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Opportunities to Improve Work Zone Zipper Merge Compliance with Behavioral Science

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Abstract: Research demonstrates that zipper merges (or late merges) are safer and faster than a traditional early merge under heavy traffic conditions. However, in implementation, zipper merges can be less efficient due to a lack of compliance on the part of drivers, who tend to be more accustomed to early merging. Behavioral science has been applied to a many transportation-related challenges, such as increasing seat belt usage and decreasing drinking and driving, but has not yet been applied to the zipper merge. Based on the literature, we have identified seven behavioral science concepts to leverage in zipper merge communications including (1) instructions, (2) information, (3) social norms, (4) appeals to reason, (5) emotional appeals, (6) humor, and (7) activators. To evaluate the prevalence of these concepts, we reviewed existing physical sign and online communications from U.S. state Departments of Transportation. Across the 16 states currently using zipper merges, instructional signs and appeals to reason were most frequently employed. More research is needed to determine the effectiveness of using behaviorally informed communications to increase zipper merge compliance.

1. INTRODUCTION

Although the zipper merge has been common practice in parts of Europe since the 1970's, it hasn't been employed in the United States until the 2010's. Zipper merging is a traffic management system implemented at merge points where a two-lane road merges into one lane. Mostly, this method is applied in temporary road closure zones, such as construction work zones. Traditionally, in such a situation, drivers would be directed to merge when possible as soon as they are notified of the lane closure ahead. However, in a zipper merge, drivers are encouraged to utilize both open lanes until just before the merge point, and then merge when directed. Drivers should then alternate, taking turns in letting those in the closing lane merge into the open one.

Studies demonstrate the superiority of zipper merging under heavy traffic conditions (Grillo, Datta, & Hartner, 2008). In light traffic, it is still faster and safer to encourage drivers to early merge. However, once traffic starts slowing down, zipper merging has been shown to produce shorter queues and safer merges in work zone lane closure situations. Shorter queues and safety can go hand in hand. Not only do long, slow moving traffic back-ups cause frustration and stress in drivers, they also can frequently get so long that they extend beyond signage indicating lane closure ahead which can increase risks of crashes if drivers have received no warning that traffic may be stopped ahead. Additionally, the unused capacity created by the early merge allows for queue jumping, which, especially given heightened frustration and emotional duress typical of drivers stuck in slow moving traffic, can lead to road rage on the part of other drivers which could also lead to higher risk of accidents. A zipper merge alleviates these risks by creating a uniform system of merging that uses the full capacity of the road and increasing the fairness of merging under conditions that are high-stress for many drivers.

Despite the benefits, zipper merge compliance is difficult to achieve for many states. Zipper merging is counter-intuitive for most drivers, who were taught to get over early when a lane is closing ahead (Grillo, Datta, & Hartner, 2008). This leads many commuters to have concerns that no one will let them in when they get to the merge point, or that they will be negatively perceived

as a queue jumper or generally rude driver. All these factors contribute to drivers' hesitancy to implement zipper merging.

One way in which states may be able to improve zipper merge compliance is by improving the way in which they communicate about them. Behavioral science has been applied in other transportation communications and it seems likely that a more behaviorally minded approach to communicating about zipper merges could be effective. The purpose of this paper is to provide a review of various behavioral science concepts currently being utilized by states in their zipper merge signs and other communications, and to identify where additions could be made to further improve public communication.

2. LITERATURE REVIEW

Behavioral science has been used to encourage tax compliance (Cialdini, Martin, & Goldstein, 2015), increase energy efficiency behavior (Allcott & Mullainathan, 2010), and reduce cybersecurity risk (Pfleeger & Caputo, 2012). Across these scenarios, researchers are able to leverage behavioral theories to design communications that encourage desirable behaviors. Here, we highlight three theoretical frameworks that are particularly relevant for increasing zipper merge compliance, the (1) knowledge deficit model, (2) social cognitive theory, and (3) elaboration-likelihood model.

The knowledge deficit model proposes that non-compliant behavior is driven by a lack of knowledge. Therefore, this model suggests that if people are informed about the benefits of zipper merging, there will be high driver compliance. This model has primarily been discussed in the context of science communication and why nonexperts do not follow scientific advice (Sturgis & Allum, 2004). However, there is increasing recognition that knowledge alone is not sufficient for behavior change (Scheufele, 2013). Empirical research suggests that this model is over simplified and does not account for the diverse factors that influence behavioral intentions.

