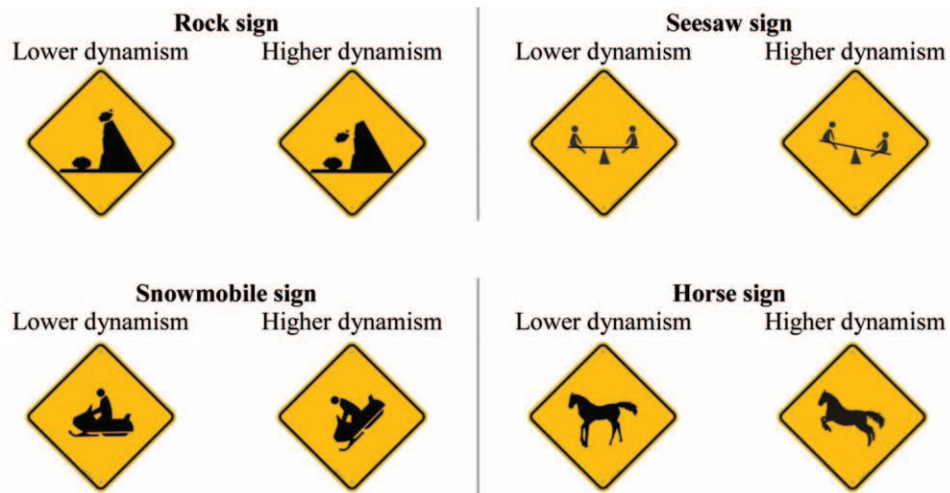
perfect copies) of existing signs used in the United States. The signs are shown in figure 4.

In a first pretest, 240 people from an online pool (administered on Amazon Mechanical Turk) were randomly assigned to view only one of the eight signs in a between-subjects design. Participants were asked to rate the sign on its familiarity, visual appearance, visual complexity, and informativeness. The familiarity scale was a 7-point scale adapted from Clark (1970) and Dahl, Manchanda, and Argo (2001). The sign visual appearance, visual complexity index, and informativeness scales were 9-point scales adapted from Cian et al. (2014; see the appendix for details). Results show no significant difference (all p 's > .1) between the higher dynamism and lower dynamism versions of each sign icon on our measures of familiarity, visual appearance, visual complexity, and informativeness.

A second pretest was conducted to ensure that the higher dynamism and lower dynamism sign icons differed on perceived movement. One hundred and sixteen undergraduate students from the University of Michigan participated in the pretest in exchange for course credit. Each participant was

FIGURE 4

SIGNS USED IN STUDY 1 (EYE TRACKING)



randomly assigned to view either the lower or the higher dynamism version of each sign icon. We used a two-item scale to measure perceived movement adapted from prior literature: “How much movement did you see in the icon depicted in the traffic sign?” (1 = “No movement at all,” 9 = “A lot of movement”); and “How dynamic was the icon depicted in the traffic sign?” (1 = “Not at all dynamic,” 9 = “Extremely dynamic”; $r = .78$, $p = .01$; Cian et al. 2014). As expected, we found a significant difference between the higher dynamism and lower dynamism version of each sign icon on our measure of perceived movement (all p 's < .05), with the higher dynamism sign icon leading to more perceived movement than the lower dynamism sign icon.

After the pretest, we inserted these eight signs in realistic road settings. Specifically, we created two sets of four stimuli (eight total stimuli) depicting a first-person driving view, with four lower dynamism and four higher dynamism sign icons (fig. 5). We used four different driving scenes and backdrops. Each scene contained a road from a first-person perspective, as well as the windshield and hood of a car, which did not change across scenes. In each scene, we placed a traffic sign (lower or higher dynamism) at a different location on the right side of the road to avoid participants fixating in the same exact area across scenes.

Main Study

Fifty undergraduate students from Brigham Young University completed study 1 in exchange for course credit. Since we are exploring the consequences of perceived movement within the context of traffic sign icons, in all studies using traffic signs, we screened participants for only those living in the United States and possessing a driver's license.

Data were collected using a high frequency (120 Hz) eye tracker (Tobii T120) that was able to collect raw eye movement data points every 8.3 milliseconds. This eye tracker is integrated into a 17-inch TFT monitor and has no visible “tracking devices” that might affect participants' behavior. The eye tracker uses near infrared illumination to create reflection patterns on the viewer's cornea and pupil, with two image sensors that capture images of the eyes.

Participants came individually into a conference room every 10 minutes. The experimenter invited each participant to take a seat in front of the eye tracker. Each participant was taken through a calibration procedure before the eye tracking recording was started. Upon failing calibration, participants' chairs were adjusted, or the monitor was adjusted, to provide accurate recognition of their eyes. Participants were instructed that they were to evaluate several different pictures of landscapes from the United States as if they were driving on a road trip and that the scenes were shown from a first-person perspective in a car. All instructions and stimuli were presented on the 17-inch TFT monitor in full-color bitmaps with a 1,280 × 1,024 pixel resolution.

Each scene was presented for 10 seconds and then advanced on its own. Between each scene, participants saw a “fixation clue (+)” in the middle of the screen for 1,000 milliseconds.

This was done to center fixation and thereby ensure that every scene had the same centered attentional focus.

Participants were randomly assigned either to a condition with only lower dynamism sign icons or to a condition with only higher dynamism sign icons. In both conditions, the participant evaluated all four signs in the same order (rock, seesaw, snowmobile, horse).

Results and Discussion

Time to First Fixation. For measuring “fixation,” we created a specific area of interest around the traffic sign. An identically-sized area of interest was applied to all scenes. Our dependent measure was the time to first fixation in the area of interest from stimulus onset. We ran a repeated-measures, mixed-model ANOVA with sign (rock/seesaw/snowmobile/horse: within-subjects, repeated factor) and dynamism (lower/higher: between-subjects factor) as independent variables and time to first fixation as the dependent variable. Figure 6, part *a*, shows the means for each scene.

The ANOVA shows a significant main effect for dynamism ($M_{\text{lower dynamism}} = 1.46$, $M_{\text{higher dynamism}} = .82$ seconds; $F(1, 48) = 4.23$, $p < .05$) but not for its interaction with sign ($F(3, 144) = 1.66$, $p > .1$). The results of the ANOVA and the mean times to first fixation show that a higher dynamism sign decreases time to first fixation and does this similarly for all four signs. This is consistent with our hypothesis (hypothesis 1a). The ANOVA also reveals a significant main effect for sign icon ($F(3, 144) = 9.15$, $p < .01$), showing that some sign icons (whether in lower or higher dynamism form) lead to faster times to first fixation than others.

Attentional Vigilance. Per our hypotheses, dynamic imagery evokes greater attentional vigilance within the environment (hypothesis 1b). If people are generally more vigilant after seeing a more dynamic sign icon, we should find a greater scanning to other areas around it. We analyzed the eye tracking data for number of visits to the areas surrounding, but not including, the warning sign following initial exposure to the warning sign icon (“number of re-fixations”).

