



# Are longer advertising slogans more dangerous? The influence of the length of ad slogans on drivers' attention and motor behavior

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Published online: 15 August 2018  
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## Abstract

The purpose of this project was to verify whether slogans displayed on roadside advertisements created a distraction for drivers. In order to explain the mechanisms underlying this phenomenon, Study 1 examined the impact of slogan length on attentional processing efficiency. Study 2 investigated the relationship between the length of the slogan and the motor behavior of respondents driving a car simulator. We assumed that slogan length would decrease the drivers' task performance in both studies. Study 1 was conducted on a group of 70 participants, who completed a modified version of the Attention Network Test (ANT; Fan et al. *Journal of Cognitive Neuroscience*, 14(3), 340–347, 2002). The task consisted of visual ads intended to distract respondents from the primary task. Reaction times were significantly longer when ads had longer slogans compared to shorter slogans. Study 2, involving a car simulator, was conducted on a group of 53 drivers performing a task of driving in a convoy. Participants were shown billboards with ads at the roadside in random order (two pairs of corresponding ads with short and long text on it). Participants' driving performance decreased when longer slogans were presented in comparison to the short-slogan condition. In conclusion, we interpret the results of Study 1 to indicate that longer slogan leads to a greater load of attentional processing. This subsequently leads to a reduction of the processing efficiency within attentional systems and further increases the amount of time to resist the irrelevant stimulus. A consequence of this, as shown in Study 2 using a car simulator, is a decrease in cognitive resources necessary for safe driving and therefore worse performance on a driving task.

**Keywords** Slogan length · Attentional processing · ANT · Road advertising · Distracting information

## Introduction

### How a Driver Obtains Relevant Information in a Traffic Situation

Approximately 90% of a driver's information about the current traffic situation is provided by eyesight (Boyce 2009). However, only about 1.5 angular degree for which the central

vision mechanism is responsible allows for an acute vision. This mechanism is essential for road maneuvers (Schieber et al. 2009), because it allows for the most effective distinction between the characteristics of the object and for the recognition of the symbols (Rybak et al. 1998). It is estimated that distracted driving, understood as a delay in identifying the information needed to safely perform a task, caused by an inappropriate allocation of attention causes up to 25% of road accidents (Stutts et al. 2001). One of the most salient visual stimuli that competes for a driver's attention is billboard advertising. Distractors in the driver's visual field sum up, forming a visual noise which interferes with the ability of the driver to effectively process relevant information. Roadside ads are thus a risk factor (Bendak and Al-saleh 2010). Although the drivers' visual field is filled with various signs and signals aimed to focus their attention (Kaber et al. 2015), studies using car simulators, and often eyetracking methods, show that ads are more distracting than other visual stimuli, for example road signs (Kaber et al. 2015).

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## How Roadside Advertisements Capture Attention from the Roadway

First, ads are designed specifically to attract attention. They contain various visual properties and persuasive mechanisms to achieve this goal. Adverts can interfere with attentional guidance through either physical characteristics (e.g. color, brightness, location) working as bottom-up factors or engaging top-down processing of information (Awh et al. 2013).

Second, billboard advertisements are located similarly to the road signs – in a vertical position near the road. Driver looking for a road signs information, explore the dynamic visual scene and might be prone to be misguided by the irrelevant objects, including ads. Additionally, Specific situational contexts can determine the extent of driver's engagement in reading ads. Just participating in different road traffic scenarios can lead to conditions in which certain properties of advertising content may be distracting for different drivers. For example, specific situations on the road such as a complex intersection with a number of road signs or a tediously long highway route may lead to drivers being more easily distracted by external factors.

## Why the Visual Clutter Might Be Dangerous in Road Situations

The driver's perception is optimal when she/he is able to see things that are relevant to driving safety (other road users, signs, course of the lane etc.) in a complex environment. Proper perception is therefore a function of visual attention, and more precisely - the aspect of attention that is responsible for attracting sight to important objects. Visual attention (Posner 1994) is widely studied in road safety research (Wallace 2003). The processes of perceiving, understanding and anticipating together create situational awareness (i.e., the ability to detect and understand information that is important for safety at a given moment, and anticipate the development of the situation in the near future). Situational awareness forms the basis for the driver's decisions and thus becomes essential to the road safety (Farah et al. 2008). However, to date, studies on road safety using various methods such as comparing accident rates, experiments and observational studies (e.g., Belyusar et al. 2016; Bendak and Al-saleh 2010; Smiley et al. 2005; Wallace 2003), have produced inconsistent findings concerning the effect of advertising on motor and ocular behavior.

Road hazards can also be caused when the driver's attention is distracted by non-driving content that leads to "looking without seeing." For example, "looking without seeing" can lead to the inability to identify the subject at which the person is looking and as a result lead to delayed risk recognition and decision-making. It is thought that 30% of "looking without seeing" cases are caused by external

factors (Stutts et al. 2001), including advertising. However, the problem of covert attention is difficult to study in context of road traffic because it does not have observable implications such as eye or head position changing (Petersen and Posner 1990).

## Examining the Mechanisms Used in Ads Underlying the Distraction

Distracted driving as the result of visual stimuli is related to both the psychological characteristics of the driver (e.g. needs, attitudes, intelligence, personality, psychophysical efficiency, etc.) and the message design. The first factor (psychological characteristics), may relate to the driver's ability to pay attention, and is hopefully controlled in the procedure for obtaining a driving license, and in psychological assessment when relevant. The second factor can be controlled by legislative solutions. The message design includes: movement, light emission, shape of the carrier, and location (Crundall et al. 2006; Izadpanah et al. 2014; Smiley et al. 2005), all of which engage bottom-up attention, as well as the content of advertisements which activates top-down processing (Shinoda et al. 2001).

