Flip Animated Road Warning Sign

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March 16, 2017

Abstract

Studies of visual effects of road signs have shown that having dynamic imagery, and even better, animation, helps improve road signs as it increases a viewer's attentiveness. However, currently existing animated imagery signs, which are usually digital billboards, have drawbacks including distraction caused by bright LED lights, large energy consumption, and expensiveness. To overcome the problems, this project proposes creating a Flip Animated Road Sign, a new road sign without the use of a digital display that uses a mechanism of an automatically running mechanical flip book to produce animated imagery. The project proposes that features of animated visuals through flip animation can lead to perceived movement and prepare the observer for action. The research is operationalized within the context of warning sign icons and show how animated iconography can affect human behavioral response. Experiments measuring attention, quickness of response to, and perceived movement and risk of animated warning sign icons using driving simulations and surveys showed that there was no statistical difference between the data sets of flip animated warning signs and the data sets of regular warning signs. However, none of the flip animation or designed images were shown to make the meaning of the sign too confusing to understand.

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1 Introduction

People often comment that a particularly pleasing painting, photograph, or sculpture captures some sort of movement. As the survey by Friedman and Stevenson (Friedman and Stevenson [8]) and the results of the experiments on picture perception Freyd [7] suggest, this aesthetic may be due to the nature of the mental representations of such art. One of the reasons for excitement when viewing an artwork, say a painting or a sculpture, might be that the mental representation of the artwork is particularly dynamic; that we anticipate the potential movements of the static form. The property of movement that can be perceived in even the simple displays with skillful techniques that makes the works seem to come alive through the dynamics underlying their physical construction can appreciable as art, and go even further to give rise to the perception of goals and even mental states.

The perception of simple motion cues is important in imagery road signs, such as stop signs, school crossing signs, or directional arrows that play an important part in road safety. The impact of these signs and the important roles that they serve can especially be noticed when one explores a new city. Since people constantly encounter signs in their everyday lives, it is important to consider whether they can be improved to enhance the viewer's attentiveness and safety, and be enjoyable to looking at.Cian et al. [3]

Recent studies involving street signs and advertisement signs have indicated that static visuals with dynamic imagery, as shown in Figure 2 increases a viewer's attentiveness, as well as preparation for any action or future consequence that might be implied by the imagery (Cian 2015). For example, in the context of school traffic signs, viewers are likely to turn their attention more quickly towards the dynamic version of the sign shown as shown in Figure 2 (Cian 2015). Recreating signs with more dynamic imagery helps viewers pay more attention to the signs and improving road conditions.

Redrawing images into ones that have more implied motion is an option, but the most certain way to add dynamic stimulus to a sign is to actually show the animation of the moving road sign icon. Studies have shown that people instinctively pay attention to a series of moving images better than a static image (Pratt et al. [23]). Signs will therefore improve if they actually display rather than imply some movement. Animated signs, however, have not replaced static signs widely yet due to some drawbacks. There is a large energy consumption problem due to animated signs being digital, and many of them using LED lights. The signs are also expensive to build than static signs, with maintenance costs added to it (Greene and Valentini [9]). Animated signs are also challenging to design because they can become distracting if the duration of the animation is made too long. Most of all, LED signs have been observed that are considered to be excessively bright, serving as a distraction to especially drivers (Group [11]). Animated signs can gain more attention and have a kind of dynamic messaging that printed signs and graphics cannot provide, but

Figure 1: Example of a common flip book.

transforming existing signs into a digitally animated form is not the best solution.

In order to dynamically improve static signs, this project aims to create a new effective animated imagery road sign that overcomes the problems of the current digitally animated imagery signs. This new sign must at least consume less energy, be inexpensive, and not be distracting than the current animated sign. Since the high energy consumption of animated signs is due to the signs using a digital display or some kind of light, it is favorable if the new sign does not have this characteristic. If a sign does not use lights, the cost to maintain it will also be reduced. The distraction issue can be resolved by altering the animated images with a deeper understanding of the distracting features, which can be learned from existing research studies about distraction caused by animated signs to viewers.

These problems are hypothesized to be solved if the imagery of the road signs can be animated without any digital display. The method to do this that the project proposes and will tests, is creating a new type of sign called the ”Flip Animation Sign”, an automatically rotating large flip sign powered by a motor and programmed with an Arduino Uno to display a series of slides with sign images that subtly change so that the when flipped through the slides create an animated effect. The proposed Flip Animation Sign uses the same mechanism as flip book, which as a reminder, looks like Figure 1. It is similar to a mechanical flip book, except a stepper motor will make it operate automatically, and it is made controllable and programmable with an Arduino to make the flip animation stop at any specific slide. This sign will be created in order to prove that animated signs can be made without digital or LED lighting, and because it is the best proposed hypothesized method to make an animated road sign without the current disadvantages of animated signs. This new sign is theoretically expected to consume less energy, be inexpensive, and not be distracting than any currently existing digitally animated signs. After the proposed improved sign is created, an evaluation will be conducted to prove that the sign is indeed cost efficient and useful.

Figure 2: Example of dynamic road sign imagery

The Flip Animation Sign is ultimately an automatically running mechanical flip book that shows an animation of road sign icons moving and acting what it is warning the driver about. The mechanism is more appealing to create, and gives another level of appeal to the animation that it shows, compared to an animation shown on an LCD digital display. In this day when everything is always working towards becoming digitalized, the Flip Animation Sign also allows the viewer to look back and appreciate the art of this primitive form of animation. This study focuses on the design of road sign imagery because it was believed that the audience will be more interested to follow the study of non modern forms of art being positive integrations for something practical. Road signs are something we see everyday, we depend on, and always can be improved for our safety and help.

