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Exploring the impact of "soft blocking" on smartphone usage of young drivers

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ABSTRACT

Smartphone usage while driving, and particularly texting, are well recognized as a major road safety concern. This paper presents an attempt to evaluate the effect of countermeasures aimed at mitigating this usage. These countermeasures, which are automatically activated, may be considered "soft blockers": silencing and hiding notifications, as well as sending an automatic reply to the person trying to contact the driver. A naturalistic study was conducted with 167 young Israeli drivers, who installed a research-oriented smartphone app, which continuously monitored their smartphones usage while driving and, in addition, activated “soft blocking” in the study’s intervention stage. The evaluation is based on measures which capture the number of times drivers "touch" their smartphone screens, and on the vehicle’s speed when these screen-touches occur. The results, based on 6633 hours of driving logged on 23,019 trips, indicate that a reduction of approximately 20% was obtained in the average number of screen-touches during the intervention stage of the study; that is, in the experimental groups but also in the control group, which was merely monitored. In addition, when young drivers touched the screen, the vehicle was more likely not in motion. The current paper highlights the potential of “soft blockers”, as well as the awareness of being monitored, for mitigating smartphone usage while driving.

1. Introduction

Smartphone usage while driving is a major road safety concern and is likely to remain a key issue as smartphone usage continues to rise. In recent years, the prevalence of drivers operating smartphones while driving has become a social epidemic. Many recent studies indicate that actions involving usage of smartphones and smartphone applications (apps) while driving - such as texting, surfing the web, getting notifications from social networks - may distract drivers from the primary task of driving, thus increasing the risk of a crash (Asbridge et al., 2013; Caird et al., 2014, 2008; Carney et al., 2018; Fitch et al., 2013; Handel et al., 2014; Klauer et al., 2014; Strayer et al., 2013).

Of the many types of smartphone usage, *texting* was found to be the most risky behavior (Dingus, 2014; Hedlund, 2011; Klauer et al., 2014; Victor et al., 2014). There is no doubt that texting while driving negatively affects lane position control, reaction time, speed and headway deviation (Fitch et al., 2013; Owens et al., 2011; Yager, 2013; He et al., 2014; Caird et al., 2014). While the public perceives smartphone usage while driving, and especially texting, as significantly compromising safety, these views are unfortunately not associated with actual driving behavior (Atchley et al., 2011; Hamilton et al., 2013; Marcoux et al., 2012; Musicant et al., 2015; Hayashi et al., 2017; Kim, 2018). A staggering fact related to texting while driving is that drivers engage in this risky behavior, despite recognizing its potential negative consequences. This may have important implications on intervention strategies (Hayashi et al., 2017). Hence, prevention strategies should be tailored to target texting while driving. Furthermore, intervention efforts should discourage texting while driving and focus on creating social norms geared towards deterring other risky driving behaviors (Trivedi et al., 2017).

Various countermeasures from diverse disciplines have been suggested and implemented in attempts to mitigate the negative effects of texting while driving. These include bans on texting, enforcement, generating "texting zones" along freeways - rebranded rest stops that encourage drivers to pull off the road if they want to text - and massive educational campaigns. One interesting and promising means is technology-based distraction prevention. Over the last few years, an increasing amount of emerging technologies, such as smartphone apps, have been introduced into the market (see a review in Albert et al., 2016). In general, these apps are automatically activated once detecting driving and are deactivated once the trip ends. The motion detection is based on smartphones' built-in sensors such as: GPS, 3G networks,

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gyroscopes and accelerometers.

Among these apps, the various types of "blockers" should be noted; these apps prevent or limit drivers' texting (typing or reading), as well as block, hide or silence various incoming notifications while driving. Therefore, drivers are not aware of the communication attempt, and do not feel pressured to attend to it. Moreover, these apps may help drivers who wish to refrain from being disturbed while driving. Some apps that block incoming notifications can be pre-defined by users to make exceptions for certain contact persons or certain apps (such as navigation).

An interesting feature associated with "blockers" apps is their ability to provide an automatic and prompt reply to incoming text messages. Such an automatic reply can indicate that "the person you are trying to reach is currently driving". In most apps, the text of the return-reply can be edited by the users.

A study by Musicant et al. (2015) reported that 49% of 757 Israeli drivers who participated in an internet survey expressed willingness to use a blocking app, a tool readily available with various configurations. Only the most limiting configuration (complete blockage of phone calls and texting) was suggested in the survey, and the respondents were asked to indicate whether they would consider using such an app or not. It may well be the case that even higher acceptance rates could be manifested if "soft blockers" are used, that is, if less limiting apps are offered.