In order to examine what the most distracting properties of an advertisement are, we can examine the different persuasive mechanisms used (Guttman 2015). Among the distracting properties of roadside advertisements, the most frequently studied include the amount of information contained in the message (Schieber et al. 2014), the physical properties of the images such as color and location (Holohan 1979), and emotions of different valence (Megías et al. 2014; Megías et al. 2011). However, the data is still scarce. Therefore, our research aims to provide the empirical data needed to better understand the influence of advertising slogans' length on the attentional processes and motor behavior of drivers.

## The Role of Amount of Information in Road Hazards

Every visual message in road traffic carries some information. Signs are designed so that this information is comprehensive and sufficient at the same time. The number of times the mark is seen by the driver is taken into account, because of the effect of priming repetition (Crundall and Underwood 2001). Research by Di Stasi et al. (2012) on the speed of road signs and perception show that drivers respond more quickly to signs with congruent visual information (CVI) compared to signs with incongruent visual information (IVI). The longer reaction time was caused by the fact that IVI had too much information for mental processing, resulting in the drivers trying to ignore these signs (Di Stasi et al. 2012). The effectiveness of two types of road signs was similarly studied by Shinar and Vogelzang (2013). In their research, 30 traffic signs were set alongside the road using different combinations of symbols and text (symbol, text, symbol along with text). The visual reaction time of drivers was

recorded, as well as their understanding of the signs' content. It turned out that the signs containing a symbol and concise text improved the understanding of the sign best (Shinar and Vogelzang 2013). Kaber et al. (2015) tested the influence of the type of signs on the behavior of drivers in simulator driving conditions, using various types of white-on-blue logo signs. Conclusions for driver performance and attention allocation were drawn based on the difference found between reactions on types of signs. Mileage guide signs had lower frequency of fixation and shorter glance duration than six-panel and nine-panel logo signs. Therefore, to further understand the impact of a complex visual stimulus such as advertising, we control each of the above-mentioned aspects in our research and consider a detailed examination of these in our future research plans.

### Advertising Based Mainly on Text Poses a Particular Threat

Ads based mainly on text are a special type of visual stimulation. These include, for example, information adverts, containing addresses and other data to remember, but also all compositions containing the displayed slogan as the main part. In contrast to other types of advertisements, text ads have an “advantage” in attracting the attention of recipients due to the automaticity of the process of reading words, as described by Prinzmetal et al. (1991) – „words are magic” (Prinzmetal et al. 1991, p. 902). The automated process of word recognition requires comparison of perceiving symbols (words) with the stored memory codes and meanings. Even without a conscious control of all meanings being activated. Due to its automated character the process of word recognition require little cognitive capacity for literate recipients (Nathan and Stanovich 1991).

People are much faster at reading, than naming pictures. This is perfectly illustrated by the Stroop effect researches, which prove obligatory lexical processing phenomenon (Stroop 1935). And that is because of the visual features of word-like stimuli that creates its physical structure to which people are sensitive to (Prinzmetal et al. 1991). The research confirm that more processing resources are engaged when the reader is being distracted by words than symbol distractors (Reingold et al. 2016). However, some researchers argue that both intentionally or unintentionally reading is guided also by the task goal (Kinoshita et al. 2017).

The driver that has been already initially attracted to the observation of the visual message, is more inclined to process the text contained in it at a higher level. Due to the limited processing capacity, such situations might be too demanding to simultaneously perform a safe drive (Nathan and Stanovich 1991). For example, text messages convey specific information, that might be important for the driver for other reasons than performing the driving task (i.e. when the information in the slogan directly corresponds with information the driver is looking for in his life at the time, e.g. buying choices). This

kind of interest in ads might be particularly threatening because the driver may attempt to read such ads carefully to remember the information provided. Also catchy slogans may capture the driver's attention to the extent where they want to finish reading the message either out of curiosity or for entertainment (e.g. teaser ads). When the driver is involved in the processing of the message his attention resources – which are necessary to perform the primary task of driving safely - are depleted (Kahneman 1973). Considering the phenomenon in terms of attentional processing seems to be particularly promising (Posner 1994).

### How Much Information in the Slogan Is Distracting

If there is a limit to the amount of information for which the text on ads becomes too big distractor, the question arises - how to count the amount of information in ads? The slogans differ from each other by many parameters related to both formal characters (font family, font size, color, etc.), text length (number of characters) and the type of content being conveyed, e.g. typical vs non-typical expressions, or tabu words (e.g. expressions inducing strong emotions), etc. The most commonly used practice is to convert text into information bits. The more characters create a slogan, the more bits of information it contains. This approach derives from research within Shannon's information theory (Shannon and Weaver 1949), which omits the meaning (semantics) of the message, and focuses only on its syntax (Shannon and Weaver 1949).

Previous research has found a consistent effect of longer text on distraction in cognitive tasks: Longer text results in a greater task and working memory load or a processing overload (Schieber et al. 2014). Schieber et al. (2014) used the method of measuring the length of the slogan by counting the number of words in their digital billboard study using a car simulator and an eye-tracker device. In this study, participants were instructed to read billboards, displaying slogans composed of 4, 8 or 12 words, while driving. Billboards with 8 or more words in the advertisement, at the speed of 50 MPH, caused a significant deterioration in the performance of drivers who drifted away from the centerline and subsequently corrected with sudden steering wheel movements. On the basis of these results, the researchers proposed preliminary guidelines for roadside billboards: Dependent on the speed limits on the road (25 or 50 MPH), long slogans (8 and 4 words, respectively) should be limited in the driver's visual field (Schieber et al. 2014).

In conclusion, based on previous research on attention and distracted driving we assume that decreased processing efficiency leads to changes in motor behavior that negatively affect safe driving. Slogans of varying length have different impacts on processing efficiency due to the different amounts of information that each message conveys. Therefore, the ability to examine the extent to which a slogan results in information saturation is of great importance for road safety research.

## Current Study

To verify the impact of long and short ad slogans on drivers' behavior we propose two experiments testing: a) reaction times in attentional tasks (Study 1), and b) driving performance in a car simulator when advertising billboards are displayed at the roadside (Study 2). The studies engaged different groups of drivers (i.e. participants from Study 1 did not take part in Study 2).