2 Background and Related Work

No studies have been conducted on ways to create an animated sign without the use of a digital display. However, research involving the effects of dynamic imagery on signs and the pros and cons of animated/digital signs exist, which will be beneficial to this project.

2.1 Dynamic Imagery Increases Attention

Visual imagery has been studied extensively within the fields of psychology and consumer behavior research in order to make clear what kind of actions are evoked from certain dynamic and static imagery. Studies using brand logos revealed that static dynamic visual element can evoke a perception of movement, and thereby affect consumer engagement and attitudes. Perceived movement evoked by the logo demonstrates that the evoked dynamic imagery affects the level of consumer engagement with the brand logo (Cian et al. [4]).

The ability to perceive movement was shown in another study where observers were given an image of an arrow that signaled at some direction, and were asked to localize the final position of an imaginary moving target that moved along the direction pointed by the arrow. The judged position was usually displaced from the actual position (Koch and Ullman [16]). There was a mental processes derived from a number of invariant and non invariant principles that produced the mislocalization in memory, proving that there was a selective visual attention enhanced from what the participant saw. The displacement from the true vanishing point is due to a high level cognitive mechanism capable of utilizing knowledge about probable target location that the dynamic image can imply. Images that contain analogues to friction and gravity are considered to influence people's perception of static forms (Hubbard [13]) and judgments of the locations of horizontally moving targets (Hubbard and Bharucha [14]).

Dynamic imagery therefore increases the viewer's visual attention. Even a still photograph of an object in motion may convey dynamic information about the position of the object immediately before and after the photograph was taken. Medial temporal/medial superior temporal cortex MT/MST is one of the main brain regions engaged in the perceptual analysis of visual motion. In an experiment, it was examined whether MT/MST is also involved in representing implied motion from static images. There was a stronger functional magnetic resonance imaging activation within MT/MST during the viewing of static photographs with implied motion compared to viewing of photographs without implied motion. These results suggest that brain regions involved in the visual analysis of motion are also engaged in processing implied dynamic information from static images. Psychophysical and physiological evidence also indicated that the visual system of humans evolved a specialized processing focus moving across the visual scene (Kourtzi and Kanwisher [18]).

2.2 Increased Attention through Dynamic Imagery leads to Positive Outcomes

Via dynamic imagery, static visuals can lead to perceived movement and prepare an observer for action. Research within the context of warning sign icons, show how subtle differences in iconography can affect human behavioral response. 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 attentiveness (Cian et al. 2015). Consumer behavior studies also highlight the importance of incorporating dynamic elements into icon design to promote imagery and thereby elicit desired and responsible consumer behavior. Visual product depictions within advertisements, such as the subtle manipulation of orienting a product toward a participant's dominant hand, were discovered to facilitate a mental simulation that evokes motor responses (Elder and Krishna 2012). Viewing an object was revealed to lead to similar behavioral consequences as interacting with the object, as the human mind mentally simulates the experience. For example, visually depicting a product that facilitates more embodied mental simulation results in heightened purchase intentions. Occupying the perceptual resources required for embodied mental simulation attenuates the impact of visual product depiction on purchase intentions. For negatively valenced products, facilitation of embodied mental simulation decreases purchase intentions.

The mental simulation of a certain experience that the imagery depicts can help viewers make better judgements. A study revealed that consumers often imagine themselves in a scene and engage in that self imagery while processing information, and the goals that they have when they engage in such imagery can influence how the mental images they generate affect judgments (Jiang et al. [15]). The study showed pictures from very different perspectives to participants, and those trying to imagine themselves in the scene were shown to shift visual perspectives in order to imagine the entire experience. This shift in visual perspective led to an increase in the ability to process difficulty.

There have also been studies conducted to determine the viability of a scenario procedure as a compliance technique. In one experiment, subjects who, through the use of a structured scenario, were led to imagine themselves experiencing certain events came to believe more strongly that the events would befall them (Gregory et al. [10]. This was true for both positive events, such as winning a contest, and negative events, such as being arrested for a crime. The scenario procedure was shown to influence not only probability judgments but also behavior. For example, homeowners who imagined themselves utilizing a cable television service were subsequently more likely to subscribe to such a service when requested to do so weeks later. It was determined that the effect of structured scenarios on compliance is not due to additional information provided by the scenario, but instead due to an interpretation based on the availability heuristic (Jiang et al. 2014).

Mental imagery is receiving increased attention in consumer behavior theory and research. Many researchable propositions for the relationship between high elaboration imagery processing and consumer choice and consumption behaviors, as well as specific methods for studying imagery are being proposed (Macinnis and Price [19]). One study that asked participants to mentally imagine consuming food typically leads to a decrease in subsequent intake (Morewedge et al. [21]). Habituation to a food item was found to occur even when its consumption was merely imagined. The results suggested that mental representation alone can engender habituation to a stimulus. Other existing research and commercial usage suggest that appeals urging consumers to imagine the product experience have powerful effects on product preferences (Petrova and Cialdini [22]). Imagery accessibility has an important role, and difficulty of imagery generation can reverse the generally observed positive effects of imagery appeals. When participants were low in imagery abilities or when the product was not presented in a vivid way, imagery appeals were not only ineffective but even had a negative effect on product preferences.