Creaser et al. (2015) described the Minnesota Teen Driver Study, which incorporated cellular phone blocking functions via a software app for 182 novice teen drivers. Teens were asked to self-report how frequently they talked on the phone or engaged in text messaging while driving. Their results showed that blocking cellular phone use while driving was effective at reducing the frequency with which teenage drivers called and texted while driving. They reported that the rate of text messages sent per mile driven for the two intervention groups that used the blockers was significantly lower than in the control group. A recent survey conducted among 766 young Israeli drivers focused on technologies for mitigating smartphone distraction while driving (Albert and Lotan, 2017). In this study, a large percentage of young drivers reported the difficulty, to a large extent, to resist the temptation of reading (82%) and writing texts (64%) while driving. It was found that 44% of the respondents declared they would be willing to use a technology that silences notifications, 33% stated they might use it, and 23% indicated they would not consider using such a technology. Pertaining to a technology that hides pop-up notifications, 49% of the respondents declared they would be willing to use a technology that silences notifications, 31% stated they might use it, and 20% indicated they would not consider using it. Pertaining to the auto-response option, 50% of the respondents declared they would be willing to use the automatic response option, 34% stated they might use it and only 16% indicated they would not consider using such an option.

No doubt, "blockers" potentially have a lot of safety advantages if they are used while driving. The most notable benefit is their ability to reduce or even completely prevent smartphone-related driving distraction - mainly texting. Furthermore, their usage may facilitate new norms among smartphone users and help decrease unnecessary communication during driving, in general. The feature that enables automatic replies helps users to disengage from their devices while driving without feeling pressured to initiate a reply. However, these apps may not be widely used and accepted by the general public. Albert et al. (2016) described an extensive experts' study with 37 specialists who cover several areas of expertise (13 safety experts, 7 government experts, 8 technology experts and 9 human factors experts). The study concluded that while considering smartphone apps' ability to mitigate risky driving behavior versus their general acceptance – both criteria are thought to be of almost equal importance. Texting prevention - no typing (that is, the keyboard is blocked while driving) and texting prevention - no reading (that is, all types of text messages are not available for reading while driving), were rated high by the experts pertaining to their potential to reduce risky driving behavior, but rated low regarding their level of acceptance.

It seems that as yet, very little research has been conducted to investigate the effectiveness of such "blocking" apps on actual daily smartphone usage while driving. In Benden et al. (2012), a literature review on cell phone use while driving was conducted. Of all 74 reviewed articles, only 13 mentioned texting while driving as a specific driving behavior, and only limited information regarding how to control texting while driving was reported. It was also suggested to conduct further research pertaining to essential techniques to minimize risky behaviors in an increasingly technology-dependent world (e.g., cell phone blocking devices). In Funkhouser and Sayer (2013), two custom applications were used in a study with 44 participants, all Michigan Department of Transportation employees, who each received a cell phone filtering/blocking application on their employer-provided cell phones. Data were collected for a period of three weeks prior to the test and for three weeks afterwards (the test itself also took three weeks). The results show that fewer incoming calls at non-zero speeds during the blocking period were answered, participants placed outgoing calls at lower speeds and more calls at zero speed during the blocking period. Based on responses to a questionnaire, participants were overall neutral regarding the safety benefits from the cell phone blocking applications. To the best of our knowledge, no research has been conducted to investigate the effectiveness of the automatic reply on actual daily smartphone usage while driving.

In order to fill this gap, this paper deals with the effect of "soft blockers" features on the smartphone usage of young Israeli drivers, such as silencing and hiding notifications, and an automatic reply which is sent to the person trying to contact the driver, saying: "I'm currently driving; while driving – just drive". The evaluation is based on measures presented in the Methodology section. The Methodology section also presents a detailed description of the study. Then, the results are described followed by a discussion and conclusions.

2. Methodology

2.1. General framework

"Drive Mode" is a naturalistic study conducted with 260 young Israeli drivers - 147 males (64%) and 113 females (36%), aged 17–23 (average 19.4, SD = 1.7) - who have been in possession of a driving license for at least three months and drive, on average, at least two hours a week. None of them had been involved in a prior crash. In this study, each participant had been driving in his or her family-owned car for a period of four months. In the first stage of the study, which lasted for one month, only monitoring of actual smartphone usage while driving was performed. This first stage of the study is described in Albert and Lotan (2018). In the second stage of the study – the intervention stage - which lasted for two months, each participant was introduced with a specific intervention aimed to mitigate smartphone usage while driving. There were four types of intervention groups and a control group. Participants were randomly allocated to these groups. In the third (last) stage of the study, which lasted for one month, only monitoring of smartphone usage while driving was performed, similar to the first stage of the study. The recruitment procedure continued for six months; therefore, not all participants started (and ended) at the same point in time. Participants were informed during the recruitment procedure about the type of information they would be provided with. During the study period they received notifications from the research team before transitions between the study stages, which have been done automatically, and few days before the end of the research period. The communication was done mainly via WhatsApp, a popular free messaging smartphone app in Israel.