We conducted a similar repeated-measures, mixed-model ANOVA with number of re-fixations as the dependent variable (see fig. 6, part *b*, for the means). The ANOVA shows that higher dynamism sign icons led to significantly more visits outside the sign than lower dynamism sign icons ($M_{\text{lower dynamism}} = 2.04$ visits, $M_{\text{higher dynamism}} = 2.53$ visits; $F(1, 48) = 4.39$, $p < .05$), suggesting greater attentional vigilance when movement is anticipated. Neither the main effect for sign ($F(3, 144) = 1.71$, $p > .1$) nor the interaction between sign and dynamism ($F(3, 144) = .72$, $p > .5$) were significant.

The eye tracker results in study 1 support our hypotheses (hypotheses 1a and 1b) that, in a situation of alert (imagining driving, in this case), static pictures evoking more (vs. less) perceived movement are able to draw attention more quickly, resulting in an earlier fixation. Moreover, dynamic imagery increases attentional vigilance within the environment, as indicated by a higher number of visits beyond the sign.

FIGURE 5

DRIVING SCENES USED IN STUDY 1



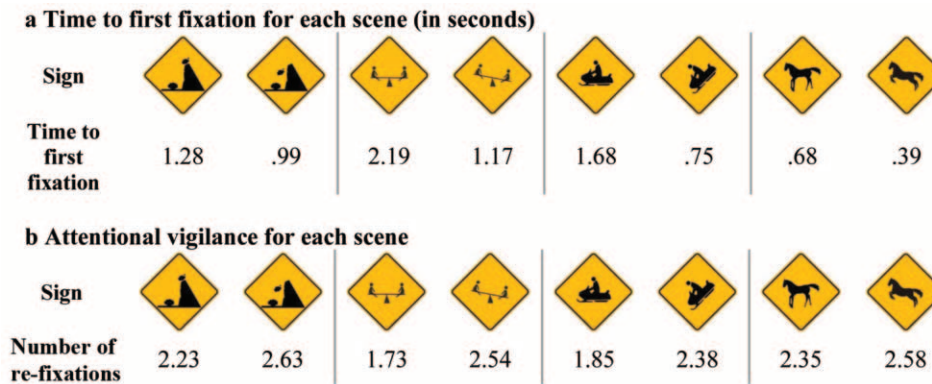
STUDY 2 (DRIVING SIMULATION): THE IMPACT OF DYNAMIC ICONOGRAPHY ON REACTION TIME

While study 1 tests for attention, study 2 tests for quickness of response to a traffic sign icon. Specifically, we had participants watch a video driving simulation from a driver's

perspective. To the right of the driving scene, we placed traffic signs. We were interested in how quickly participants would respond to the signs in this scenario. The "drivers" had to press a key on the keyboard to indicate their reaction. If, as we hypothesize, the body sees a sign and gets ready for action in the active concept, then even though pressing a key is not the same as pressing the brakes or turning the

FIGURE 6

EYE TRACKING RESULTS



wheel, the resulting action should be faster when viewing a higher (vs. lower) dynamism sign icon. However, given the difference between the actions, this is a conservative test of our theory for faster “driver” reaction time to more versus less dynamic traffic sign icons (hypothesis 2).

Stimuli

In order to design a realistic and involving reaction time study, we created a driving video simulation from a first-person (driver’s) perspective. We edited a video showing a drive along a country road as seen from the driver’s point of view. The video was 16 seconds long.

We were interested in participants’ deliberate reactions to traffic warning signs and not participants’ reaction time to “anything appearing on the screen” (resembling a mindless reaction time to a visual appearance). Thus, if we were to have only traffic warning signs appear on the screen and have participants hit a key when they appeared, participants would hit a key when “anything” appeared on the screen (since everything appearing would be a traffic sign). In order to avoid this problem and still keep the driving simulation realistic, we created two types of traffic signs—“warning signs” and “informative signs.” These two signs warranted different reactions from the participants, hence necessitating some deliberation and not mindless hitting of a key. We instructed participants that warning signs signaled unexpected conditions on or adjacent to a highway, street, or private road and to situations that might not be readily apparent to road users and that these may ask for a reduction of speed. They correspond to the “warning signs” category in the American driver’s manuals. We also told participants that informative signs were signs used to identify a direction or a general service. Informative signs provide additional information but do not require a reduction of speed. They correspond to the “general information/general service signs” category in the American driver’s manuals (we adapted these definitions from the 2012 DOT Manual on Uniform Traffic Control Devices).

We asked participants to press the “w” key for a warning sign and the “i” key for an informative sign.

In all, we created 12 road signs—4 informative signs and 8 warning signs. For warning signs, we used the same 8 signs created in study 1, which were variants of existing signs (4 with lower dynamism and 4 with higher dynamism). The 4 informative signs are shown in figure 7 (these signs were adapted from the 2012 DOT Manual on Uniform Traffic Control Devices “general information/ general service signs” category). For the informative signs, we use the same background (yellow diamond) as that in the warning signs, so that participants have to make their decision based on the icon contained in the sign and not on the shape of the traffic sign.

Note that reaction time studies are typically based on pictures or words (Gawronski and Payne 2010; Fiske, Gilbert, and Lindzey 2010). In our reaction time study, we use a first-person driving video simulation, necessitating a synchronization of video and reaction time measurement, something that was far from trivial. Additionally, since reaction times vary widely across individuals (Broggi et al. 2008; Manning, Tolhurst, and Bawa 2012), we wanted to look at within subject differences in reaction times for lower versus higher dynamism warning sign icons. However, we did not want to give participants lower and higher dynamism versions of the same warning sign icons as this may appear suspicious and lead to possible demand effects. Additionally, participants may become faster at recognizing a sign because of increased familiarity (seeing two versions of it).

To deal with the concerns mentioned above, we programmed the video so that the 16-second video looped four times on the left half of a 14.5-inch computer screen. On the right half of the screen, one warning sign and one informative sign appeared (in random order) for 1 second each. The first sign (informative or warning) was programmed to appear after 5 seconds, the second (warning or informative, respectively) after 8 seconds. Thus, each participant saw a 64-second (16 seconds × 4) video and was exposed to all

FIGURE 7

INFORMATIVE SIGNS USED IN STUDY 2



four informative signs and all four warning signs. Two of the four warning sign icons were in their lower dynamism form and two were in the higher dynamism form (as discussed above). Whether the sign icons appeared in their lower or higher dynamism version was randomly assigned across subjects. As stated earlier, on seeing a traffic sign, participants had to press the “w” key for warning sign or the “i” key for informative sign.

Pretest

A pretest was conducted to ensure that people were able to discern informative from warning signs. Sixty undergraduate students from the University of Michigan participated in the pretest in exchange for course credit. We presented the participants the definitions of warning and informative signs and then showed them two examples of each. The examples used differed from the signs participants were tested on. Participants were told that they would be viewing several traffic signs and that they were to determine if the sign was a warning sign or an informative sign, a binary choice. Furthermore, they were instructed to base their decision on the icon depicted on the sign and not on the shape of the traffic sign (yellow diamond), which was the same for all signs.