2.3 Dynamic Imagery can Best be Depicted Through Moving Imagery vs. Static Imagery

The benefits of moving imagery can first be explained with the way people view animate motion. Across humans' evolutionary history, detecting animate entities in the visual field such as prey and predators, has been critical for survival. Studies comparing the times for people to detect objects that were moving showed that the objects that were moving unpredictably or underwent animate motion were responded to more quickly than objects that underwent inanimate motion (Pratt et al. [23]). It is animate motion, such as humans or animals in action, or anticipated change in direction and speed, that captures visual attention, not just motion per se, such as active nature scenes (Kourtzi and Kanwisher 2000). The onset of motion is what especially attracts attention (Abrams and Christ 2003). A study has even revealed that new motion captures attention over colour change, regardless of the observer's goals (Aidroos et al. [1]). When a stationary object begins to move, visual spatial attention is reflexively deployed to the location of that object. This conclusion entails that new motion is an important determinant of when, and to where, visual spatial attention is deployed.

The onset of motion captures attention during visual search even if the motion is not task relevant, which suggests that motion onsets capture attention in a stimulus driven manner (Cosman and Vecera [5]). The onset of motion can capture attention more effectively than either the offset of motion or continuous motion (Guo et al. [12]). Attention can be prioritized on the basis of perceived motion onset by an object in the absence of low level luminance transients. This may reflect an evolutionary adaptation to bias attention toward objects that exhibit characteristics of animacy, such as abruptly changing from a static to a dynamic state.

Certain simple visual displays consisting of moving 2D geometric shapes have been revealed that they can give rise to percepts with high level properties such as causality and animacy (**choll.tremoulet:perceptualcausality**). There have already been measures such as just using dynamic animated symbols to explain traffic regulations without words (Korica and Maurer [17]). There are also studies on drivers' behavior towards road signs, how they react, and actions taken once they see warning given, and overall the drivers do give positive responses to animated signs display (Mahasan et al. [20]). Thanks to the latest technology, drivers now can get the latest and updated traffic info with Variable Message Signs, VMS. Compared to static and printed signs, VMS is more compatible because it displays signs and also captures the driver's attention with bright lights including LED lights, which can deliver more visual impact and alert drivers. Instead of using long text which takes four to six seconds for drivers to read, this study that attempted to improve the VMS display and simplify all long text and static signs into animated versions to discover a new method to deliver messages by using animated signs. Drivers respond to the message given by pressing car brake's when they saw the message display on VMS board. The study supported the importance of ensuring that drivers are able to understand and capture the messages display fast so that they can act accordingly in order to avoid accidents. This study found that drivers do give respond to animated signs and alert with the message display on VMS board. It showed that animated signs do give impact to drivers and help them understand the traffic signs easier and faster ,as well as give them more impact and alertness in order to reduce accidents compared to existing printed signs (warning danger signs).

2.4 Problems of Animated Signs

Whether the electronic billboards attract too much attention and constitute a traffic safety hazard cannot be answered conclusively based on the present data, but there has been much controversy regarding the potential safety hazard posed by digital signage. Many studies show that such signage can lead to driver distraction and traffic delays (Young [24]). There have been cases where outcries from activists and concerned citizens lead to some policymakers to regulate distracting, electronic billboard signage (Wachtel, 2009). There has been relatively little research, however, regarding the environmental and energy consumption issues raised by this new technology. There is also an increase in electronic advertising billboards along major roads, which may cause driver distraction due to the highly conspicuous design of the electronic billboards (Dukic et al. [6]). Visual behavior data shows that drivers have a significantly longer dwell time, a greater number of fixations, and longer maximum fixation duration when driving past an electronic billboard compared to other signs on the same road stretches. Electronic billboards and roadside advertising signs are also said to have an effect on gaze behavior by attracting more and longer glances than regular traffic signs or the static and non-electric billboards, and are considered to be one of the major external distraction causes (Bendak and Saleh [2]). No differences are found for the factors day/night, and no effect has been found for the driving behavior data. There has also been a study that was precipitated by concerns raised by the City of Minnetonka, Minnesota in regard to the installation of two LED, light emitting diode, billboards (Group [11]). While the concerns were precipitated by LED billboards in particular, this report examines more broadly dynamic display signage which is defined as any characteristics of a sign that appear to have movement or that appear to change, caused by any method other than physically removing and replacing the sign or its components, whether the apparent movement or change is in the display, the sign structure itself, or any other component of the sign

3 Flip Animation Sign Project Objective

The Flip Animation Sign is a kinetic art that absorbs the viewer's interest and fascination with its minutely toothed gears, clips, nuts, bolts, racks, worm wheels and sprocket. The mechanical construction, despite the possibility of it to wear out, creates a movement that leads to the illusion of motion that makes the viewer want to flip through the images over and over again. Although the illusion of motion is pretty fast, the real-time movement of the Flip Sign creates a tasteful amount of time for the viewer to unconsciously stop and wait for the next motion to happen. This was anticipated to make the participants in the study of the project pay attention to the animation more and slow down in whatever action they were in. This act of slowing down is something that the world today frequently dismisses, as many things like electronic devices or animation are always rapidly made to be more efficient and faster.

The goal of the Flip Animation Sign Project was to prove that it is possible to create a low cost, energy-efficient, and non-distracting animated road sign without using a digital display and LED lights. I hypothesized that the Flip Animation Sign would catch the attention of the viewer/driver more than regular static signs and be more effective in warning a potential happening. The outcomes were though to be valuable in proving the importance of dynamic stimulus in road sign imagery, and exploring further possibilities to improve signs that play an important part of everyday life. The non-digital animation was achieved with the Flip Animation Sign's mechanism that automatically rotated and flipped through a series of static images to create an animation. The Arduino allowed the timing and halting of the flipping of the slides to be programmable and controlled.