We assessed the changes in processing efficiency of attention as a reaction to different slogans' length using tasks taken from a modified version of Attention Network Test (ANT, Fan et al. 2002) proposed by Weaver et al. (2013). The tool has been based on Posner's theory of attention (Petersen and Posner 1990). Posner defines attention as a system that directs the flow of information and controls its validity. This influential theory describes three attention systems, located in specific neuroanatomical areas. Each system has its own function: alerting, orienting, and executive attention. The three systems are basic to the selection of information for conscious processing (Petersen and Posner 1990). The method developed within this approach – the Attention Network Test (ANT, Fan et al. 2002) – involves measuring the activity of individual attention systems. The test consists of a series of trials in which the subject's task is to determine in which direction the arrow (signal) is pointing, presented a few centimeters above or below the center of the screen of the eye fixation point. The reaction time and correctness of response are indicators of the processing efficiency of attention. The method has many alternative versions, modified for different research purposes. Description of the tasks we used in this research is presented below (the *Study 1* section). Our method consisted of introducing the advertisements as additional stimuli (task-irrelevant distractor) before the tasks performed in the test (see Fig. 2). As this experiment was a part of a bigger project, in this paper we report only the results related to the information ads (i.e. ads consisting mainly of words). The processing efficiency of attention was quantified by the use of reaction time measures (Fan et al. 2002). We expect that interfering with the primary task (determining which direction an arrow is pointing) by displaying advertisements with longer slogans (compared to the shorter slogans) will result in longer reaction times (RTs).

In Study 1 we also used eyetracking device to measure eye fixations as an indicator of visual attention allocation. Since eye movements are related to the visual attention mechanism, the recorded saccades and fixations of the drivers are convenient quantitative indicators of visual attention mechanisms (Wilson et al. 2007). If ocular fixations on areas other than the one directly in front of the vehicle (e.g., on a dynamically changing advertisement in the vicinity of the lane) increase the driver's reaction time, they will also be responsible for increasing the distance the vehicle, driven by a distracted driver, will

travel to when changing its trajectory or stopping. This may have enormous effect on road safety, especially on high-speed roads where faster speeds will increase distances travelled in a given time. For example, at 50 km per hour a vehicle will travel 2.8 m in just 0.2 s and 13.9 m in a full second. Eye tracking methods are widely used in driving research (Costa et al. 2014, 2018) for they help to measure the detectability of road signs. Giving various measures of the ocular movements, for example the first fixation duration, they enable researchers to capture the moment when the road signs or other roadside objects are being spotted. Also long or short glances indicate on the presence or absence of a conscious awareness in sign processing (Costa et al. 2014, 2018). In our research we used an eyetracker measures to control the participants' visual attention allocation.

To check if slogan length influenced the motor behavior of drivers, we designed an experiment using a car simulator. The driving scenario required driving a vehicle in a convoy, while billboard ads with slogans of varying length appeared at the roadside. The ads were selected from real advertising campaigns and were adapted to the required format. We measured drivers' task performance with the ad occurrence, taking into account the distance from the preceding vehicle and the time to collision with it. As we assume that longer slogans involve considerably more attentional processing decreasing attentional processing efficiency, we expect that longer advertisements will lead to impaired accuracy in the drivers' assessment of the traffic situation. We expected that the task performance will decrease when the roadside billboards displayed longer (compared to shorter) advertising slogans. We chose the visual ads carefully to control other ads' features (emotional content or color saturation etc.) and thus make sure that slogans differ only in the amount of information. We described this procedure in the *Method* sections of each study.

The pre-condition for safe driving is to maintain the right balance between top-down and bottom-up processing (Shinoda et al. 2001; Wickens et al. 2003, therefore paying visual attention to a redundant information displayed on the roadside ads can negatively affect safe driving. Consequently, we aim to better understand the potential impact of text length on driver's distraction by exploring what this longer distraction of attention may mean. We discuss our results in terms of amount of information presented in slogans and propose an exploration of other possible measures of slogans' information saturation.

Based on the literature analysis, we have chosen some demographic characteristics of the drivers to study the impact of advertising. The first distinguished factor was the age of drivers, the second - experience in driving a car. For example, Edquist et al. (2011) conducted a study on a group of 48 drivers in three age groups. Using the driving simulator, they checked what effect the passed billboards have on the driving quality. The results showed that the presence of billboards distracted the drivers from the road ahead and delayed



reactions to road signs, as well as increased the number of mistakes made on the road. This effect was particularly strong in the case of novice drivers (aged 18 to 25, who obtained a driving license less than one year before the test) and even stronger in the case of older people (people aged over 65). Another study, conducted by Belyusar et al. (2016), provides the data for comparison of two age groups aged 20 to 29 years and 60 to 69 years. All participants met the criterion of having a driving license for at least three years and driving a car at least three times a week. The findings suggested that the older people in particular were dedicating more visual attention to the roadside at the moment when the advertising appeared. Taking into account this results we decided to control the age and driving experience of participants as well.

### Study 1: Tasks from a Modified Version of the Attention Network Test (ANT)

The study tests our assumptions that reaction times will vary based on slogan length and the role of processing efficiency of attention in this relationship. We expected that the RTs measured after the task with ads with longer slogans will be longer compared to the task with shorter-slogan ads.

#### Method

We used tasks from a modified version of the *Attention Network Test*, *ANT* (Fan et al. 2002) provided by Weaver et al (Weaver et al. 2013). The original test is based on Posner's theory of attention (Petersen and Posner 1990), which defines attention as a system that guides the flow of information and controls its validity. This theoretical approach was used to create the behavioral method of measuring individual attention systems computer test of attention networks which consists of a series of trials in which an arrow is presented a few centimeters above or below the eye fixation point located in the centre of the screen. The subject's task is to determine which direction the arrow is signaling, and both their reaction time and the correctness of their response are calculated. Further, other stimuli are presented around the signal depicting arrows that are either congruent or incongruent with the expected correct reaction (e.g., an arrow pointing the opposite direction). The trials with incongruent arrows force participants to inhibit improper reactions and reject distraction. The measurement enables to calculate the efficiency index of the executive control, orienting and alerting attentional systems (Fan et al. 2002).