In this paper, data was collected and analysed for 167 participants - 106 males (64%) and 61 females (36%) - are presented as follows: 64 participants from the control group - "Group A"; 48 participants who

Table 1
Participants' socio-economic characteristics per groups.

Group	A (Control)	B	C	Total
Age	19.3 (sd = 1.8)	19.7 (sd = 1.7)	19.1 (sd = 1.6)	
Gender				
Female	29	13	19	61
Male	35	35	36	106
Residence area				
Urban	49	37	39	125
Rural	15	11	16	42
Economic cluster of residence (scale from 1 to 10)	6.2 (sd = 1.6)	6.2 (sd = 1.6)	6.5 (sd = 1.7)	

were introduced with the intervention that silences and hides notifications - "Group B"; and 55 participants who were introduced with the intervention that silences and hides notification plus sends an auto-response to the texter - "Group C". Participants' socio-economic characteristics: age, gender, type of residence and residential economic cluster according to the National Bureau of Statistics (ranked on a scale of 1–10, where 10 represents the highest socio-economic level) are shown in Table 1. It should be noted that due to random allocation into groups, it was not possible to control for socio-economic characteristics; however, as can be seen they turned out to be similar. The portion of females in the control group is higher; although the safety literature does not report any evidence to significant gender differences in smartphone usage (Creaser et al., 2015; Albert and Lotan, 2018) the comparison to the intervention groups should be regarded with caution, as will be further discussed.

The other intervention groups (which included the rest of the 93 participants in the "Drive Mode" study) were excluded from the analysis, since these types of interventions did not capture comparable characteristics and do not refer to blocking technology, but to other countermeasures used in the "Drive Mode" study.

A Self-reported questionnaire was also developed and administered to participants. The questionnaire was Internet-based and participants were asked to complete it before and after the data collection phase of the study. The questionnaire included ten self-reported items regarding smartphone usage and behavior while driving. The ten items are presented in Table 2. Some of the items were reversed, due to the opposite wording of the question in a way that would suit the other questions. The response scale ranged from 1 to 5; a high score indicating more intensive smartphone use (number of touches, reading and writing activities).

Each participant received a modest compensation at the end of the study (equivalent to $60) independent of his/her behavior during the study.

Table 2
Self-reported items regarding the impact of the intervention on smartphone usage while driving.

item	Description
1	Performing screen-touches when the vehicle is in motion
2	Performing screen-touches when the vehicle is stationary
3	Focusing on driving
4	Feeling relaxed while driving
5	Writing text messages
6	Receiving text messages
7	Reading text messages
8	Receiving phone calls
9	Being available
10	Checking the smartphone

2.2. Technology

A smartphone app available for Android mobile operating systems has been adjusted and configured especially for this study. Each participant received a unique user name and password, and installed the app on his/her privately-owned smartphone.

In its research-oriented version, this app continuously monitors smartphone usage while driving. The monitoring is done automatically through a smart detection of driving via several indicators (e.g., Bluetooth connection, GPS and NFC (Near Field Communication), and includes - depending upon the smartphone type and operating system - foreground apps, time stamps and speed. Most importantly, the monitoring captures the number of times the young driver actually touches the smartphone screen. If, for some reason, the app started monitoring when the young driver wasn't driving, then he/she was asked to turn off the app by marking the "I am not driving" option. In order to respect the user's privacy and increase acceptance among users, cell phone content was not monitored at all.

In the study's intervention stage, the two types of interventions (Group B and Group C) were automatically implemented by this research-oriented app. With regard to Group B, incoming messages and notifications were automatically muted and hidden. With regard to Group C, in addition to muting and hiding incoming messages (as done in Group B) a pre-editable auto-response SMS saying: "I'm currently in drive mode, while driving just drive", was promptly sent to the person trying to contact the driver. It should be noted that during the entire data collection phase, including all three stages, monitoring of smartphone usage, as described earlier, was systematically performed.

All the information collected during all stages of the study was transferred on-line to a central server, where all the data were stored. The multiple collected parameters included: the number of screen-touches, identification of apps used by drivers, incoming/outgoing calls durations, and vehicle speed.