Each participant next saw the whole battery of 12 signs (4 informative signs, 4 lower dynamism warning sign icons, 4 higher dynamism warning sign icons) in random order. They were allowed to view each sign for as long as they wished and were asked to indicate whether each sign was an informative sign or a warning sign. The error rate was small and acceptable (7.50%); therefore, participants recognized the warning (informative) signs as such. To further analyze the data, we used a generalized estimating equations (GEE) model, which is a generalized form of logistic regression for choices observed under a within-subjects design (Ge, Häubl, and Elrod 2012; Liang and Zeger 1986). Within this model, the 12 signs were used as the independent variable and choice (correct/incorrect) as the dependent variable. Neither the main effect of sign (Wald = 6.53, 11 *df*, $p > .8$) nor the pairwise comparisons of all sign combinations were significant (p 's $> .1$), indicating that participants were able to discern if a sign was a warning or an informative sign without any significant difference in terms of the likelihood of across the 12 signs.

Main Study

Procedure. Two hundred and seventy-five undergraduate students from the University of Michigan participated in the main study in exchange for course credit. First, participants read the test instructions. They were told that this was a reaction time driving test, and they were instructed to imagine themselves driving while answering as quickly and as accurately as possible. Similar to the pretest, definitions and examples of warning signs and informative signs were provided. Participants were asked to answer based on the icon depicted on the sign and not on the shape of the traffic sign itself. They were instructed to press the “i” key when they saw an informative sign and the “w” key when they saw a warning sign. Second, participants performed a practice trial (in which we used four signs different from the main study). Inaccurate categorizations were followed by the word INCORRECT in red font for 1.5 seconds. Finally, participants went on to the main study. Reaction times were captured after the onset of each sign. Figure 8 shows a screenshot taken during the study.

Results and Discussion

We followed the data analysis procedure outlined by Meier et al. (2007), Ratcliff (1993), and Robinson (2007) for analyzing reaction time data. First, we deleted inaccurate trials where the informative (warning) sign was misread by the participant as a warning (informative) sign (12.27%). Second, we log-transformed the response times for correct trials to reduce the typical skewed distribution of reaction time data. Finally, we replaced log-latencies faster or slower than 2.5 standard deviations from the log-latency mean with these cutoff scores. Log transformation followed by 2.5 standard deviations replacements seems to be one of the best procedures to prevent capitalizing on chance (Robinson 2007). Analyses were conducted on log-transformed data, but means are also reported in raw milliseconds to facilitate comprehension. The reaction time means for each sign are reported in figure 9.

Note that what we are interested in is the difference in reaction times between lower and higher dynamism traffic sign icons. The reaction needed for the two signs is the same in that they require pressing the same key (“w” with the left

FIGURE 8

A SCREENSHOT FROM THE REACTION TIME MAIN STUDY (STUDY 2)



NOTE.—Screenshot of what participants saw during the reaction time study. The 16-second video appears on the left; a sign appearing for 1 second is on the right.

hand) and the only thing that varies is the dynamic nature of the icon in the sign seen. For the informative sign, participants pressed the “i” key with their right hand, adding a “hand” confound, but with most participants being right-handed this would make the informative signs a conservative control. Remember that each participant saw eight traffic signs (four informative, two higher dynamism, and two lower dynamism) and that whether the participants saw the lower or higher dynamism version of the warning signs was randomized across subjects.

We performed two types of analyses—one was a regression analysis on individual sign data and one was a repeated measures analysis on data pooled across signs. We begin with the regression. We are interested in the difference in reaction time between the lower and higher dynamism sign icons. A regression with effect coded dummies for the four warning signs (sign type), an effect coded dummy to indicate lower and higher dynamism (dynamism), and their interactions, yielded significant effects for dynamism ($\beta = -.09$, $t = -2.84$, $p < .01$). No interactions were significant (p 's $> .4$). The significant effect for dynamism supports our hypothesis 2 that a higher dynamism sign will evoke faster reaction time. The nonsignificant interaction between sign type and dynamism indicates that the difference in reaction times for a particular “lower dynamism–higher dynamism” pair of warning sign icons is not significantly different from the other three warning sign icons. Since we are specifically interested in the difference in reaction times between lower and higher dynamism warning sign icons, the lack of the interaction allows us to pool data across warning sign icons.

In a repeated measures analysis, we pooled the data across signs for each of three sets of signs that each subject saw—thus, we had three pooled reaction times per participant, for the informative signs, higher dynamism sign icons, and lower dynamism sign icons (the regression analysis discussed previously also justifies the pooling). The reaction time means for each of these three variables are reported in figure 10.

Supporting our hypothesis 2, a repeated measures ANOVA showed that sign type had a main effect on reaction time (Wilks's Lambda = .97, $F(2, 256) = 4.67$, $p < .05$). Planned follow-up contrasts revealed that participants reacted significantly faster to warning signs with higher dynamism icons than to warning signs with lower dynamism icons ($F(1, 257) = 6.23$, $p < .05$) or to informative signs ($F(1, 257) = 8.41$, $p < .01$). There was no significant difference between warning signs with lower dynamism icons and informative signs ($F(1, 257) = .02$, $p > .8$). Similar results were obtained if we omitted the informative signs and just performed our analyses using the lower and higher dynamism sign icons.













Study 2 exhibits additional behavioral consequences of greater perceived movement within traffic signs. Specifically, higher dynamism sign icons led to quicker reaction time than lower dynamism sign icons or informative signs (as predicted in hypothesis 2). In addition, study 2 increases the external validity of the findings by placing them within a more realistic driving simulation. Note also that a difference of 50 milliseconds, in a car traveling at 60 miles per hour, is a distance of 4.4 feet and can mean the difference between having an accident versus not.

STUDY 3: BEHAVIORAL CONSEQUENCES OF DYNAMIC ICONOGRAPHY

Studies 1 and 2 test attention and quickness of response to a traffic sign icon, respectively. Study 3 tests whether more (vs. less) perceived movement within traffic warning sign icons leads to more compliant and cautious behavior, as indicated by where one decides to stop a car. We hypothesize that drivers will stop farther back from the traffic sign when perceived movement resulting from the sign icon is higher (i.e., when the observer is more likely continuing the movement in her mind) than when it is lower (hypothesis 3). We test this in two progressive studies in different consumer contexts.