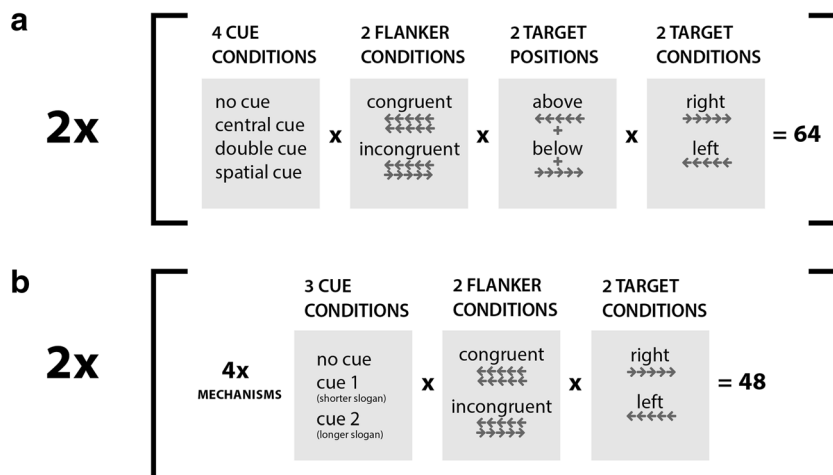
In the tasks we used, advertising stimuli are presented to the subjects randomly before the main task which requires a reaction. We only measured the impact of advertising on RTs and not the three aspects of attention. Furthermore, we make

use of a shortened version of the test described above (brief-ANT). The tasks we used are based upon a 10-min version of the ANT (Weaver et al. 2013) developed by the Centre for Research on Safe Driving Attentional Network Task (CRSD). More information on the CRSD-ANT method is available at the company's website: <http://www.millisecond.com/download/library/ant/#sthash.K5oXNvJi.dpuf>. CRSD-ANT consists of 2 Blocks of 64 trial sequences each in which the order is randomly determined. In the block, the sample sequences (a total of 64) are as follows: 2 (repetitions)  $\times$  4 (cue conditions: no cue / center cue /double cue/spatial cue)  $\times$  2 (flanker conditions: congruent vs. incongruent)  $\times$  2 (target positions: above or below)  $\times$  2 (target directions: right or left). For each sample the sequence is (one sequence for each cue condition) as follows: fixation (randomly\* chosen presentation time: 400 ms–1200 ms) -> cue (100 ms) -> fixation (400 ms) -> target (1500 ms)-> inter-trial interval (3000 ms). In the tasks we used, the fixation point was either an advertisement or a cross. We set a fixed presentation time of 2000 ms. We chose a 2 s display, because in the transport psychology literature this is the time considered to be critical for safe driving (see Rockwell 1988). Paying attention to advertising for 2 s or longer while driving can create risky situations on the road. The next in the sequence, according to the classic ANT, was cue, presented in the time of 100 ms. However, we reduced the secondary fixation time from 400 ms to 100 ms to reduce the time between advertising and the response. If real-world advertisements distract drivers and if shortly afterwards motorists have to react to traffic situations, longer fixation times would result in a worse adjustment of this cognitive task to the situation on the road. At the end, the target (1500 ms) was exposed. The whole experiment (see Fig. 1) consisted of 2 blocks of 48 trial sequences each in which the order was randomly determined. In the block (i.e. research stage), the sample sequences (a total of 48) were the following 4 (persuasive ads mechanisms)  $\times$  3 (cue conditions: no cue/cue 1/cue 2)  $\times$  2 (flanker conditions: congruent vs. incongruent)  $\times$  2 (target directions: right or left).

We used this method to study eight advertising mechanisms of persuasion. Different types of ad contents were devoted to each mechanism: textual ads (varying slogan length), erotic associations, negative emotions, positive emotions, amount of image, color saturation, teaser, and shape of the format. All advertisements were first verified in a pilot study, to examine if they adequately reflected the given content and in order to choose ads that did not differ in terms of attractiveness. This paper will only present the results from the textual ad content.

Additionally, for 30 participants we used an eyetracking device – SensoMotoric Instruments system (SMI) iView X Hi-Speed (Pellicer-Sánchez et al. 2018) of accuracy 0.5 degrees - to measure the participants' eye fixations on ads,

**Fig. 1** Diagram showing our modification (b) to the original version of the ANT (a)



displayed in a set time of 2 s. The eyetracker has a sampling rate of 500 Hz and is connected a desktop computer and a 16-in. screen placed 50 cm from the subject's eyes. The fixation detection parameters were default settings of BeGaze software, used in SMI HiSpeed recordings, when no specific expectations are formulated. The fixation has been defined as 80 ms recording with max dispersion 100 px. We used monitor with resolution  $1920 \times 1080$  dpi, so 1 pixel corresponds to approximately 0.3 mm. When observing from distance 500 mm, fixation window area equals  $\text{ctg}((0.3 \times 100) / 500)$ , which corresponds to approximately 3.4 degrees. We expected to find more fixations on ads with longer slogans.

## Stimuli

Ads from real advertising campaigns were used as stimuli. The images have been adapted to a uniform size format of  $450 \times 300$  px and were displayed on a 26-in. monitor with a resolution of  $1920 \times 1080$  dpi. Two pairs of stimuli manipulated slogan length (each pair in one block). Each of the four ads contained a single image placed on the left or right side of the composition and was no larger than one-third of the advertisement area. Next to the image, slogans of varying lengths and number of characters were placed on a white background, occupying about 2/3 of the advertising space. In each pair of slogans, the longer slogan consisted of more than twice as many characters as shorter one. For example, the first pair has 12 characters (2 words) and 34 characters (6 words); the second pair has 9 characters (3 words) and 19 characters (6 words). Figure 2 presents the sequence of screens in a trial with some example stimuli.