Social cognitive theory proposes that individuals learn from observing how other people behave. Thus, if other drivers are early merging, then drivers will be more likely to early merge, regardless of communications directing drivers to zipper merge. Empirical research suggests that individual behavior is highly influenced by perceptions of social norms. For example, sending households messages that they use more electricity than their neighbors have been effective for decreasing residential electricity use (Allcott & Mullainathan, 2010). However, if households are informed that they use less electricity than their neighbors, there is a tendency to increase consumption. Research suggests that messaging that affirms the desirable behavior can mitigate this effect (Schultz et al., 2007).

The elaboration-likelihood model of persuasion suggests that messages are more persuasive when the audience is motivated and able to fully process the message. The audience must pay attention to, understand, and agree with the message for it to be effective (Petty & Cacioppo, 1981). Therefore, for zipper merges, messages must be easy to understand and use appeals that most people will find compelling. These appeals may allude to reason/logic or emotion to be convincing (Bator & Cialdini, 2000). In addition, messages need to be memorable to encourage long-term shifts in attitudes. This may be achieved through humor or other memory activators. In the extended elaboration likelihood model (Slater & Rouner, 2002), evidence suggests that entertainment-education messages that use humor are more effective because the audience is in a less critical, more agreeable state (Moyer-Gusé, 2008). In a world with competing messages, more memorable communications are likely to be more effective by drawing more attention. Using consistent messaging with memorable components, such as a rhyming jingle, can support persuasion efforts (Keller, 1987).

In the context of transportation, behavioral science has been consistently applied to improve the effectiveness of communications. In a review of behavioral approaches to seat-belt use, Geller (1988) proposes an ABC model that uses Activators to encourage Behavior which has Consequences. Activators, or pre-behavior efforts, include reminders (such as stickers, signs, and blinking lights in cars) and modeling of desirable behavior (by celebrities and images in public service announcements). Consequences, or post-behavior efforts, include both positive and negative reinforcement. For seat belt use, positive reinforcement may include entering seat-belt wearing drivers into a raffle while negative reinforcement includes fines from police for noncompliance. In a review of persuasion campaigns for road safety, Guttman (2016) reviewed existing materials to develop 5 main types of approaches, which include, (1) appeals to reason, (2) appeals to negative emotions, (3) appeals to positive emotions, (4) threat of enforcement, and (5) humor. He found that most communications use appeals to reason, but more research is needed to determine which messages (or combination of messages) are the most effective. Behavioral research has also been applied to encourage more environmental travel choices, such as carpooling and use of public transportation. In these cases, messages related to reduced travel time and cost as well as employer support are effective (Wachs, 1991; McFadden, 2007).

3. METHODS

In this study, we performed qualitative analysis of existing zipper merge materials to determine the current use of behavioral science strategies.

3.1. Materials

We collected public-facing state-level DOT communications by searching “zipper merge” OR “late merge” on each U.S. state’s website. These materials included all public-facing documents that included an announcement of zipper merge implementation, a description of how to do one, or information about zipper merge specific signs. Excluded materials included construction updates that mentioned zipper merges but provided no information for the public about what to expect from a zipper merge, such as how to zipper merge or signs to look for. We also excluded any materials that mentioned zipper merges but were obviously not public facing, such as transcripts of department planning meetings or documents from inter-departments presentations. The materials span the years from 2011-2020.

This analysis separates communications that describe signs used at zipper merge locations and any public communication to inform the public about zipper merges in general or the implementation of a zipper merge in a particular location. Communications that describe signs were almost exclusively construction updates intended to inform the public about a particular zipper merge location and what signals and instructions to watch for. Public communications more broadly include press releases, radio ads, videos, and articles that explain what a zipper merge is, how to do it, and how or where the department intended to implement them.

3.2. Analysis

Using a deductive approach, we characterized the use of behavioral science strategies based on existing theories. Based on the literature review, we developed a coding scheme that included six categories, (1) instructions, (2) information, (3) social norms, (4) appeals to reason, (5) emotional appeals, (6) humor, and (7) activators summarized in Table 1. The coding was performed by two independent coders and any disagreements were resolved by a third member of the research team.

Table 1. Summary of the Coding Scheme for Behavioral Science Strategies.