FIGURE 9

REACTION TIME MEANS FOR EACH SIGN TYPE (STUDY 2)

a Warning Signs		Reaction Time Mean (milliseconds)	Reaction Time Mean (log-transformed)
Seesaw		1105.20	6.97
		1075.85	6.92
Snowmobile		1144.12	6.98
		1053.09	6.91
Horse		1014.51	6.89
		1006.70	6.85
Rock		1062.09	6.94
		980.72	6.85
b Informative Signs		Reaction Time Mean (milliseconds)	Reaction Time Mean (log-transformed)
Gas		1087.53	6.94
Lodging		1014.10	6.88
Food		1222.93	7.07
Directional arrow		1011.91	6.88

Study 3A: Children Crossing

We created four stimuli, with each stimulus containing a road with a road sign of children crossing as seen from above. All stimuli (800 × 600 pixel images) were identical except for the icon depicted in the warning sign. Figure 11 shows an example of the stimulus, with all four signs shown below for illustrative purposes. Two of the signs had visual icons of children (with lower and higher dynamism), and these served as the main experimental stimuli. They are manipulations (but not perfect copies) of the existing sign used in the United States to represent a school crossing. We also had two control conditions that used verbal signs (“children ahead” and “running children”). These verbal depictions allow us to test whether differences in behavior are due to differences in inferred conceptual meaning from the signs or if dynamic imagery from visual cues evokes unique behavioral reactions. Thus, we had a one-way design with four conditions (lower dynamism visual, higher dynamism visual, verbal control–children ahead, and verbal control–running children).

Pretests. Similar to study 1, in a first pretest conducted online ($n = 55$), participants rated the two visual traffic signs on dimensions of familiarity, visual appearance, visual

complexity, and informativeness (all p 's > .2). A second pretest with 110 undergraduate students from the University of Michigan revealed significant differences between the two visual signs on perceived movement ($p < .05$) in the expected direction.

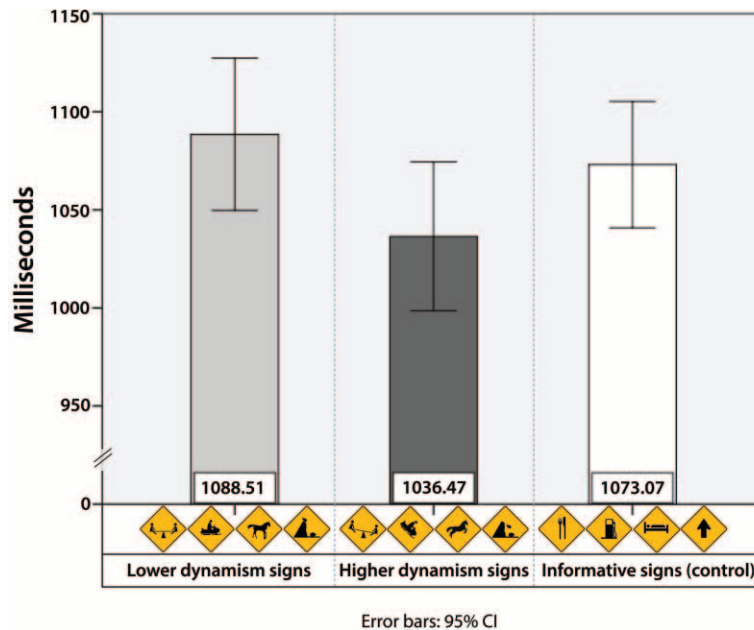
Main Study. One hundred and fourteen participants from an online panel participated in the study in exchange for money. Participants were randomly assigned to view one of the four conditions and were instructed to imagine themselves driving on the road depicted in the picture. They were further told to click on the location of the road where they would start to slow down their vehicle in response to the traffic sign. Using JavaScript, we programmed the survey to place a small car where the participant clicked. The final position of the car represented our main dependent variable of interest.

Results and Discussion. Our main dependent variable of interest (“car position”) was calculated in terms of geometrical distance from the origin (bottom left of the image) to the point where participants clicked with the mouse. Lower numbers represent shorter distances from the origin and consequently longer distances from the sign.

We conducted a one-way ANOVA with the sign condition

FIGURE 10

REACTION TIME MEANS FOR EACH SIGN TYPE (STUDY 2)



as the independent variable. The resulting ANOVA was significant, showing a difference in car position among the signs ($F(3, 110) = 3.10, p < .05$). Simple-contrasts provide support for our hypothesized effects (see fig. 12): the means indicate that participants would begin to slow down earlier when shown a higher dynamism (vs. a lower dynamism) visual sign ($F(1, 110) = 4.69, p < .05$). Additionally, they would slow down significantly earlier with a higher dynamism visual sign versus both the verbal control “children ahead” sign ($F(1, 110) = 7.08, p < .01$) and the verbal control “running children” sign ($F(1, 110) = 6.54, p < .05$). There was no significant difference between the lower dynamism sign and the two verbal control signs (all p 's $> .6$). Figure 12 gives the heat map for each condition. Each heat map is a graphical representation of data displaying where participants placed their car. Together this suggests that it is the dynamic imagery evoked from visual cues that affects behavior and not simply the activation of the concept of movement.

Study 3B: Shopper Crossing

Study 3B tests if the results of study 3A carry over to another consumer setting and with completely unfamiliar signs. In recent years, 30%–40% of the pedestrian injuries occur within parking lots (NiTS 2012; Tschida 2013), mostly at shopping malls or grocery stores. We created an aerial view (440 × 550 pixels) of a mall parking lot with a road sign. The road sign icon portrayed a shopper with a shopping cart. We made two such icons, one having more perceived

movement than the other. We manipulated the image of the shopper and shopping cart to ensure that the two icons contained identical content. The only difference between the stimuli was how the images were stylized (lower/higher dynamism; fig. 13). Neither version of the sign corresponded to an existing traffic sign in the United States.

Pretests. As in the previous studies, a first pretest with 54 participants from an online pool revealed no significant difference between the two sign icons (all p 's $> .2$) on familiarity, visual appearance, and informativeness. A second pretest conducted with 40 participants from an online pool revealed significant difference between the two sign icons on perceived movement ($p < .01$).

Main Study. Ninety participants from an online panel participated in the study in exchange for money. Participants were randomly assigned to view one of the two maps and were instructed to imagine themselves driving along the blue arrow (black arrow if the reader is seeing the figures in black and white) through the parking lot depicted in the picture. Participants then clicked on the map where they would stop their car. In place of their cursor, we programmed a car to appear. The rest of the instructions and the procedure were similar to study 3A.

Results and Discussion. We conducted a one-way ANOVA with icon dynamism (lower/higher) as the independent variable and “car position” as the dependent variable. As in the prior study, participants indicated earlier positions to begin slowing down when shown a higher dy-

namism versus lower dynamism sign icon ($M_{\text{lower dynamism}} = 377.79$ pixels, $M_{\text{higher dynamism}} = 352.31$ pixels; $F(1, 88) = 4.57$, $p < .05$). Figure 14 depicts a heat-map summary of the click data.

Study 3B replicates the results of study 3A, while generalizing the findings in a different setting with novel icons. The two studies together support our hypothesis (hypothesis 3) showing the effect of icon dynamism on behavior.