2.3. Measures

The evaluation of smartphone usage while driving was mainly achieved by exploring the characteristics of the screen-touches. Clearly, when the driver touches the smartphone screen, it involves several types of simultaneous distractions: visual (the driver's eyes are off the road), manual (the driver's hands are off the vehicle controls) and cognitive (the driver's mind is engaged in other tasks). When applicable, the speed at which the screen-touches occurred, which may serve as an indication of extremely risky driving behavior, was also referred to in the evaluation.

Hence, the evaluation is based on the following three measures:

(1) *Screen- touches per minute of driving* – this value is calculated by the total number of screen-touches divided by the total duration of the trips. Therefore, it can be calculated per any unit, i.e., time period, group of participants, etc. Clearly, high value indicates intensive smartphone usage.
(2) *Percentage of screen- touches when the vehicle stops (i.e., is not in motion)* - this measure refers to the percentage of screen-touches made when the vehicle was at a speed of less than 5 kph; that is, at traffic lights, in traffic jams, when parking, etc. This measure can be calculated only if the smartphone's GPS was activated. A plausible assumption may indicate that screen touches performed when the vehicle is not in motion are more acceptable from a safety point of view, since the consequences may be relatively mild compared to when the vehicle is in motion.
(3) *Screen-touches at high speeds index* – this index is based on the assumption that screen-touches occurring when the vehicle is in motion, and especially at higher speeds, may have more problematic consequences. That is, touching the smartphone screen when driving at 80 kph is riskier than touching the smartphone screen at

20 kph, when all the other variables (e.g., location, traffic conditions) are similar, and hence implies a higher value for this index. As the concept of screen-touches is novel, the effect of vehicle speed when performing screen-touches needs to be further investigated. The calculation of the index is adjusted to Elvik (2009), who developed a risk index that calculates the change in drivers' risk level as a function of the average speed, giving high (exponential) weight to high speeds. This index can only be calculated when the smartphone's GPS is activated.

It should be noted that various measures, other than the three presented above, can be further developed based on the data collected. However, it is plausible to assume that these three measures provide a comprehensive assessment of smartphone usage while driving, using screen-touches as a key indicator, as proposed by Albert and Lotan (2018).

3. Results

3.1. Trips statistics

During the three stages of the study period, a total of 23,019 trips (with a minimum duration of three minutes each) were undertaken by the 167 participants and 6633 h of driving were logged. Table 3 presents summary statistics of the three groups according to the three stages of the study. In 18,832 out of the 23,019 trips (82%), the smartphone's GPS feature was switched on, and therefore speed data were also collected. The data were used to evaluate both measures: *Percentage of screen- touches when the vehicle stops* and *Screen-touches at high speeds index*.

In order to enable a comprehensive comparison among groups and stages, the control group (Group A) was also examined according to three stages in order to capture changes over time, although no intervention was introduced to the control group throughout the whole study period. This means that, similar to the other groups, the four-month study period is split into three phases.

The trips' statistics in Table 3 regarding young drivers' travel patterns are in line with figures reported in other naturalistic studies that dealt with young drivers in Israel (Toledo et al., 2014; Albert et al., 2014). That is, young Israeli drivers make relatively few and short trips (on average: one or two per day, around 15–20 min each).

These statistics obtained from the Table 3 indicate that the average duration of a trip is 17.2 min (sd = 7.6) in Group A; 17.4 min (sd = 7.8) in Group B; 17.3 min (sd = 7.2) in Group C.

Participants in the control group made fewer trips per participant compared to both intervention groups: (and, hence, logged fewer driving hours per participant) 0.9 trips per day compared to 1.3 trips per day in each intervention group. This difference is significant ($F_{(2,499)} = 4.73$, p value < 0.01). Although the safety literature, best to our knowledge, does not take into consideration this variable of the number of trips per day in smartphone usage analysis, the comparison to the control group's behavior should be regarded with caution, as will be further discussed.

Table 3
Overall statistics of trips undertaken by the participants.

Group	Total driving minutes	Total no. of trips	Total no. of trips with GPS (%)
A (Control)	114,700	6,671	5,418 (81%)
First stage	34,100	2,035	1,543 (76%)
Second stage	55,065	3,128	2,608 (83%)
Last stage	25,535	1,508	1,267(84%)
B	132,862	7,646	6,254 (82%)
First stage	48,432	2,764	2,156 (78%)
Second stage	47,056	2,705	2,205(82%)
Last stage	37,375	2,177	1,893 (87%)
C	150,396	8,702	7,160 (82%)
First stage	46,242	2,670	2,186 (82%)
Second stage	68,160	3,909	3,186 (82%)
Last stage	35,995	2,123	1,788 (84%)
Total	397,958	23,019	18,832 (82%)

Table 4
Screen-touches per minute of driving per group - General statistics.