The method of Herman Casler, the inventor of the mutoscope, of mounting slides to a rotating cylinder was used in the Flip Animation Sign. The few seconds long animation was split into twenty-four still images printed onto flip cards, that were then attached to the rotating axis of the spindle. A plastic flip card stopper helped flip through the cards more controllably and stop at any specific slide if desired.

The sign's usefulness was be tested with an evaluation experiment containing two tasks for participants to complete online. The first task collected realistic reaction time using a short driving simulation video from a driver's perspective, and the second study measured the effect of dynamic imagery and perceived risk of certain road signs using a survey.

4 Flip Animated Sign Design and Construction

An animated road sign without the use of a digital display was made similarly to a mechanical flip book, except a stepper motor programmed by Arduino Uno R3, a micro-controller board, was used to make

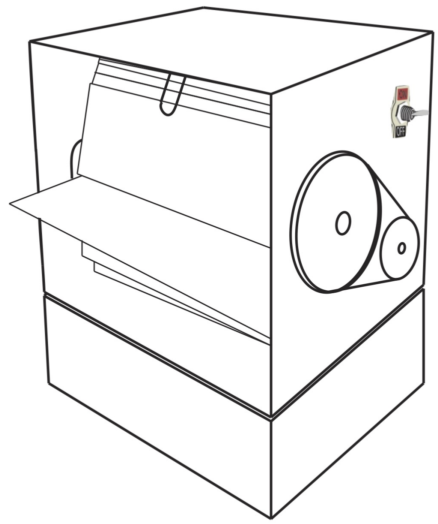

Figure 3: Design of the Flip Animated Sign

it operate automatically and to make the animation stop at any specific slide. From the art perspective, this device incorporated not only icon designing and painting for each image slide, but also the primitive form of animation using flip books. Benefits of incorporating this early motion picture device can be that its attractive animation can give the viewer the moment to stop to look at the unfamiliar animation, and as a result slow down in a positive way due to concentration.

Four different animated road warning signs were made with this device: a school crossing sign, a deer crossing sign, a steep hill sign, and a falling rocks sign. The design of the outward appearance of the Flip Animated Sign is shown in Figure 3. As evident in the Figure, the Flip Animated Sign was constructed as a box with no lid on the side where the animation is to been seen. The spindle that is inside rotates because of two extending dowel pins on both sides of the spindle that rest on two bushing holes made on the sides of the box. The dowel pin on the right side of the viewer's view of the box is attached to a crank pulley. This attachment to the crank pulley allows the spindle to rotate when the crank is rotated. The stepper motor is attached to the back bottom right side of the box, with its shaft sticking out from a hole the right side of the driving scene on the wall. On the outside, the shaft is connected to a fitted pulley. The stepper motor is connected to an Arduino Uno R3, a micro-controller board, through a motor driver, which is powered with an AC adapter that can be plugged to the wall. The Arduino is also connected to a toggle switch that is also protruding from a hole on the back top right side of the wall so that the sign's motion can be controlled with the switch. The fitted pulley and the crank pulley on the outside of the right side of the box is connected with a rubber belt, so that when the stepper motor moves the fitted pulley, the crank pulley will also move to rotate the spindle. The Arduino was used to program the speed of the stepper motor, and control the

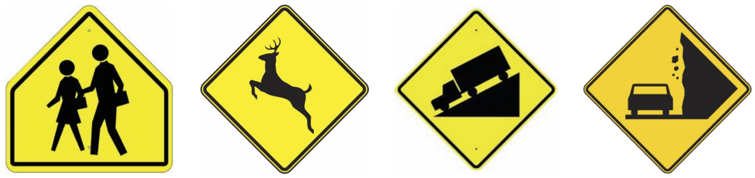

Figure 4: Four existing warning signs that were made into Flip Animated warning signs

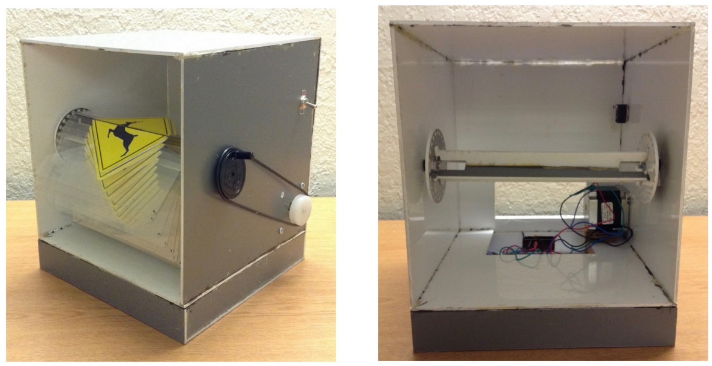

Figure 5: The built Flip Animated Sign

number of slides that was be flipped through and where the flipping stopped at. In order to make the Flip Animation Sign stop at a specific slide, a plastic flipper and page-catch was attached to the inside of the top of the box on the opening side.