STUDY 4: DYNAMIC ICONOGRAPHY AND PERCEIVED RISK

The purpose of the study 4 is twofold. First, we seek further support for hypothesis 3 and formally test our proposed conceptual framework. Per our conceptual framework (fig. 3), we suggest that higher dynamism icons lead to greater mental completion of the depicted movement than lower dynamism icons. This imagined movement (e.g., a rock falling on the road) is represented by a more vivid

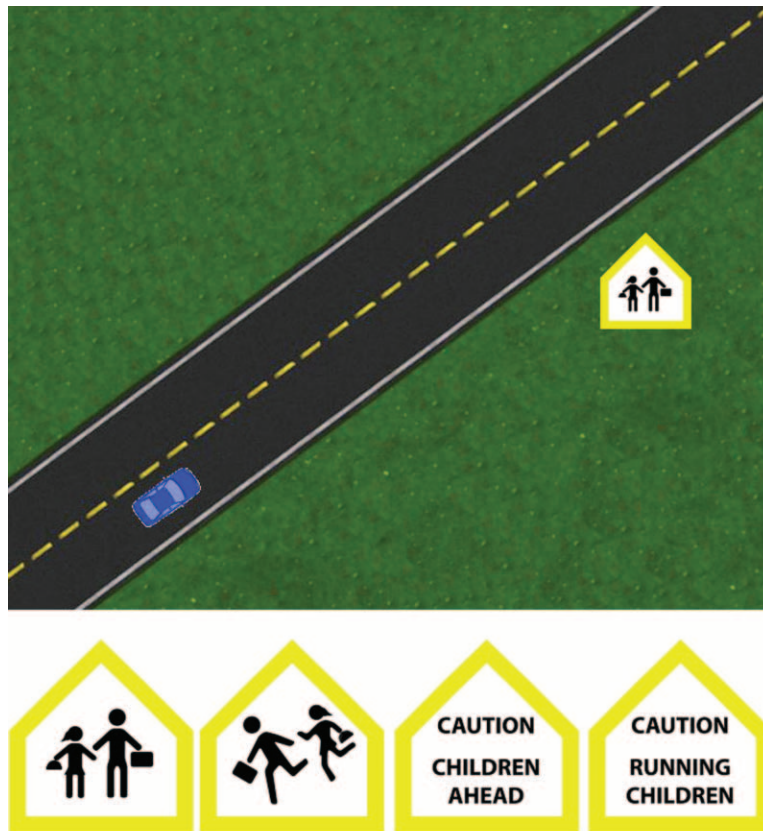
image of the depicted act (Callow et al. 2006; Smallwood et al. 2004).

The second purpose of study 4 is to explore if the underlying process for the effect of icon dynamism stems from the dynamic imagery the icon evokes or if it requires participants to engage in directed mental simulation. Mental simulation is defined as the construction of hypothetical scenarios in the form of imagined situations (Taylor and Schneider 1989). In studies 1–3, we asked participants to imagine themselves driving through the scene depicted in the picture (i.e., directed mental simulation). It is possible that when participants are asked to imagine themselves in the scenario, they are also more likely to imagine the completion of the act shown in the warning sign. While we propose imagery to be the underlying mechanism behind how the icon impacts the completion of movement, we argue that the imagery is contained within the icon itself. In other words, when one sees an image conveying motion, one completes the motion, with or without directed mental simulation.

Thus, in study 4, we instruct participants either to imagine

FIGURE 11

STUDY 3A STIMULI



NOTE.—Above, a screenshot of study 3A showing the location of the sign inside the map and the car that appeared when subjects clicked with their computer mouse. Below, the four signs used in study 3A.

FIGURE 12

HEAT MAPS AND MEANS FROM STUDY 3A

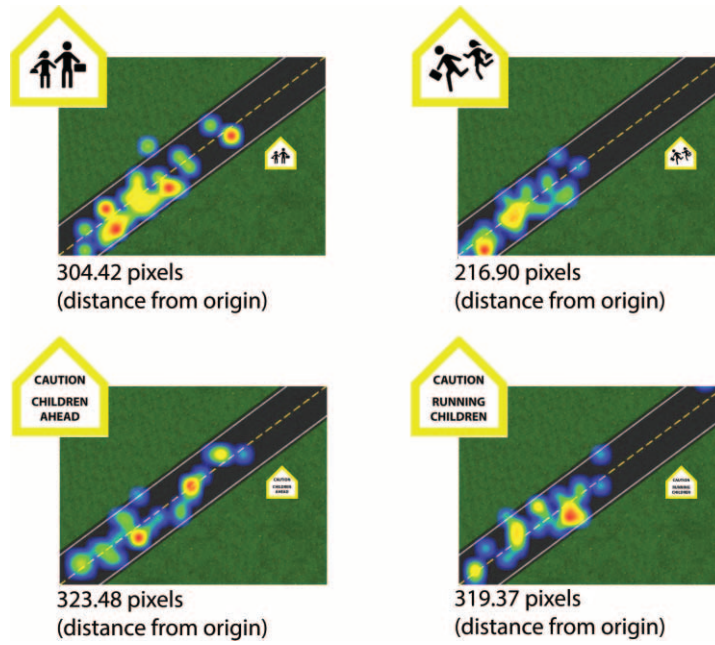


FIGURE 13

STUDY 3B STIMULI

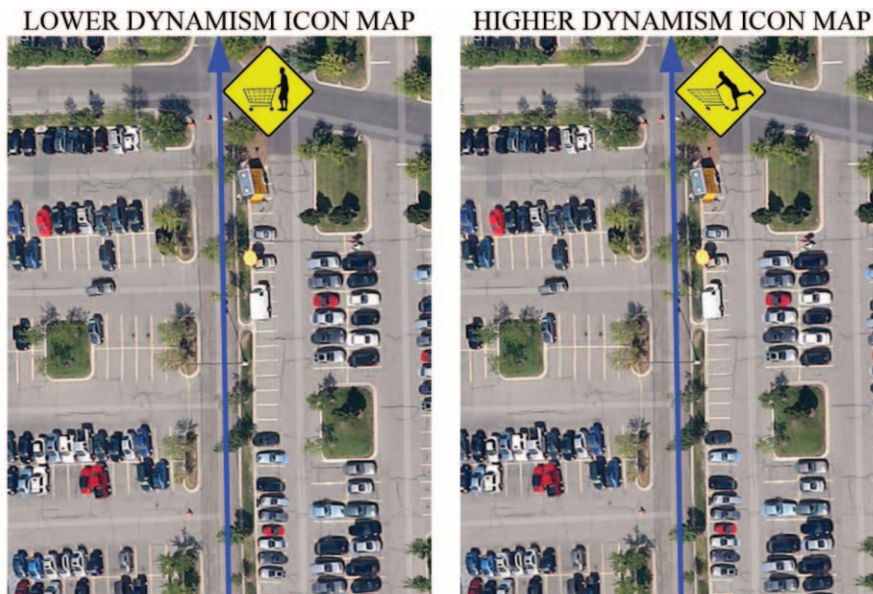
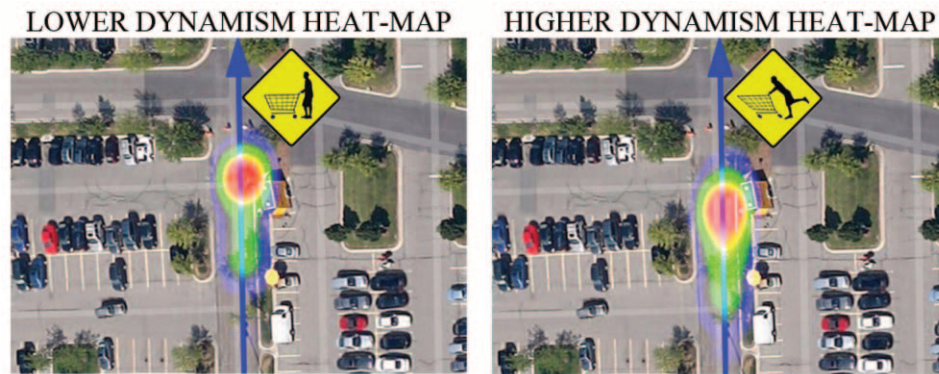