The stimuli were chosen in a pilot study (prior to the research) on a group of 30 participants that did not take part in Study 1 nor Study 2. They rated each advertisement on 7-point

Likert scale in terms of attractiveness, clarity, level of being understandable and amount of information (e.g. 1-*little amount of information*, 7-*high amount of information*). From 10 pairs of ads we have chosen those that did not vary between each other (short slogan ads vs long slogan ads) in any scale except the amount of information.

## Participants

We had 70 adults (44% male) participated in the current study. The average age was 39, we divided participants into three age groups: 18 to 25 years old ( $n = 16$ ), between age 26 and 45 ( $n = 17$ ), 46 years old and above ( $n = 18$ ). Each participant had to have a valid driving licence and no sight defects.

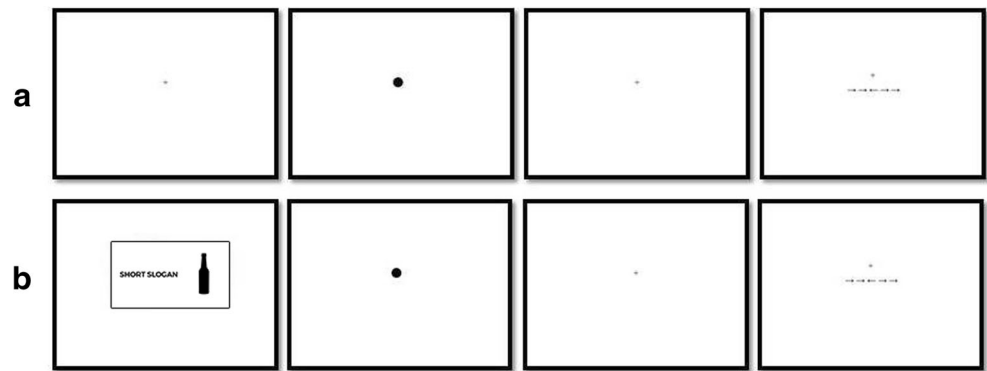
## Results and Discussion

We analyzed the results using  $t$ -tests for dependent samples. All measures (except fixation count) are given in milliseconds. The findings confirm our hypothesis that ads with longer slogans decreased RTs in the task that followed the ad. The average RT in trials with ads with a shorter slogan ( $M = 627$  ms,  $SD = 225$  ms) was faster than the average RT for ads with a longer slogan ( $M = 658$  ms,  $SD = 246$  ms). The difference was statistically significant:  $t(69) = -1.799$ ;  $p = .038$  (one-sided); Cohen's  $d = .22$  (see Fig. 3).

Eyetracking data showed a significant difference in the number of fixations ('fixation count') on ads with short ( $M = 7.33$ ;  $SD = 1.79$ ) and long ( $M = 8.12$ ;  $SD = 1.66$ ) slogans,  $t(29) = -3.450$ ;  $p = .001$  (one-sided); Cohen's  $d = .63$ .

Our results suggest that a longer slogan text requires more intensive attentional processing and/or activates more conceptual categories which extends the time of stimulus processing at the cost of starting the processing the task appropriate stimulus. We interpret this interference effect as the reason for decreased attentional processing efficiency.

**Fig. 2** The sequence of screens in a trial in the original version of ANT (a) and in the tasks we used in our study (b)



### Study 2: Effect of the slogan’s Length on Driving in a Car Simulator

As a part of a larger study using a car simulator we verified the impact of textual ads (ads consisting mainly of slogans) with different numbers of characters on driver’s distraction. Distraction was measured with the accuracy with which the driving task was completed. We used ads from real advertising campaigns: one pair of stimuli with short and long slogans of 12 and 38 characters, respectively. Their content (image and text proportions) were similar to those ads used in the Study 1, and their size was adjusted to the format of advertising media used in the simulation, which was: 6144 × 2560 px (72 dpi). We assumed that slogans with a larger number of characters, appearing along the road, would decrease attentional processing efficiency more than those with fewer number of characters, and therefore, would lead to worse driving task performance as measured by a change in the distance to the vehicle in front of them in a convoy.

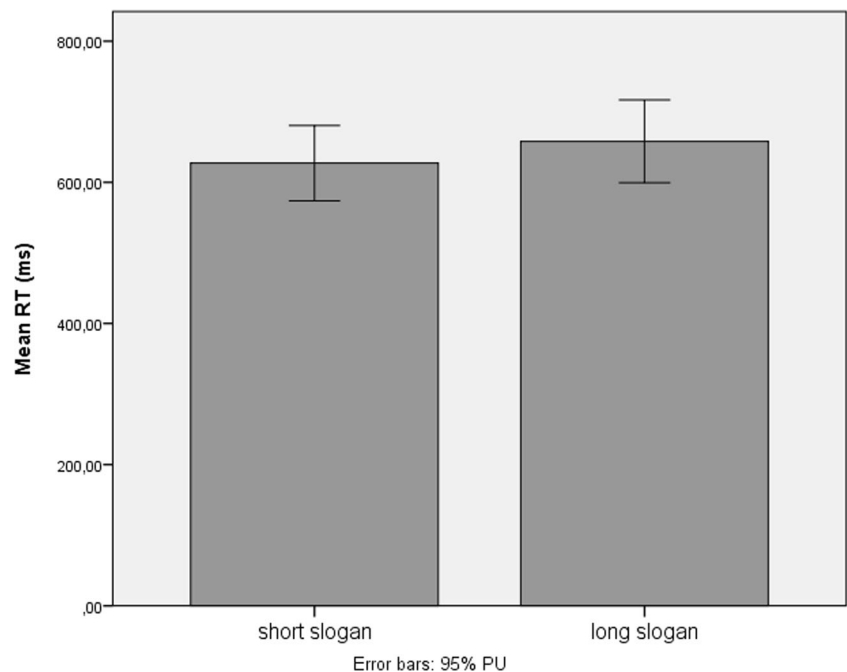
### Method

An Opel Astra AS 1200–6 car simulator was provided by the Car Transport Institute in Warsaw. This simulator vehicle is equipped with a multiwork image display system covering the whole visual field in the driver’s view in the range of: 200° horizontal and 40° vertical with the frequency of 60 Hz. The distance between the driver’s point of view and the screen is 2.5 m. Figure 4 presents the view from inside the vehicle. The cabin is placed on a mobile platform with six degrees of freedom to simulate the movements of the vehicle during driving. The cabin is also equipped with a system of 3 monitors that act as mirrors. The description of the driving scenario is presented in the *Procedure* section.