Group	Median	Average	SD
A (Control)			
First stage	1.38	1.72	1.50
Second stage	0.75	1.46	1.67
Last stage	0.82	1.24	1.28
B			
First stage	1.37	1.82	1.38
Second stage	1.08	1.39	1.10
Last stage	1.09	1.34	1.05
C			
First stage	1.08	1.38	1.18
Second stage	0.83	1.12	1.15
Last stage	0.87	1.44	1.64

3.2. How many times do young drivers touch their smartphone screens?

The first measure -*Screen-touches per minute of driving* – is calculated based on the trip characteristics presented in Table 3 and the number of screen touches. The results are presented in Table 4 and the trends are illustrated in Fig. 1.

For all of the three study stages, no significant differences were found using MANOVA among the three groups (F = 1.50 in the first stage, F = 0.91, in the second stage, F = 0.29; where $F_{crit} = 3.05$). However, while Group C's average screen-touches per minute of driving is notably smaller compared to the other groups both in the first and second stages, in the last stage it is the highest. Its trend is typical to the impact of intervention: a decrease of 19% (pvalue = 0.11) in the intervention stage compared to the first stage, and then an increase of 21% (pvalue = 0.11) in the last stage, to an even slightly higher value than the initial one. None of the changes among stages with regard to Group C were significant. Group B's trend is interesting: a significant reduction of 24% (pvalue = 0.05) in the intervention stage compared to the first stage, which continued and became even more prominent in the last stage: a reduction of 26.5% (pvalue = 0.03) compared to the first stage. No significant differences were found when comparing the sequential phases of the control group; a reduction of 15% in the second stage compared to the first stage and a reduction of 15% in the last stage compared to the second stage. However, this general trend of reduction is observable: a significant reduction of 28% (p value = 0.03)

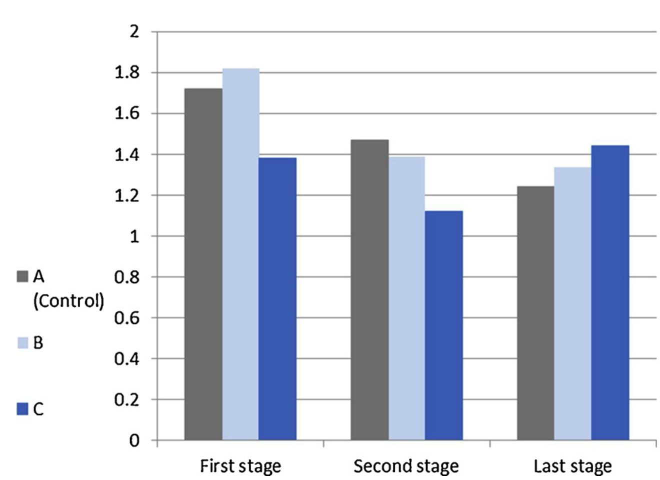

Fig. 1. Average screen-touches per minute of driving per groups.

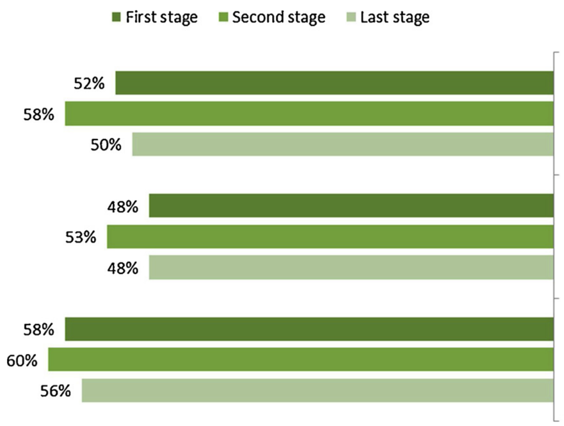

Fig. 2. Percentage of screen-touches when the vehicle stops.

when comparing the First and Last phases.

3.3. Do young drivers touch their smartphone screens when the vehicle stops?

The second measure - *Percentage of screen-touches when the vehicle stops* – differentiates between screen-touches which are performed when the vehicle is not in motion (speed less than 5 km/h) and screen-touches performed when the vehicle is in motion. The results are presented in Fig. 2.

As can be seen, during the intervention stage there was an increase in the percentages of screen-touches performed when the vehicle was not in motion. It is interesting to note that this pattern occurred also in the control group.