FIGURE 14

HEAT MAPS FROM STUDY 3B



themselves in the scene (directed mental simulation, replicating the instructions of study 3A and study 3B) or to not imagine themselves in the scene (no directed mental simulation). We predict that even in the no directed mental simulation condition, icon dynamism will impact participants' behavioral response through our proposed process. Consequently, we propose that in both conditions (directed mental simulation—yes, no) icon dynamism will have a significant impact on participants' behavioral responses and that this will occur through movement completion (captured by imagery vividness). Thus, we predict that icon dynamism will have a main effect on behavior mediated through imagery vividness (as shown in fig. 3) irrespective of whether directed mental simulation is present or absent. The study is therefore designed to identify the source of imagery underlying the effects.

Stimuli and Pretests

In study 4, we operationalize dynamic imagery using a warning sign (wet floor) inside a grocery store aisle. This set of stimuli allows us to keep our focus on warning signs, while changing the consumer setting. Similar to studies 3A and 3B, we created an aerial view (417×550 pixels) of the grocery store aisle with the sign placed near the top of the image. The sign contained an icon of a man slipping on the floor. Both the higher and lower dynamism icons were identical in form, with the only difference being the angle of rotation of the man depicted in the icon. The lower dynamism icon depicted a man more upright, with the higher dynamism icon rotated 45 degrees counterclockwise (see fig. 15).

We conducted a pretest with 40 students from the University of Michigan. Each participant was randomly assigned to view one of the two pictures shown in figure 15. Participants were told that they would be viewing and evaluating a sign shown in a grocery store aisle. After viewing the picture, we asked participants to evaluate the sign on

dimensions of familiarity, visual appearance, visual complexity, and informativeness, as used in the prior studies (all p 's $> .1$). Furthermore, with an open-ended question, we asked participants to describe the meaning of the sign. Two independent trained coders, who were blind to the hypotheses, coded the responses. For the higher dynamism icon, 20 out of 20 participants correctly recognized the sign. For the lower dynamism icon, 17 out of 20 participants correctly recognized the sign. In a second pretest, 48 people from an online pool revealed significant differences between the two signs on perceived movement ($p < .05$).

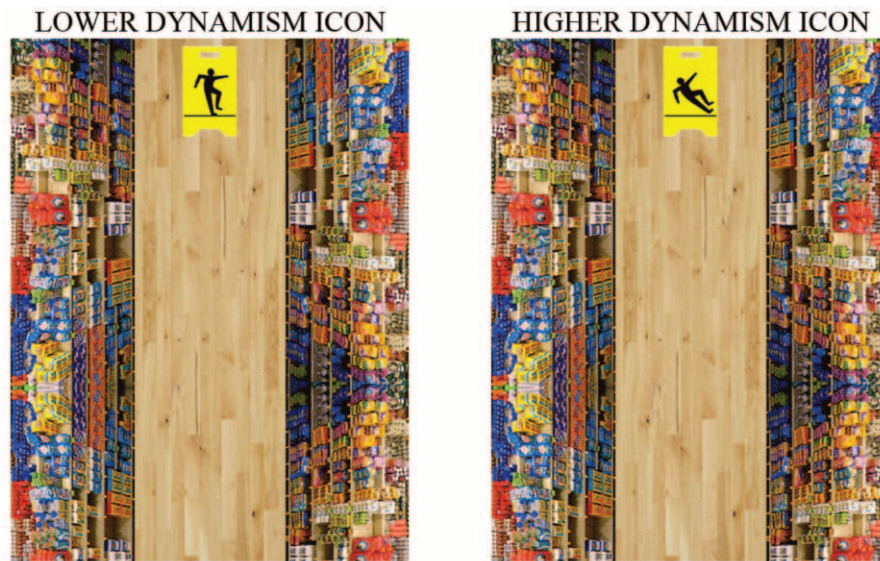
Main Study

Design. Study 4 was a 2 (directed mental simulation: yes, no) \times 2 (icon dynamism: lower, higher) between-subjects design. Our dependent variables were stop position, perceived risk in the scenario, imagery vividness, and sign familiarity.

Procedure and Measure. One hundred and forty-three participants from an online pool completed the study in exchange for money. Each participant was told that s/he would be evaluating a shopping scenario. To induce an alert state, we began the questionnaire instructing participants that they would be viewing warning signs within a grocery store setting. Following these initial instructions, participants were randomly assigned to directed mental simulation conditions. In the "yes" directed mental simulation condition, participants were given the following instructions: "We ask that you use your imagination to make your responses. Visualize yourself in the shopping scenario and use the power of your imagination to make your choice." In the no directed mental simulation condition, participants were given the following instructions: "We ask that you be well-reasoned in your responses. Do not use your imagination when making your decisions. Rather, try to make a logical choice." We could have chosen to not give any instructions to participants

FIGURE 15

STUDY 4 STIMULI



in the no directed mental simulation condition. However, as McGill and Anand (1989) note, people tend to imagine themselves in a situation even in the absence of instructions to imagine. Therefore, we adapted the “logic” instructions from McGill and Anand (1989) to discourage the use of mental simulation. To ensure participants correctly read the manipulation, each was asked to indicate their understanding: “I understand that I will visualize myself in the scenario and use the power of my imagination to make my choice” or “I understand that I will try to make the most logical and rational choice,” depending on the condition. Participants were asked to answer “yes” or “no.” Only participants who answered “yes” continued the survey.