### Stimuli

The two pairs of ads have been chosen from the pilot study ( $n = 30$ ) as described in Study 1 in the *Method* section.

**Fig. 3** Mean reaction times in tasks with short and long slogans (Study 1)





**Fig. 4** Screenshot from inside the vehicle while driving in a convoy task

Additionally, as the research was a part of a larger project which included stimuli with different persuasive mechanisms, we asked respondents to rate the roadside ads on a 7-point Likert scale in terms of compliance with their intended expressions of *sexual, arousing negative emotions, composed of a large amount of information, attracting attention, expressive, understandable* (e.g., *To what extent do you agree that: the advertisement is sexual?*). This manipulation check was done using a paper and pencil questionnaire.

## Procedure

Participants were introduced to simulator driving by performing a 10-min adaptation drive. The actual driving task, which occurred after a 5-min break, included roadside billboards with advertisements appearing in a random order. These stimuli displayed different aspects of advertising content: sexual associations (advertisements depicting women's silhouettes revealing intimate parts of the body), ads evoking negative emotions (social ads depicting situations after road accidents or related to domestic violence) and ads containing different amounts of information in the slogan (described above). The subjects had to perform the task of driving the vehicle in a convoy while remaining 35 m behind the vehicle in front of them (3 vehicle platooning task, 3VPT). After the completion of the drive, participants received the paper and pencil manipulation check questionnaire.

## Participants

A group of 53 participants was recruited by an external recruitment company and received a fee for participation in the study. We wanted to get the most representative sample we could, which is why we subjected it to the stratification in terms of the factors described in the literature of the traffic psychology as affecting the proper driving of the vehicle.

The average age was 39, we divided participants into three age groups: 18 to 29 years old, 30–45 years old, over 54 years old (28 males, 25 females). The group was diverse in terms of education and place of residence. Their sex, education, experience as a driver, the fact of participation or causing collisions and road accidents, as well as self-assessment in the field of driving a car were controlled. The drivers could have eye sight corrections (glasses or lenses) if they had sight defects. At the beginning of the experiment the participants were instructed that the project concerns road safety topic, and before the proper riding task, they were told to watch the roadside advertising if possible.

## Results and Discussion

We analyzed the simulated driving task results using *t*-tests for dependent samples. The manipulation check questionnaire confirmed that the perceived content of each stimuli corresponded with the intended content. The term “composed of a large amount of information” was more often attributed to compositions with a longer slogan ( $M = 3.19$ ,  $SD = 1.57$ ) than those with a shorter slogan ( $M = 2.33$ ,  $SD = 1.294$ ):  $t(55) = -5.651$ ;  $p < .001$ ; Cohen's  $d = .76$ .

Analysis of the distance-to-the-vehicle-preceding-standard-deviation variable (measured in meters) for ads with short ( $M = 1.55$ ;  $SD = 1.20$ ) and long ( $M = 2.17$ ;  $SD = 1.79$ ) slogans, showed that displaying ads with longer slogans at the roadside caused an increased variation in maintaining the distance to the vehicle in front:  $t(52) = -2.996$ ;  $p = .004$ ; Cohen's  $d = .41$ .

Analysis of the time-headway-standard-deviation variable (measured in seconds) for ads with short ( $M = .08$ ;  $SD = .06$ ) and long ( $M = .10$ ;  $SD = .08$ ) slogans, also showed significant differences:  $t(52) = -2.738$ ;  $p = .008$ ; Cohen's  $d = .38$ . Time headway refers to the time when - if the preceding car stops suddenly - the vehicle driven by the participant will appear exactly in its (the preceding car) position. Thus, it is a good indicator of a time left to a possible collision. The results show higher variation rates in maintaining this time interval when performing the driving task included roadside ads with longer slogans.

The mean-distance-to-the-vehicle-preceding and mean-time-headway variables did not differ significantly for short and long slogans. Descriptive statistics for each variable are presented in Table 1.

To control the participants' driving experience we compared the groups according to the variable Experience, which was calculated from the data on drivers monthly mileage, and years of having the driving license. In this way, two groups of drivers were created with a smaller (having driving license up to 11 years and mileage below 850 km per month) and a greater (over 26 years of having driving license and mileage above 850 km per month) driving experience. We found no



**Table 1** Descriptive statistics for *t*-test results on car simulator data from Study 2

Slogans' length	Mean-distance-to-the-vehicle-preceding		Distance-to-the-vehicle-preceding-SD		Mean-time-headway		Time-headway-SD	
	M	SD	M	SD	M	SD	M	SD
Short slogans	34.45	6.17	1.55	1.20	1.35	.28	.08	.06
Long slogans	35.13	6.03	2.17	1.78	1.38	.29	.10	.08

differences between the two groups of drivers. We found no difference between groups of long and short ad's slogans in terms of age nor sex groups neither. Descriptive statistics for the controlled variables are presented in Tables 2 and 3 in the Appendix section..

The findings confirm the hypothesized relation between the slogan's length and driving task performance. When displaying advertisements with a longer slogan, the driver's driving fluency decreased, as measured by a higher variation of the distance kept from the preceding vehicle and in the given time-to-collision indicator (time headway). We suggest that this occurs as a result of a higher information saturation in the longer slogans which causes decreases in attentional processing efficiency, followed by the observed changes in motor behavior.