Intriguingly, in Group B the percentages of screen-touches performed when the vehicle was not in motion were relatively low compared to the other groups.

3.4. Do young drivers touch their smartphone screens when driving at high speeds?

The third measure - *Screen-touches at high speeds index*– gets a high value when many screen-touches occur at high speeds. The results are presented in Fig. 3. The vertical axis represents the calculated value of the index. As indicated in the Figure, the control group exhibit the most moderate patterns of smartphone usage when driving at high speeds. A comparison of the results between Group B and Group C shows that participants in Group B exhibit more dangerous patterns: they not only perform a higher percentage of screen-touches when the vehicle is in motion (as indicated by the second measure in Fig. 2), they also do so at

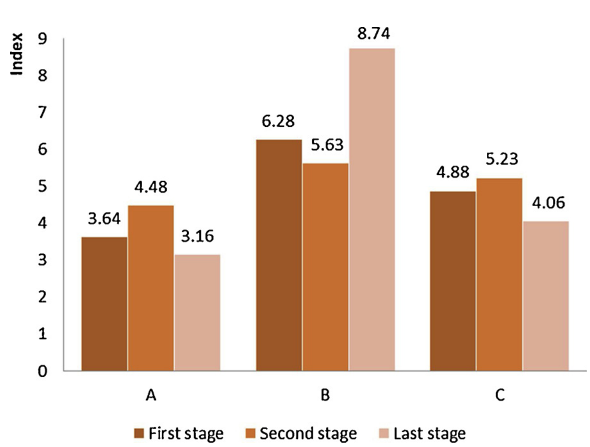

Fig. 3. Screen-touches at high speeds index.

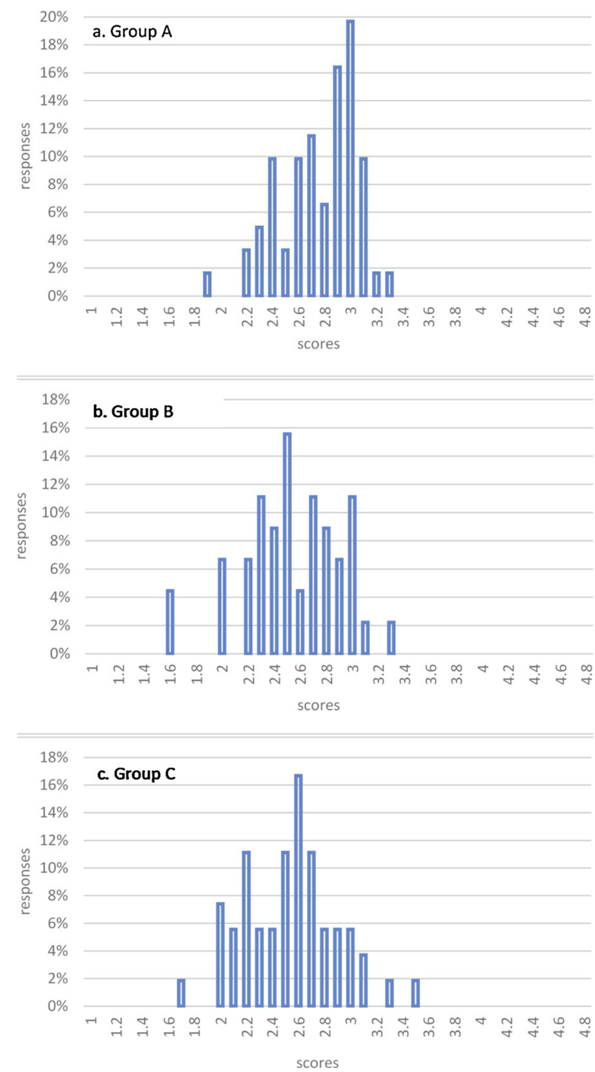

Fig. 4. Distribution of the self-reported average scores, which represent the perceived level of smartphone usage.

high speeds. It is interesting to note two notable and inexplicable findings: first, the index for Group B in the final stage is extremely high. Second, although minor, the index for Group C in the intervention stage is higher compared to the other stages.