Next, participants were randomly assigned to either the lower or higher dynamism icon conditions. They were told to click on the location in the aisle where they would start to slow down in response to the sign. The final click position, indicating where the participant would start to slow down (“stop position”), was our first dependent variable of interest. Participants were then asked for their perceived risk in the scenario, imagery vividness evoked by the icon, and sign familiarity. Perceived risk was measured with two items (“How cautiously would you walk down this grocery store aisle?” anchored on 1 (not at all cautiously) to 9 (very cautiously), and “Relative to your normal pace, how slowly would you walk down this grocery store aisle?” anchored on 1 (the same speed as normal) to 100 (extremely slower than normal); $r = .73$, $p < .01$ on the z -scores). Imagery vividness evoked by the icon was measured by asking participants to rate the mental image they formed of themselves slipping on the floor while looking at the sign (on the fol-

lowing dimensions: 1 (Not at all vivid/intense/lifelike/sharp/defined); 9 (Extremely vivid/intense/lifelike/sharp/defined); $\alpha = .96$; adapted from Bone and Ellen 1992). Finally, sign familiarity was measured using the same items used in the previous studies ($\alpha = .89$).

Results and Discussion

We first conducted a 2×2 ANOVA on our dependent variables with directed mental simulation and icon dynamism as our independent variables. As predicted, the interaction of directed mental simulation and icon dynamism was not significant for stop position ($p > .5$), perceived risk ($p > .3$), or imagery vividness evoked by the icon ($p > .9$). Additionally, the main effect of directed mental simulation was not significant for stop position ($p > .2$), perceived risk ($p > .1$), or imagery vividness ($p > .8$) either. Thus, for our primary analysis, we collapsed across the two directed mental simulation conditions.

We next conducted an ANOVA with dynamism (lower/higher) as the independent variable and stop position as the dependent variable. As in the prior studies, participants indicated earlier positions to begin slowing down (indicated by lower pixel numbers along the y -axis) when shown a higher dynamism versus lower dynamism icon ($M_{\text{lower dynamism}} = 320.23$ pixels, $M_{\text{higher dynamism}} = 284.47$ pixels; $F(1, 141) = 4.18$, $p < .05$). An ANOVA with icon dynamism as the independent variable and perceived risk as the dependent variable revealed a similar pattern of results on z -scores (ranging from -2.87 to 1.54). Specifically, the higher dynamism icon led to significantly higher perceived risk than the lower dy-

namism icon ($M_{\text{lower dynamism}} = -.20$, $M_{\text{higher dynamism}} = .19$; $F(1, 141) = 6.94$, $p < .01$). Our third ANOVA examined the impact of dynamism on vividness evoked by the icon. The higher dynamism icon led to greater vividness of the action depicted in the icon than the lower dynamism icon ($M_{\text{lower dynamism}} = 5.03$, $M_{\text{higher dynamism}} = 6.04$; $F(1, 141) = 8.90$, $p < .01$). A final ANOVA showed that the two icons did not differ in term of familiarity ($M_{\text{lower dynamism}} = 2.37$, $M_{\text{higher dynamism}} = 2.44$; $F(1, 141) = .114$, $p > .7$).

Serial Multiple Mediation. With significance across our dependent measures between conditions of icon dynamism, we tested the process underlying the results. Specifically, we tested the path from icon dynamism (lower/ higher) \rightarrow imagery vividness (as result of mental completion of movement) \rightarrow perceived risk \rightarrow behavior (stop position) using a multiple mediator model with serial mediation and bootstrapping (5,000 resamples; Hayes 2013, model 6). The examination of the serial indirect effect of icon dynamism on stop position through both mediators (vividness first, and perceived risk second) shows that the path from icon dynamism to vividness is significant ($B = 1.01$, $p < .01$), as is the path from vividness to perceived risk ($B = .10$, $p < .05$), and also from perceived risk to stop position ($B = -41.07$, $p < .01$). This full path of serial indirect effects is significant, with a 95% confidence interval between .83 and 11.29. In addition, when both mediators are included in the model, the direct effect of icon dynamism on stop position is no longer significant ($p = .1$).

Thus, we find support for our hypothesized model that higher dynamism within the icon is represented by a more vivid image of the act depicted, affecting perceived risk, and ultimately behavior. Despite the usage of our manipulation of directed mental simulation in prior research (McGill and Anand 1989), it is possible that in our no directed mental simulation condition the instructions to suppress imagery may have still led to imagery, as spontaneous image generation has been shown to be a rather ubiquitous process (Jiang et al. 2014). Indeed, attempts to control one's thought process may lead to ironic effects of intention to control or concentration, with imagery generation resulting from instructions not to imagine (Wenzlaff and Wegner 2000). However, our results suggest that the process is driven by the spontaneous generation of imagery through dynamic iconography and not from directed mental simulation. Instructing participants to imagine themselves in the scene does not make them more likely to imagine the completion of the act shown in the warning sign.

GENERAL DISCUSSION

Our findings show the behavioral consequences of perceived movement from static visuals. Across five studies, using multiple methodologies and technologies, a higher dynamism (vs. lower dynamism) icon results in earlier attention to, more attentional vigilance, and faster reaction to signs (studies 1 and 2) and safer behavior (studies 3A, 3B, and 4). Specifically, using eye tracking in study 1, we show

that higher dynamism icons draw earlier attention and increase attentional vigilance (hypothesis 1) when compared with lower dynamism icons. In study 2, we use a driving simulation video and show that higher (vs. lower) dynamism icons lead to quicker reaction time (hypothesis 2). In studies 3A and 3B, increased dynamism within a static visual of a traffic sign leads to stopping at a safer distance from a potentially dangerous situation (hypothesis 3). Additionally, in study 4, we provide support for the conceptual framework we propose (see fig. 3) and exhibit the process underlying our effects.

Our work contributes to the literature on dynamic imagery (e.g., Cian et al. 2014; Clark and Paivio 1991) by exploring the behavioral consequences and the underlying process of such imagery. Our work also contributes to the literature exploring the impact of visual cues on consumer behavior (e.g., Greenleaf and Raghubir 2008; Patrick and Peracchio 2010; Wang and Peracchio 2007) by showing how a variation in the dynamism of a static picture can affect consumer attention, risk perception, and behavior. Our exposition of the effects of perceived movement on behavior provides a foundational framework for future research within consumer psychology and behavior. However, further exploration of when and how dynamic imagery is elicited, as well as how it differs fundamentally from static imagery, is important.

The implications stemming from dynamic imagery also need further exploration. For example, do the cognitive processes that underlie dynamic imagery require additional resources relative to static imagery? A core consequence of perceived movement is misplacement of the object depicted in memory in the direction of the movement (Freyd and Finke 1984); however, should there be additional resources devoted to form a dynamic image, there may be positive memory consequences, such as increased memory for the stimulus. From both a consumer behavior and cognitive psychology perspective, understanding how the brain interprets dynamic visual cues, re-creates them within imagery, and ultimately remembers them provides a compelling area for future research.

Across our studies we find persuasive support for our conceptual model. However, we do not test the entire model in one study, but rather use a chain of studies to provide support for the underlying process (see Lee and Schwarz 2012; Spencer, Zanna, and Fong 2005 for similar methodology). As we were focused on identifying and exploring the basic elements of the process, we did not fully explore the exact order between the elements, nor their boundary conditions. For example, in addition to the warning signs we used in our studies, we also used informative signs. It is possible that such informative signs, even when imbued with higher dynamism, follow a different path in affecting behavior.