## General Discussion

The length of the slogan displayed on roadside advertisements, translating into an amount of information present in motorist's visual field, may be a critical factor in distracted driving. The two experiments reported in this paper were designed to check the possible effect of billboard advertising on driver's attention and motor behavior. We focused on ads consisting mainly of text. Slogans of different length served as distracting stimuli both in the attention tasks (Study 1) and in the simulator driving in a convoy task (Study 2). We have designed the study in such a way as to avoid loading the subjects with an additional motor task, such as reading advertising slogans aloud (Schieber et al. 2009), which might delay switching to the basic task (Rogers and Monsell 1995), i.e., delay the start of processing information from the stimulus appropriate for the performance of the primary task. We also used stylistically consistent advertising stimuli, only manipulating slogan length, to eliminate unnecessary confounds. The results support our hypothesis that longer slogans cause extra visual demands for participants, thereby resulting in less spare capacity for attentional processing of the primary task.

Results of the first experiment (Study 1) confirmed that longer slogans caused a delay in reaction times during attention tasks using a modified version of Attention Network Test (ANT; Fan et al. 2002; Weaver et al. 2013). We propose that a greater involvement of attentional processing decreased the processing efficiency of executive control contributing to this

effect. Consequently, as observed in Study 2, there is also a reduction in the cognitive resources needed to drive the vehicle properly (according to the task's instructions), and amount of time that the driver can devote to the appropriate motor reactions in order to keep the vehicle in the Field of Safe Travel described by Gibson and Crooks (1938, as cited in Castro 2009). According to the models of driver behavior (e.g. Ajzen 1991; Rumar 1982) the basis of the driver's action plan is information "at the entrance" regarding the perception of individual elements of the situation on the road. Their interpretation is that the correctness of perceiving and processing information enables motorists to make proper choices and maneuvers. Roadside advertising creates a specific, external, and driver-independent risk factor in traffic situations. Ads contain information that is essentially task-irrelevant stimuli for the driver. Due to their content and ability to attract attention, they can 'cheat' the selective attention of the driver, thereby distracting him or her from the primary task which is to keep the vehicle in the Field of Safe Travel. According to contemporary models of visual attention, activation of irrelevant task objectives in the working memory is a huge source of distraction (MacLeod 1991; Wagner et al. 2001).

Therefore, we chose to design an experiment using tasks that enabled us to measure attentional processing efficiency. Study 1 showed that reaction times were slower with longer slogan ads compared to shorter slogan ads. We therefore conclude that longer slogans engage attentional processing to a greater extent. Further Study 2 suggests that as a result of this engagement of attentional processing, drivers performed driving task worse when they were distracted by longer slogan ads compared to when they were distracted by shorter slogan ads.

Previous literature explains distracted driving by suggesting that the recipient of the advertisement, who wants to finish reading the message, returns their gaze towards the ad thus turning away from the road, which may create risky situations. The likelihood of traffic incidents increases significantly when driver's turn their eyes away from the road for more than 2 s (Klauer 2006). The phenomenon is well described by the so-called Rockwell's 2-s rule (Rockwell 1988), according to which the driver can take his/her eyes off the road situation for no longer than 2 s. If the time without information about the traffic situation is longer than 2 s, the driver may be distracted (Rockwell 1988). Our hypothesis is that it is not looking at advertisement per se that distracts but rather the fact that the observer has to process the observed content (and the of

varying amounts of information conveyed). In particular, advertisements containing sale offers accompanied by phone numbers and addresses or other data to be remembered are loaded with information. Too much information saturation may distract the driver's attention beyond a safe level.

Research on visual search strategies show that the distraction effect is small when one knows what she/he is looking for but that it increases when they do not and the number and type of visual stimuli increase the likelihood of being distracted and omit important safety instructions (Hughes and Cole 1984; Wallace 2003). This hypothesis is also supported by empirical evidence on secondary tasks influencing driving behaviour by modulating attention (e.g. Klauer 2006). However, we should also consider the relation between distraction and attentional engagement by roadside advertising and different levels of driver's arousal. According to Hebb's arousal-performance law (Hebb 1955) the relationship between performance and arousal is curvilinear (see also Yerkes & Dodson, 1908). In the context of traffic safety this would indicate that too much boredom and too much stimulation create opportunities to fail to correctly perform driving tasks. The opposite of visual overload (e.g. monotonous landscapes during a tedious drive) provides too little stimuli to force the driver to pay attention and may also be a reason for unsafe behaviour on the road. Indeed the literature on arousal and driving performance indicates that drivers respond faster to targets when arousal is high (Chan and Singhal 2015). However, the role of advertising in the context of very low-arousal-environments is not so clear. Visual stimuli from outside the vehicle can either help the driver to tackle their arousal level and focus on the ride, or the boredom may increase the distracting properties of ads in the absence of other compelling tasks. The nature of this relationship requires further research. To conclude, we assume that if there is a possibility to reduce risk factors to minimum, one should do so. This means both reducing the visual clutter (number of ads and their distracting features) especially in complex road sections (e.g. intersections, junctions, areas of high traffic density) and researching the impact of ads in monotonous environments.

### The Amount of Information

Another important consideration is the question of how to convert the ads' content to a measure of the amount of information in the ad. This is an essential issue with legislative implications. To analyse advertising slogans in terms of their involvement, the most obvious practice is to count the number of graphical signs (letters) that make up the slogan. Results obtained this way are easy to translate into legislative solutions as was done, for example, by the South African authorities (Department of Transport 2000). In this case, the maximum number of letters, numbers and graphic characters were specified and converted into bits. The admissible amount of information in advertising slogans is, for

example, a maximum of 6 bits alongside national roads and 10 bits on a route other than the highway; and if they are numbers they can contain at most 8 digits. In Saudi Arabia, guidelines convert words, numbers, and symbols displayed in the advertisement into bits and allow 6 bits in each ad (United Arab Emirates Department of Transport 2013). However, discrepancies in the methods of measuring the distracting content of the ads makes it difficult to directly translate their legislative solutions to other cultures. Thus, in many countries (including Poland) no legal regulations have yet emerged. Based on our findings we think one should be cautious when using 7 or more words in advertising slogans. It is, however, just a suggestion for advertisers and not a legal provision, as this issue requires further research.