3.5. Self-reports: smartphone usage and the impact of intervention

A key goal of the self-reported questionnaires was to capture the impact of the interventions on smartphone usage as perceived by the participants. As noted in the Methodology section, the response scale for each item presented in Table 2 ranged from 1 to 5; a high score indicating more intensive smartphone use (number of touches, reading and writing activities) compared to the first phase of the study. For example, a score of 5 on item no. 5 means that the respondent self-reported writing many more text messages while driving. Based on these responses, an average score for all 10 items for each respondent was calculated, a high score indicating more intensive smartphone usage during the intervention. The results are presented in Fig. 4. As can be seen, the distribution of the average score in each group is somewhat similar to a normal distribution. Group A's average score (2.76, sd = 0.29) was found to be significantly different from those of both Group B (2.54, sd = 0.37) and Group C (2.54, sd = 0.36). The results of Groups B and C were very similar. It should be noted that responses regarding smartphone usage in the first stage of the study, as well as in the last stage, did not yield significant differences among the groups.

In general, all participants self-reported that while driving they usually react to a communication attempt by answering a call or reading a message, but do not initiate communication by calling or writing a message. With regard to the qualitative questions, all participants pointed out their increased awareness of smartphone use and texting, following their participation in this study.

4. Discussion

Over the years, smartphones have gradually become an integral part of our lives, which affects social norms and behavior. It seems that the need to stay connected raised the temptation to use the smartphone also while driving. Clearly, driving in the smartphone era has become much more distracting and hence, poses a major safety problem.

This paper, which is based on a naturalistic study with 167 young Israeli drivers, attempts to capture and evaluate the effect of countermeasures aimed at mitigating driving distractions caused by smartphones, through a smartphone app. The statistics regarding young drivers' travel patterns found in this study are in line with figures reported from other naturalistic studies, which dealt with young drivers in Israel: few and short trips; on average: one or two per day, around 15–20 min each (Toledo et al., 2014; Albert et al., 2014). The countermeasures probed may be considered "soft blockers", and were activated automatically while driving: silencing and hiding notifications, as well as sending an automatic reply to the person trying to contact the driver saying: "I'm currently driving; while driving – just drive".

The novel method of objectively measuring smartphone usage by the actual number of smartphone screen-touches, introduced in Albert and Lotan (2018), is explored and the evaluation is based on three measures: the *average number of screen-touches, percentage of screen-touches made while the vehicle stops* (i.e., the speed is less than 5 km/h) and the *screen-touches at high speeds index*. From a safety point of view, distraction is mitigated when the *average number of screen-touches* decreases, the *percentage of screen- touches while the vehicle stops* increases and the *screen-touches at high speeds index* declines.

It should be noted that various measures, other than those used in this paper, can be developed based on the collected data. However, the three measures we used provide a comprehensive and complementary assessment of smartphone usage while driving, which is complex to interpret from a safety point of view. For example, it can reflect a behavior in which both the *percentage of screen-touches when the vehicle stops* as well as the *screen-touches at high speeds* increase. From a safety point of view, this behavior is associated, on one hand, with less dangerous behavior as screen-touches occur at zero speed. On the other hand, if this behavior is associated with more screen-touches occurring at high speeds, then the combined effect is compounded. As presented in this paper, some results are ambiguous, and this clearly indicates the need for more research to shed additional light on such behaviors.

The trend of the first measure - the *average number of screen-touches* – for Group B - intervention that silences and hides notifications - is interesting: the significant reduction in the intervention stage persisted and became even more prominent in the last stage. The trend of Group C - intervention that silences and hides notifications plus sends an auto-response to the texter - is more typical to interventions (a U-shape): a decrease in the intervention stage compared to the first stage, and then an increase to a slightly higher value than in the first stage. None of the changes among stages for Group C were significant.

The second and third measures take into account the vehicle's speed when the screen-touches occurred. During the intervention stage, there is an increase in *the percentages of screen-touches performed when the vehicle stops* followed by a decrease in the last stage of the study. This trend is expected when illustrating the effect of an intervention. The results of *screen-touches at high speeds* are confusing: There is a desired decrease for Group B in the intervention stage, followed by a massive increase in the last stage. For Group C, we observed a minor increase in the intervention stage, followed by a decrease in the last stage. Comparing the results of Group B to those of Group C shows that participants in Group B exhibit more dangerous patterns; they not only perform a higher percentage of screen-touches while the vehicle is in motion, they do so at high speeds.

As mentioned previously, comparison to the results of the control group should be regarded with caution as, despite the random allocation of participants to groups, the results show that participants in the control group drove less. This may have affected their smartphone usage patterns while driving even though the safety literature, best to our knowledge, does not report on such impact. It was found that participants in the control group exhibit the most moderate patterns of touching the smartphone screen when driving at high speeds. Additionally, there is a general trend towards a decrease in the average number of screen-touches throughout the study period, and a significant reduction is obtained when comparing the first and last phases of the study. This may indicate that even monitoring in itself over time can affect behavior. Therefore, the control group in this study is not a "regular" control group. This conclusion is strengthened by the self-reported findings which specify that participants in the control group perceived a change in their smartphone usage patterns. Pertaining to "soft blockers", the impact perceived by participants in both intervention groups is very similar.