The box, slides, and spindle assembly parts were delicately designed to create a Flip Animation Sign with a 10 inch by 10 inch window frame for the opening. The box walls and spindle parts were designed on Adobe illustrator, and cut out of acrylic sheets with a laser cutting machine. The slides that attached to the spindle were cut out from 0.5 mm thin plastic sheets. The animation of the four types of warning signs, which were variants of existing signs of school crossing, deer, steep hill, and falling rocks shown in Figure 4 were first designed, and each type of sign was divided into an image sequence of twenty-four images, matching the number of twenty-four slides that the spindle can hold. After deciding on the image sequence of each type of sign from a number of trials, the images of each slide were painted with acrylic paint on canvas paper, cut out, and glued to each plastic slide. The slides were then attached to the spindle in the right order. Figure 5 shows the completed Flip Animated Sign device, and Figures 6, 7, 8, 9 show stills of the Flip Animated warning signs.

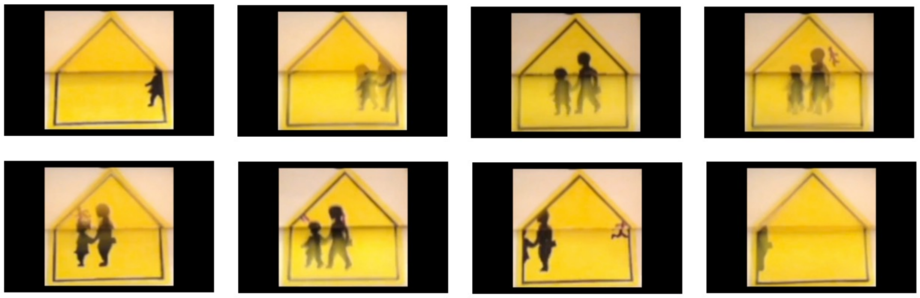

Figure 6: Stills of the School Crossing Flip Animated Sign

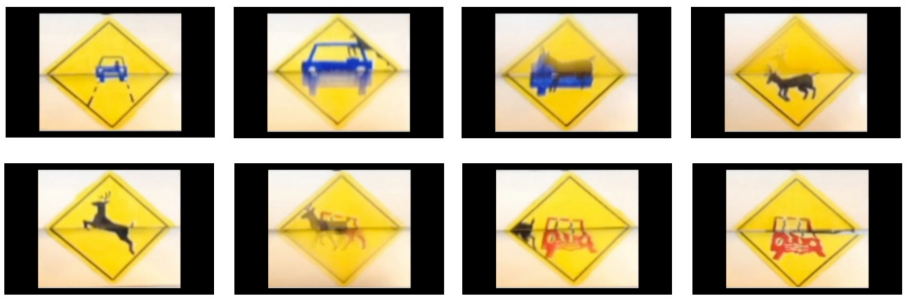

Figure 7: Stills of the Deer Crossing Flip Animated Sign

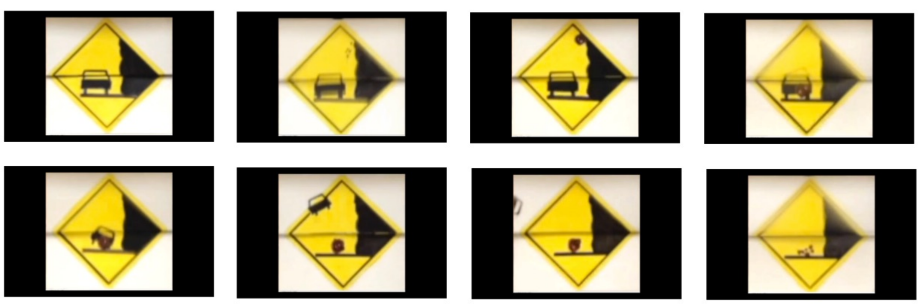

Figure 8: Stills of the Falling Rocks Flip Animated Sign

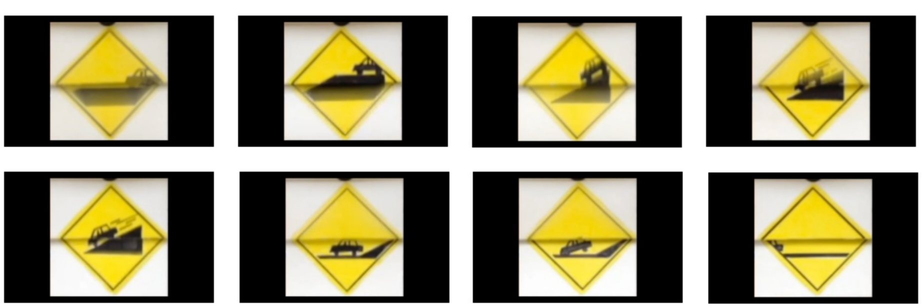

Figure 9: Stills of the Steep Hills Flip Animated Sign

Figure 10: A screenshot from the reaction time study (Task 1)

5 Flip Animated Sign Evaluation Experiment

The experimental procedure compared the effects of the still version and the flip animated version of the signs. The two tasks that were made were based on Cian's experiment mentioned earlier, which tested attention and quickness of response to a warning sign icon, and also whether perceived movement within warning sign icons lead to more cautious behavior. The first task collected realistic reaction time using a short driving simulation video from a driver's perspective that showed static versions and the Flip Animation version of the signs on the side of the road, with participants being asked to indicate when they recognized certain signs. The second study measured the effect of dynamic imagery and perceived risk of the flip animated road signs using surveys. The online experiment was built using Wextor, an online experiment design tool, and uploaded it onto Amazon Mechanical Turk, an online marketplace that asks workers to complete Human Intelligence Tasks.