One possible limitation of our current set of studies is the manipulation of an alert state prior to stimulus presentation. Being in an alert status may indeed influence attention. Human attention has a very high degree of flexibility; it can be directed on small and specific regions or it can have a

more holistic and distributed focus (Pashler 1998). Neurological evidence has concluded that attention focuses only on the location (or object) with the highest priority, and that the locus of attention reflects converging sensory and goal-related signals (Gottlieb, Kusunoki, and Goldberg 2005; Koch and Ullman 1987; Ptak and Fellrath 2013). Thus, based on our theoretical framework, the state of alert may speed the initial attention directed to the warning sign because the detection of possible dangers represents a priority. In absence of a state of alert, the ability of dynamic icons to attract earlier attention may decrease, because our attentional priority is not focused on detecting possible threats. However, once the warning sign is detected, this should increase the state of alert, as well as perceptions of risk. Because a dynamic icon leads to a spontaneous completion of movement (independent from instructions), once the sign is attended to, we predict the effects of dynamic iconography to obtain as shown across our series of studies. As we do not have empirical support for this claim, however, this question warrants future research.

The icons that we used in our studies (with the exception of the shopping cart icons) were similar to those used in the real world. It is possible that the level of familiarity with the signs can affect our results. When viewing completely unfamiliar visual stimuli, processing may, for example, be limited to interpreting the base form of the stimulus and not the movement of the stimulus. While we have pretested all stimuli to be equated on novelty, it is possible that the level of familiarity with the sign, or perhaps even the context the sign is placed in, would moderate our effects.

In addition to the level of familiarity with the sign, the type of behaviors depicted by the sign may evoke a form of mimicry. While in studies 1–3 the signs referred to behaviors of external agents (e.g., rocks falling, children crossing, horses running), the sign in study 4 referred to one's own behavior (i.e., slipping and falling). The dynamism contained within the sign led to more cautious behavior, but another way to evoke the desired behavior is to portray the icon in a way that leads to mimicry (e.g., a man cautiously walking). In study 4, the two icons that we used differed in terms of perceived movement but also possibly in terms of mimicry. In the lower dynamism condition, the sign could have been interpreted as a tiptoeing man, while the higher dynamism condition represented a slipping man. The first condition, while lower in dynamism, facilitates people to mimic that action and walk more carefully. The fact that the more dynamic condition led to higher vividness, perception of risk, and preventive behavior allows us to make a distinction between icons that evoke mimicry versus attention/vigilance. However, this distinction needs further study. In certain contexts, dynamism and mimicry may be opposing forces. For example, based on our findings one would want the children crossing sign to convey dynamism, with running children being better than walking children for driver behavior; however, for the pedestrians, mimicking running across the street may have unintended consequences. Therefore, the resulting behaviors from the sign

icons may be driven by expectations. The interplay between top-down and bottom-up processes provides an intriguing area for future research.

In all our studies, we used “frozen motion” as a way to evoke a perception of movement from static icons in traffic signs. However, other antecedents of perceived movement could also be explored and tested for their efficacy. Looking at the cognitive psychology literature, visual friction, a concept wherein visual cues touching each other inhibit their perceived movement (Hubbard 1995; Kerzel 2002), could be used to alter dynamism within a consumer context. Within traffic signs specifically, drawing borders around the existing icons may inhibit perceived movement, ultimately reducing desired behavior. For example, a deer crossing sign with a thick black border may convey less dynamism than one without the border, leading to slower reaction times. Drawing from the art literature, we can also find other methods of conveying movement, such as color (Mazow 2013) and repetition (Boccioni et al. 1910).

As the findings from our research have direct implications on consumer welfare, our work also adds to the domain of transformative consumer research and its primary focus on individual and social well-being (Mari 2008; Mick 2008; Mick et al. 2011). Since variations in traffic iconography systematically resulted in safer behavior, this research could impact accident-related injuries and even mortality rates from traffic accidents. Secondary effects would be seen with reductions in automobile repair expenses, as well as car insurance health care costs. It is important to note that studying perceived movement from static images is particularly relevant in a consumer setting. In most instances where icons are used (e.g., traffic signs, warning icons, and informative icons), these icons cannot be animated due to economic and technical reasons. Furthermore, the icons often cannot be accompanied by verbal descriptors for space limitations or because of multiple languages being used in a country. Consequently, our research contributes to the understanding of a basic characteristic of visual grammar, showing how perceived movement can affect cognitions and behavior (such as time to first fixation, reaction times, risk perception, and behavior) that are crucial in dangerous contexts. More specifically, these findings can be used to facilitate more responsible consumption.

While we have chosen to operationalize our research primarily within the context of traffic icons, the practical applications of our theoretical contributions extend well beyond this domain. Since higher dynamism leads to behavioral reactions, then increasing dynamism in recycling icons, consumption cues for health foods, or other domains should also have behavioral implications. Exploration of these additional contexts should prove valuable from public policy and consumer welfare perspectives. Our studies show dynamic imagery to be an important and underexplored construct within both cognitive psychology and consumer behavior. We hope that this work will spur further exploration of this topic.

DATA COLLECTION INFORMATION

The third author supervised the collection of data for study 1 (eye tracking) by research assistants at the Marriott School of Management, Brigham Young University, during January and February 2014. The first author collected the data for the other studies, from summer 2013 to May 2014. The first author collected the data either at the Behavioral Lab of Ross School of Business (University of Michigan) or using the Amazon Mechanical Turk panel (the details are described in the methods section of the studies). The first author analyzed the data collected in all studies.

APPENDIX

The familiarity scale was an adaption from Dahl et al. (2001) and Clark (1970) and consisted of three items: "How often have you seen the sign before?" (1 = "I have seen this sign very often," 7 = "I have never seen this sign"); "This is an existing sign" (1 = "Strongly agree," 7 = "Strongly disagree"); and "This is a well known sign" (1 = "Strongly agree," 7 = "Strongly disagree").

The sign visual appearance scale, the sign visual complexity index, and sign informativeness were adapted from Cian et al. (2014).

The sign visual appearance scale consisted of three items: "I like the way the sign looks" (1 = "Strongly disagree," 9 = "Strongly agree"); "The sign is attractive" (1 = "Strongly disagree," 9 = "Strongly agree"); and "The sign is aesthetically appealing" (1 = "Strongly disagree," 9 = "Strongly agree").

The sign visual complexity index was measured through two items. In the first item, participants were instructed to rate the complexity of the sign on a 9-point scale in which 1 indicated very simple and 9 indicated very complex. Complexity was defined as the amount of detail or intricacy of line in the sign. Participants were told to rate the complexity of the drawing itself rather than the complexity of the real-life object it represented. The second item consisted in asking: "How would you evaluate this sign?" (1 = "Not complicated," 9 = "Very complicated"). Sign informativeness was measured by asking participants to evaluate how informative was the sign, on a 9-point scale in which 1 indicated "Not informative at all" and 9 indicated "Very informative."

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