It seems that, due to the "soft blockers", drivers are not aware of receiving any communication attempts; when they "check", they exhibit self-regulated behavior and do it when the vehicle is not in motion. This, together with the general tendency to respond to a communication rather than initiate one while driving, as revealed in the self- reports, may impact driving behavior. Young drivers perform less screen-touches when driving, but they "compensate" for this by "checking" their smartphone when the vehicle stops. However, it seems that there is no effect of "soft blockers" when it comes to mitigating the speed of the vehicle if the screen-touches occur when the vehicle is in motion.

Do these effects last when the soft blockers are deactivated? The findings of this study indicate that the main effect occurs when they are activated, i.e., in the intervention stage. There are also some changes in the last stage compared to the first stage. It seems that raising awareness about the topic, in addition to the countermeasures themselves, have an impact on smartphone usage behavior. This may also provide insights into the changes among participants in the control group, even though they did not receive any active intervention throughout the study.

There are no prominent differences between the effects of the two countermeasures. The impact of the automatic reply sent to the person trying to contact the driver, saying: "I'm currently driving; while driving – just drive" seems to be unclear and hence may suggest some insights. On the one hand, this is an interesting approach with which to address distracted driving, as it shifts the "responsibility" to the person texting the driver (the texter). The texter can then decide whether to continue trying to contact the driver or postpone the communication. This can help create a new desirable norm according to which young drivers declare the fact that they are driving, and their friends respect it, meaning, they do not necessarily expect them to be available while driving. On the other hand, it seems that young drivers are neither mature nor ready enough for this: they want to control all of the messages being sent from their smartphone, and those receiving such message do not clearly realize the meaning of such a response. The complexity associated with auto-reply may indicate that a more sensitive activation should be further explored. In particular, young drivers should be able to control and differentiate the type, timing and context of the messages sent from their smartphones, as a tool to increase potential acceptance and wide dissemination of such countermeasure.

While this study seems promising, its limitations should be acknowledged. The novel concept of screen-touches and the three derived measures, capture only few aspects of the overall driving behaviors which are necessary for evaluating distracted driving. In addition, there are concerns regarding the accuracy of data captured through a smartphone app, and the potential functionality and reliability of this technology (e.g., drivers' ability to override by marking the "I am not driving" option), which should be further tested and verified. Furthermore, even though the results are based on a relatively large sample, it is likely to be biased towards individuals who possess a high level of road safety awareness. Therefore, like most naturalistic studies, the sample is not representative of the target population.

5. Conclusions

This paper attempts to evaluate the effect of countermeasures aimed at mitigating distracted driving through a smartphone app. These countermeasures may be considered "soft blockers", and are activated automatically while driving: silencing and hiding notifications, as well as sending an automatic reply to the person trying to contact the driver saying: "I'm currently driving; while driving – just drive". Unlike other typical "blockers" tools, these countermeasures do not, by any means, limit smartphone usage while driving. Therefore, their level of acceptance by drivers should be more promising compared to more limiting blockers.

The novel scheme of an objective means with which to measure smartphone usage by the user's actual smartphone screen-touches, as introduced in Albert and Lotan (2018), is explored. Hence, the evaluation is based on three measures: The *average number of screen-touches; Percentage of screen-touches when the vehicle stops* and *screen-touches at high speeds*. From a safety point of view, distraction is mitigated when the *average number of screen-touches* decreases, the *percentage of screen-touches while the vehicle stops* increases, and when *screen-touches at high speeds* declines.

The results presented here are based on a naturalistic study involving 167 young drivers who drove in their own cars and used their own smartphones for a study period of four months. The study was divided into three stages. Over the three stages of the study period, a total of 23,019 trips were taken and 6633 h of driving were monitored. The results indicate that "soft blockers", as well as merely monitoring, have the potential to be used as an efficient means to mitigate smartphone usage while driving. During the intervention period, a reduction in the value of *average number of screen-touches per minute of driving* of approximately 20% was obtained in all of the study groups; that is, in the experimental groups and in the control group. It seems that when such means are activated, drivers tend to reduce their number of screen-touches. In addition, when the screen-touches occur, the vehicle is more likely not in motion. Therefore, "soft blockers" may contribute to increased road safety. Even more promising, the findings may suggest that even monitoring, by itself, can positively affect smartphone usage while driving.

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