5.1 Task 1 (Driving Simulation): Measuring the Impact of Animated Iconography on Reaction Time

Task 1 tested for quickness of response to a warning sign icon. The experiment had participants watch a driving simulation video from a driver's perspective, which was created in order to design a realistic and involving reaction time study. The video was edited showing a drive on a highway, an urban city street, and a rural country road, as shown in Figure 10, a screenshot of the study. In the video, warning signs appeared for about five seconds, zooming into the screen and then out. The purpose of having the signs zoom in and out was to simulate the way road signs are seen by drivers when driving, as they would appear small at a farther distance and become larger as the car approaches them. The video was two minutes long.

Figure 11: Examples of warning signs

This task was interested in how quickly participants would respond to the signs that appeared in the scenario. The participants who imagined themselves to be drivers were asked to press a key on the keyboard to indicated their reaction to a sign that appeared. I hypothesized that when a person sees a sign and gets ready for action, pressing the key should be faster when viewing the flip animated sign icon compared to a regular static sign icon. In order to gather the participant's deliberate reactions to traffic warning signs, and avoid the problem of participants hitting a key when anything appeared on the screen, two types of traffic signs, warning signs and informative signs, were included in the video. The two types of signs aimed to warrant different reactions from the participants, necessitate caution, and not a mindless hitting of a key. Before showing the video, participants were shown examples of warning signs (Figure 11), and given definitions of warning and informative signs. Participants were instructed 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 were also shown examples of informative signs (Figure 12), and instructed that informative signs provide additional information identifying a direction or a general service but do not require a reduction of speed. Participants were told that they would be viewing several traffic signs, and asked to press the "w" key when they recognized a warning sign, and the "i" key for an informative sign.

Two versions of the video were made, with each having seven road signs appearing –four warning signs and three informatory signs. For warning signs, the four animated signs made from the Flip Animated Sign device were used. The three informative signs used in the video are shown in Figure 13. The informative signs were all static signs. In order to not have the participants see the static version and the Flip Animated version of the same warning sign icons in the video, as participants may become faster at recognizing a sign because of increased familiarity, Version 1 of the video showed two of the four warning signs in their static forms, and the remaining two in the Flip Animated forms. Version 2 of the video showed the Flip

Figure 12: Examples of informatory signs

Figure 13: Informative signs used in the driving simulation video (Task 1)

Animated versions of the warning signs that were static, and the static versions of the warning signs that were Flip Animated in Version 1 of the video. The version of the video that each participant saw was chosen randomly. Thus, each participant that saw the video were exposed to all four warning signs and all three informatory signs, with two of the four warning signs being Flip Animated and two being static.

Forty-seven participants who were administered on Amazon Mechanical Turk were paid to participate in the study. When participants pressed the ”i” or ”w” key, they would see a pop up message on the screen that told them what key they pressed. Key press times other than the ”i” and”w” keys were still recorded but not informed to the participants.

5.1.1 Results

The very first reaction times or keypress times after the appearance of each sign were recorded, and all of the other keypress times were seen as inaccurate trials. To see the difference in reaction times between Flip Animated and static signs, a table for the Flip Animated warning sign times, and another table for the static warning sign times were made. An analysis was performed with a non-related t-test to determine if data sets of the flip animation signs significantly differed from those of the regular static signs. As shown in Figure 1, all p-values from the t-tests were greater than the 0.05 cut off point, meaning there was no statistical difference between the data sets of flip animation signs and the data sets of regular still signs. The nonsignificant interaction between sign type and animation indicates that the difference in reaction

Reaction Times After Flip Animated Sign Appearance:

	Falling Rocks (ms)	Steep Hill (ms)	Deer Crossing (ms)	School Crossing (ms)
AVG:	6715.5	5405.210526	5453.230769	9666.117647
MIN:	4359	261	258	49
MAX:	9834	11571	11497	17242
N:	10	19	13	17

Reaction Times After Still Sign Appearance:

	Falling Rocks (ms)	Steep Hill (ms)	Deer Crossing (ms)	School Crossing (ms)
AVG:	5383.727273	6904.230769	3302.538462	9945.176471
MIN:	2702	1367	554	536
MAX:	7965	10949	6644	23759
N:	11	13	13	17

P-Value:

	Falling Rocks Signs	Steep Hill Signs	Deer Crossing Signs	School Crossing Signs
P-value from T-Test	0.0881900718	0.1481991943	0.06322410209	0.9084858441

Table 1: Reaction time values from Task 2.

times for a particular ”static to Flip Animated” pair of warning sign icons is not significantly different from the other three warning sign icons.

5.2 Task 2 (Survey): Measuring Perceived Movement, Vigilance, and Attention

The second task was comprised of survey questions pertaining to an image of a road and a warning sign. The perceived risk of each Flip Animated warning sign compared to that of the regular static version of the warning sign was measured by having the participants look at a bird’s eye view of a road with a sign at the end as shown in Figure 15. The participants were asked to imagine that they had been driving on the road starting from the bottom side of the image that says ”start”. Two versions of the bird’s eye view of the road image were made for each of the four types of warning signs in order to not have the participants see the static version and the Flip Animated version of the same warning sign on the road image, Version 1 of the survey showed two images of static forms of two of the four warning signs appearing at the end of the bird’s eye view of the road. The other two bird’s eye view road images had the remaining signs in their Flip Animated forms. Version 2 of the survey showed the Flip Animated versions of the warning signs that were static, and the static versions of the warning signs that were Flip Animated in the images of Version 1 of the survey. Before the survey, participants were given instructions and explained that they would see a

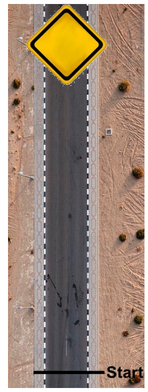

Figure 14: Bird's eye view of the road shown in Task 2.