Strategy	Definition	Example
Knowledge Deficit Model		
Instructions	Signs that explicitly tell drivers what to do	Merge in ½ Mile, Merge Here
Information	Signs that only provide drivers with information	Roadwork ahead
Social Cognitive Theory		
Social Norms	Promoting or working against a pressure felt because of a societal expectation, real or imagined, to engage in a behavior	“People generally think the polite thing to do is to merge early”
Elaboration Likelihood Model		
Appeals to Reason	Appealing to rationality by describing either benefits to be received by engaging in the behavior or costs to be received by not engaging in it	Moving faster, Fewer accidents, Less back-ups
Emotional Appeals	Appealing to a person’s feelings or emotions via messages related to generosity, which appeal to their sense of rightness or fairness and desire for the general welfare, and commiseration, which attempt to win people over by identifying with their struggle	Take Turns, “We’ve all been there”
Humor	Making audience more receptive to a message or making it more memorable by presenting it in a funny way	A talking traffic cone
Activators	Using mnemonic or other devices to help drivers remember what a zipper merge is and how to do it when they encounter it	Mnemonics (rhymes), Visual Metaphors (like a zipper)

4. RESULTS

We summarize the (1) types of existing zipper merge communications, (2) use of behavioral science strategies, and (3) comparisons between states.

4.1. Types of Zipper Merge Communications

The first state to release zipper merge communications was Minnesota in 2011, followed soon by Colorado and Vermont in 2013. Table 2 shows how zipper merge communications dramatically increased in 2016.

Table 2. Timeline of the Introduction of Zipper Merging Communications by State.

Year	State
2011	Minnesota
2012	
2013	Colorado, Vermont
2014	
2015	
2016	Arizona, Kansas, Michigan, Missouri, Nebraska, Pennsylvania, Wisconsin
2017	North Dakota
2018	Montana, Virginia
2019	North Carolina, Washington
2020	Oregon

Across the 16 states that had zipper merge materials, we found three items on average (*Median* = 2, *SD* = 2.46) as shown in Figure 1. Most states had a small number of communication materials, with only one state exceeding five communication types.

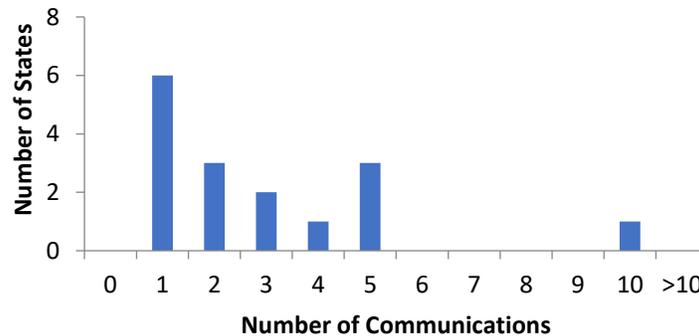


Figure 1. Number of Zipper Merge Communications per State.

States varied widely in the types of media that they used for zipper merge communications. Broadly, these types fell into four categories, (1) signs, (2) written, (3) audio, and (4) social media

communications. As summarized in Table 3, of the 16 states that had zipper merge communications, almost all used static signs and written articles. Dynamic signs and videos were also very popular and used by 9 of the 16 (56%) states. Few states used audio materials via podcasts or radio.

Table 3. Most States Used Static Signs and Written Articles for Zipper Merge Communications.

Media Type		Number of States	Description
Signs	Static	16 (100%)	Messages do not change
	Dynamic	9 (56%)	Messages may flash or change over time
Written	Article	15 (94%)	Announcements, updates, or explanations
Audio	Podcast	1 (6%)	State DOT sponsored podcast or podcast featuring a State DOT representative
	Radio	1 (6%)	Advertisements on the radio
Social Media	Video	9 (56%)	Videos produced and marketed by State DOTs

4.2. Use of Behavioral Science Strategies

We discuss the use of behavioral science in signs separately from other communications. By their nature, signs are typically limited to simple messages.

4.2.1. Signs

Two types of signs were used at construction sites to instruct drivers regarding upcoming zipper merges. Static signs are those that are fixed, stationary, and unchanging. Dynamic or variable message signs are electronic, portable signs that can be programmed to say many different messages and can have a flexible location. Dynamic signs are particularly useful for zipper merging, because the message can be changed to encourage zipper merging under high traffic conditions when zipper merging is more effective (Grillo, Datta, & Hartner, 2008). Studies suggest that dynamic signs yield higher zipper merge compliance because they respond to current conditions (Grillo, Datta, & Hartner, 2008).