However, we suggest that counting characters or words as a measure of the amount of information in a slogan might not be the most ideal solution. According to Gibson (1986, as cited in Castro 2009), the definition of the amount of information has to be more sophisticated when considering perception in the traffic context. Gibson claims that instead of thinking about information in terms of bits, we should relate it to changes in patterns (e.g., texture or contours) of what one perceives in a dynamic environment. For example, words have different quality and can involve top-down processing to different extents. Their availability in the driver's working memory or connection with, for example, strong emotional stimuli can modulate the distraction effect. According to Castro (2009), the information theory (Shannon and Weaver 1949) provides useful references for tackling traffic devices informativeness. Information in this influential framework is defined as a reduction of uncertainty, thus, more informative events or messages are those that are more unlikely to occur. But because the degree of uncertainty is difficult to measure in a driving context, other methods are often being employed. We conclude that further analysis of the slogans entropy (Jelinek 1997; Shannon and Weaver 1949) could provide insight into the understanding of our findings, that differentiate fixations in different slogans' length conditions only for one pair of ads.

The amount of information in an advertisement can be analyzed by taking into account various aspects: the slogan, the image, and the method of persuasion. The more complex the advertisement (e.g., has more logos), the greater distractor it constitutes (Zhang et al. 2013). Thus, the information load of the advertisement depends on the whole composition including the slogan length, logotype, all necessary textual information, and compilation of images (product images, contexts, graphics) of varying degrees of complexity. While in the case of a slogan, it is easy to come up with a solution to analyze the amount of information (e.g. counting the characters), analyzing the 'information load' of the image is a problem. We perceive words linearly compared to pictures. It takes more time but gives more precise semantic information. We get to know the image 'immediately' as a whole and it may carry many complex meanings (Tversky 2011). The analysis

of an image in terms of the amount of information is carried out in very different ways: from counting the elements included in the composition, to individuals’ assessments of the feature and design complexity (e.g., Pieters et al. 2010), to computer calculation of the relationship between characteristics of pixels (entropy) forming the image (e.g., Marchewka et al. 2014). Research on processing information in pictures suggests that picture stimuli may distract attention because of the impulses they trigger that an observer subsequently has to cope with. Research on self-control provided by Steimke et al. (2016) shows an effect of 3 types of picture distractors on the underlying mechanisms of selective spatial attention. Experimental conditions with appetitive (approaching reaction), aversive (avoiding reaction), and neutral (cognitive conflict) stimuli triggered by pictures were compared to non-distractor conditions in attentional tasks, accompanied by eyetracking methods. Slower reaction times and error rates were gained for all 3 types of distractors in comparison to the control condition. Eyetracking data showed behavioural effects caused by the distractors in the form of higher standard deviations for the gaze distance to the target. Additionally, erotic pictures compared to neutral and neutral pictures compared to the control condition resulted in a higher gaze distance from the target position.

Finally, the mechanism explaining the influence of the amount of information in the slogan on the behavior of drivers is more complex than it initially seems. On the one hand, a longer slogan means more time needed to read the advertisement. Drivers then drift away from the centerline and then make up for it with sudden steering movements (Schieber et al. 2014). On the other hand, longer slogans may not absorb the attention of drivers due to the excess of information: the slogan is too long, incomprehensible, treated as “a specific blur” (Di Stasi et

al. 2012). Thus, we think that future research should look into the phenomenon of ignoring irrelevant visual information (see Gaschler and Frensch 2009; Gaschler et al. 2015). According to Information-Reduction Hypothesis (Haider and Frensch 1996) discarding irrelevant information from processing increases with practice. Drivers in a natural driving environment ignore information they assume to be too engaging and too threatening in order to stay better focused on a safe driving. They learn to recognize the redundant information immediately and refuse it all without further processing, using once-for-all strategy (Gaschler et al. 2015). Discarding the irrelevant information is associated with reduced eye fixations and thereby minimizing a cognitive effort. Various explanations of this mechanism (whether it involves more perceptual or conceptual level of processing) are an interesting subject for further testing (Gaschler et al. 2015; Haider and Frensch 1999).

### Compliance with Ethical Standards

**Conflict of Interest** On behalf of all authors, the corresponding author states that there is no conflict of interest.

**Ethical Standards** All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

**Animal Studies** This article does not contain any studies with animals performed by any of the authors.

**Informed Consent** Informed consent was obtained from all individual participants included in the study.

## Appendix

**Table 2** Descriptive statistics for age groups in Study 2

Age group	Mean-distance-to-the-vehicle-preceding						Distance-to-the-vehicle-preceding-SD						Mean-time-headway						Time-headway-SD					
	18–29		30–45		54 < ...		18–29		30–45		54 < ...		18–29		30–45		54 < ...		18–29		30–45		54 < ...	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Short slogans	32.80	5.57	34.24	4.55	36.14	7.85	1.33	.98	1.43	.93	1.55	1.20	1.27	.26	1.33	.20	1.43	.36	.07	.05	.07	.04	.09	.07
Long slogans	33.18	6.31	36.08	3.54	35.86	7.60	1.62	.93	2.16	1.17	2.66	2.63	1.30	.29	1.42	.17	1.42	.37	.08	.06	.10	.06	.12	.12

**Table 3** Descriptive statistics for men and women in Study 2

Sex	Mean-distance-to-the-vehicle-preceding				Distance-to-the-vehicle-preceding-SD				Mean-time-headway				Time-headway-SD			
	Men		Women		Men		Women		Men		Women		Men		Women	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Short slogans	34.25	5.54	34.68	6.92	1.41	.98	1.72	1.41	1.35	.26	1.34	.28	.07	.05	.08	.06
Long slogans	34.88	5.71	35.41	6.48	1.76	1.15	2.63	2.23	1.37	.27	1.40	.32	.09	.06	.12	.10

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