Figure 15: Bird's eye view of the road shown in Task 2 with a warning sign and labeled areas.

bird's eye view of a road. They were shown Figure 14's image, an example image of the road that did not have a warning sign image or labeled areas.

The forty-seven participants administered on Amazon Mechanical Turk viewed the four warning signs appearing at the end of the bird's eye view image of a road. For the first question, the participants were asked to indicate where they would decide to stop or slow down their car on the road in response to the sign that they see. The image of the bird's eye view of the road had fifteen divided areas between the start line and the road sign image labeled with a sequence alphabet letters ″A″ - ″O″ as shown in Figure 15. The first area after the start line was labeled with ″A″, and the next letter labeled the next area after ″A″, and so on. ″O″ labeled the areas closest to the warning sign at the end of the road.

The second, third, and fourth questions asked to rate the sign on its cautious level, speed reduction level, and vividness level, each on a scale of 1 to 10. For the cautious level, the question of how cautiously the participant would drive up the road was asked, and the scale of 1 was ″not at all cautiously″, and 10 was ″very cautiously″. For the speed reduction level, the question of how slowly the participant would drive up the road relative to their normal pace was asked, and the scale of 1 was ″the same speed as normal", and 10 was "extremely slower than normal". For the vividness level, the question of how vivid the road image appeared to the participant was asked, and the scale of 1 was "not at all vivid/intense/lifelike/sharp/defined", and 10 was "extremely vivid/intense/lifelike/sharp/defined".

The fifth and final question asked to the participants was an open-ended question, "what is this sign conveying?" This was to see if the participants understood the meaning of each sign's image/animation.

5.2.1 Results

Results from t-tests between the measures of the Flip Animated and regular static versions of each warning sign showed that there was no statistical difference due to a p-value scale greater than the cutoff point of 0.05 as shown in Tables 1-5. To analyze the stopping points that were indicated on the bird's eye view of the road, the letter labels were translated into numbers from 1 to 15. The low number indicated an early stopping point (1="A" and 15="O"), and a higher perceived risk from the sign. The average stopping points were calculated in Table 2. The stopping points in response to the Falling Rocks and Deer Crossing flip animation signs were on average at an earlier point than the regular still signs, suggesting that participants perceived a greater risk in the falling rocks and deer crossing flip animation signs (6.72¡8.63 for the falling rocks sign, and 7.05¡9.60 for the deer crossing sign).

The average caution levels of each sign were calculated in Table 3. The highest number of 10 means the participants answered that they would proceed down the road extremely cautiously in response to the sign that they saw. On average, the Flip Animated version of the deer crossing sign and the Steep Hill sign made participants slightly more cautious than the static versions when they imaginarily proceeded forward on the road (7.27¿6.63 for the deer crossing sign, and 7.45¿6.72 for the steep hill sign).

The speed-reduction levels of each sign were calculated in Table 4. The highest number of 10 means the participants would drive slower than their normal speed when they saw a sign. Participants answered they they will drive slowly than normal for most of the flip animated signs compared to static signs. The only exception was the school crossing sign by a small difference (7.50¿7.05).

The vividness levels of each sign were calculated in Table 5. The highest number of 10 meant that the sign was clear or vivid, and easy to understand. There were no significant differences in which version of the sign was visually sharp and easy to see, although on average the Flip Animated version of the falling rocks and deer crossing signs were rated as more vivid than the static versions. However, this was likely influenced by the amount of lighting that each video of the Flip Animated signs had when being recorded, and not influenced by the actual design and coloring of each icon imagery.

All participants answered what each Flip Animation Sign warning sign expressed, as well as the static

Flip Animated Sign Stopping Points:

	Falling Rocks	Steep Hill	Deer Crossing	School Crossing
AVG	6.727272727	8.75	7.05	8.105263158
MIN	1	3	1	1
MAX	14	14	14	13
MODE	7	7	1	9

Still Sign Stopping Points:

	Falling Rocks	Steep Hill	Deer Crossing	School Crossing
AVG:	8.631578947	8.238095238	9.6	7.3
MODE:	10	8	5	1
MIN:	1	1	2	1
MAX:	15	14	15	15

P-Value:

	Falling Rocks Signs	Steep Hill Signs	Deer Crossing Signs	School Crossing Signs
P-value from T-Test:	0.1298361948	0.6065468428	0.07596360841	0.5463402906

Table 2: Stopping point values from Task 2

versions of them. Therefore, it was induced that none of the Flip Animation motion or designed animated images made the meaning of the sign too confusing to understand.

6 Conclusion and Future Work

Unfortunately, the results did not show which type of sign would be better or effective than the other. The the data sets of flip animation signs and the data sets of regular still signs may have been statistically different if there was a larger number of participants. Even in Cian et al's experiment, the results were as hypothesized but showed no significant difference even with at least 240 participants. An even larger number of participants will be favorable.