Signs were categorized as information or instructions. Informational signs conveyed updates, such as “Road Closed Ahead” or “Lane Ends 1 Mile”, to drivers without indicating how they should respond. Instructional signs, conveyed commands to drivers such as “Take Turns”, “Merge Here,” or “Merge in 1 Mile.” Most states heavily utilized instruction rather than informational signs. In some cases, there are indirect uses of other behavioral strategies. For example, some signs say “Do Not Merge Here,” acknowledging the existence of the social norm that pressures drivers to early merge.

4.2.2. Public Communications

Written, audio, and visual public communications were categorized as Social Norms, Appeals to Reason, Emotional Appeals, Humor, and Activators.

Social Norms. In the DOT communications, social norms are used in slogans or phrases that DOTs create to assist their campaign to increase zipper merge compliance. One example of this is Minnesota's catchphrase, "Resist the Urge to Merge Early." This acknowledges the existing social norm surrounding merging and encourages Minnesota motorists to re-think their merging strategy. Another way DOTs use the social norm is by citing other states who have implemented zipper merging on their roadways, thereby creating a positive social norm surrounding zipper merging for their citizens.

Appeals to Reason. Appeals to reason increase zipper merge compliance by engaging drivers' rational and logical faculties. These would include such appeals as "Zipper merges are faster, safer, and make your commute less stressful." These are not used in signs, but are used frequently in other DOT public materials. Articles or videos encouraging drivers to zipper merge usually include appeals to reason, usually several. Appeals to reason are, in fact, very rarely used individually in this application. They are almost always used in groups of two or more and frequently paired with an emotional appeal.

Emotional Appeals. These appeals appear frequently in both signs and other public communications. The most common usage are appeals to generosity. This is a situation in which an attempt is made to win drivers over to the zipper merge by means of appealing to their sense of generosity or their responsibility to contribute to the common good. This would include signs such as "Take Turns," and an urge for drivers to zipper merge because it's good for everybody. Usually, emotional appeals are used in conjunction with appeals to reason.

Humor. Humor was not used frequently in the DOT communications, but when it does appear it is used in videos to make them more engaging. Sometimes this was manifested in the eyes through which zipper merging was narrated. For example, one state had an informational video on zipper merging where a talking traffic cone was used to discuss the process and merits of zipper merging. In other situations, humor was expressed through a funny or unique twist on the presentation of the material, such as one video produced by Missouri DOT which showed children videos of adults in cardboard cars first early merging and then zipper merging and getting the childrens' opinions on which way merging should be done.

Activators. Activators make the messaging more memorable or recognizable. They appeared more frequently in educational materials than in signs. Some states created a slogan that would appear consistently on their zipper merge educational materials. Minnesota's "Zip the Urge to Merge Early" is one such recognizable message that appeared quite frequently in all their materials. It was common among these slogans for mnemonics such as rhyming to be employed, or for the same picture to be used in all their publications. These pictures were deemed "visual metaphors" because they used visuals such as a zipper to reinforce the concept of a zipper merge in the minds of their viewers. Figure 2 shows an example of one such visual metaphor from an educational public communication.



Figure 2. Example of Use of Visual Metaphor

5. CONCLUSION

Patterns are discernable in states' uses of behavioral science strategies in zipper merge communications. States noticeably gravitate towards similar strategies and phrases used in their signs and educational materials. Appeals to reason and emotional appeals were especially popular and by far the most commonly used across the board. The literature review, however, revealed that in other traffic communication applications, social norms are frequently used and predicted to be effective. Although this review is limited to materials that were currently available on state DOT websites, we believe this represents the breadth (if not the frequency) of existing zipper merge communications. It also be helpful to broaden the scope of public communications being searched and examine other mediums of communication, such as news articles.

There are many opportunities to increase the use of behavioral science strategies in zipper merge communications. However, we need evidence to determine which strategies are more effective. Future research should focus on conducting human subject experiments to measure the effectiveness of behaviorally informed communications. Online experiments would be helpful in gaining a general understanding of how drivers might respond to different messaging schemes. Simulator experiments would help gain a more specific understanding of how drivers might react in real situations, but are limited in the length of testing and the number of subjects due to the simulator's capacity limits. Given the effectiveness of behavioral communications in other domains, there is high potential for increasing zipper merge compliance with behavioral science.

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