However, the participants' understanding of the Flip Animated warning signs' meanings made the signs user-friendly, and revealed that there were no major problems caused by the Flip Animated signs. The results from stopping point question of the survey task indicated that participants perceived a greater risk in the falling rocks and deer crossing Flip Animated signs compared to their static versions. Comparing the Flip Animated falling rocks and deer crossing signs to the Flip Animated steep hill and school crossing signs (FIGURES 8 and 7) identified that the falling rocks and deer crossing signs both had more colors

Still Sign Caution Level:

	Falling Rocks	Steep Hill	Deer Crossing	School Crossing
AVG	7.318181818	6.727272727	6.636363636	8.363636364
MIN:	3	1	2	4
MAX:	10	10	10	10
N:	22	22	22	22
MODE	10	8	6	8

Flip Animated Sign Caution Level:

	Falling Rocks	Steep Hill	Deer Crossing	School Crossing
AVG:	6.826086957	7.454545455	7.272727273	8.181818182
MIN:	1	3	2	4
MAX:	10	10	10	10
N:	23	22	22	22
MODE:	10	7	8	8

P-Value:

	Falling Rocks Signs	Steep Hill Signs	Deer Crossing Signs	School Crossing Signs
P-value from T-Test	0.5165130887	0.2662566993	0.3077212222	0.7092442183

Table 3: Caution levels from Task 2

Speed Level for Still Signs:

	Falling Rocks	Steep Hill	Deer Crossing	School Crossing
AVG:	5.227272727	6.454545455	5.318181818	7.5
MIN:	1	1	1	1
MAX:	10	10	10	10
N:	22	22	22	22
MODE:	1	9	4	8

Speed Level for Flip Animated Signs:

	Falling Rocks	Steep Hill	Deer Crossing	School Crossing
AVG:	5.913043478	6.5	5.954545455	7.045454545
MIN:	1	3	1	3
MAX:	10	10	10	10
N:	23	22	22	22
MODE:	7	8	7	7

P-Value:

	Falling Rocks Signs	Steep Hill Signs	Deer Crossing Signs	School Crossing Signs
P-value from T-Test	0.4219479476	0.9472102506	0.3918323532	0.4332499828

Table 4: Speed reduction levels from Task 2

Still Sign Vividness Level:

	Falling Rocks	Steep Hill	Deer Crossing	School Crossing
AVG:	7.227272727	8.045454545	6.590909091	7.954545455
MIN:	1	2	1	2
MAX:	10	10	10	10
N:	22	22	22	22
MODE:	8	8	8	10

Flip Animated Sign Vividness Level:

	Falling Rocks	Steep Hill	Deer Crossing	School Crossing
AVG:	7.391304348	6.772727273	8.227272727	7
MIN:	3	1	3	1
MAX:	10	10	10	10
N:	23	22	22	22
MODE:	10	8	9	9

P-Value:

	Falling Rocks Signs	Steep Hill Signs	Deer Crossing Signs	School Crossing Signs
P-value from T-Test	0.8038748525	0.08230779785	0.03497734608	0.2605849535

Table 5: Vividness levels from Task 2

used besides the two colors of yellow and black. Future research on the impact of color and attentiveness will therefore be useful. The signs also had a more dynamic motion indicated in the image, specifically the motion of something jumping in or jumping out, as the deer in the Flip Animated deer crossing sign jumped into the frame of the sign, and the car in the Flip Animated falling rocks sign jumped out of the frame of the sign when the boulder fell. The implications stemming from animation and dynamic imagery will therefore also need further exploration.

Since there were no faster reaction times for the flip animated signs recorded from the driving simulation test as hypothesized, the reaction time test could be redone. Informing the participants that that the purpose of the task is to measure reaction time may lead to obtaining realistically faster response times. In order to produce more statistically different results between the Flip Animated signs and the static signs, better pretests could have been done before the tests to ensure that participants were more familiar correctly understood the differences of the signs. If the pretest before the survey task asked the participants to indicate their understanding in some way such as asking them to read the text, ”I understand that I will visualize myself in the scenario and use the power of my imagination to make my choice”, and asking them to answer ”yes” or ”no” would have increased each participant's likeliness of making a logical and rational choice.

After the implications stemming from animation, dynamic imagery, and color are found, the Flip Animated signs can definitely be improved to be more attentive or eye catching. Although the acrylic sheets were noted to durable under any temperature and moisture, the materials used for the Flip Animated Signs will still need to be reinspected to see if they can withstand the outdoors environment. To test the sturdiness of the device, an experiment in an outdoor setting on an actual road would be fitting. As drivers do give positively respond to animated signs display, the transformation process of the existing signs to animated form can potentially be done.

The Flip Animated sign is definitely energy efficient compared to the electronic signs like billboards that have digitally animated images. Although the energy consumption units differ, a digital billboard has many variables for power consumption, including size, resolution (how close pixels are spaced, aka diode density), how many LEDs are in each pixel, the color capabilities of the board (tri-color or full color), the image being displayed, and time of day because daytime operation requires more power than nighttime operation,as the image must compete with the brightness of the sun. LEDs may have lower wattage and greater luminance than the more traditional fluorescent, incandescent, or halogen bulbs. However, static and Flip Animated signage can be illuminated by only two or three ”inefficient” lamps at nighttime, compared to digital signs which are comprised of hundreds, if not thousands, of LED bulbs, each using between 2-10 watts twenty-four hours a day. Considering this simple fact, it is no surprise that overall energy consumption of digital signage exceeds that of a Flip Animated sign, and makes bulb-to-bulb comparisons irrelevant. Additionally, with all digital display types, workers who control the changeable images and the fans required to cool them must be taken into account, as they too increase energy consumption.

While being fun to see, the function of the Flip Animated Sign proves that art can be applied to more functional, everyday things. There were no real indicators that said the flip signs were more distracting, but various semiotics study on animated signs are needed to make sure that the signs meaning can be clearly understood to avoid confusion that may endanger users especially drivers

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