Available online www.jsaer.com

***Journal of Scientific and Engineering Research*, 2021, 8(7):90-95**

Research Article

ISSN: 2394-2630
CODEN(USA): JSERBR

The effect of traffic signal countdown on traffic flow

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Abstract In order to reveal the impact of signal countdown on traffic operation, this paper quantifies its substantial impact on traffic operation from both efficiency and safety. It is found that the impact on traffic flow is different in two different situations: low saturation flow and high saturation flow the same. Therefore, based on the conclusion of this study, this paper proposes the reference conditions for the signal countdown setting, which provides a theoretical basis for the setting of the countdown, and improves the safety and traffic efficiency of the intersection.

Keywords countdown; traffic efficiency; traffic safety

Introduction

The actual traffic situation in each city is different and traffic managers have different preferences for the use of countdown, and at present, whether the signal countdown is adopted at home and abroad and there is no unified and clear standards and norms, scholars on whether to set up a countdown timer formed a different view. Some scholars agree to set up signal countdown, which they believe will enable drivers to understand the remaining time of the signal lights and adjust their driving behavior accordingly, avoid dangerous driving behavior such as emergency braking and hasty acceleration, calm the driver's anxious waiting mood, reduce the driver's reaction time and cross-border delay, and improve the efficiency of cross-crossing traffic. However, some scholars do not agree to set the signal countdown, they believe that the countdown can lead to the driver at the end of the green light to accelerate through the intersection, red light early run red light and other dangerous behavior, resulting in traffic safety accidents. Therefore, many experts and scholars from the safety and efficiency of a lot of research and discussion. Because of the differences in traffic laws and regulations, drivers' driving habits, road environment and so on, the conclusions of the experts are also different, and even different. In terms of efficiency: Lum, Halim proposed to install the countdown after the yellow light during the proportion of vehicle choice to stop increased by 6.2 times, reducing the efficiency of the intersection; Ibrahim suggests that red light countdown can effectively reduce the head time difference of vehicles that line up to dissipate; Limanond et al. suggest that red light countdowns can save vehicles 22%in the initial start-up time of green lights; and Long kejun et al. have studied the increase in the time it takes for motor vehicles to pass through the stop line and the efficiency of traffic has improved significantly. In terms of safety: Wang Yan and Yang Xiaoguang studied that the countdown will induce some drivers to accelerate through intersections and red lights at the end of the green light when the head car early high-speed to the conflict point of the risky driving behavior; Chiou and Chang green light countdowns reduce vehicle late start rates and risk accelerated pass behavior; Chen et al. have found that the use of countdown devices during green lights has nearly doubled the traffic accident rate, while the countdown devices have increased accident rates by 50%over the same period during red lights. It can be seen that scholars do not comprehensive quantitative analysis of the pros and cons of countdown timer settings, nor for the setting of signal countdown or not to give a certain reference conditions. In view of this, this paper will analyze the advantages and disadvantages of quantitative settings from the aspects of efficiency and security, and make some research on their setting conditions.

1. Impact of signal countdown traffic flow efficiency

1.1. Speed

The point speed of the stop line was investigated by radar speedometer, and 115 valid data samples were obtained at the intersection of countdown signals, with an average speed of 7.84 m/s, 7.60 m/s, and the average speed at the point was approximately 3%higher than the signal intersection without countdown. Therefore, the signal countdown to a certain extent to improve the efficiency of the intersection.

1.2. Departure time

The vehicle departure time is defined as the time from the moment the green light comes on until the rear of the target vehicle passes the stop line. The recorded vehicle position number is defined as the serial number of the vehicle as it leaves the convoy when the green light is on. The following table is the mean time data of vehicles in line at various locations after data statistics, because the data samples counted are mainly cars, so the impact of large vehicles on the average departure time of vehicles is not considered.

Table 1: Vehicle departure time

Vehicle location number	There is a countdown	No countdown	The difference
1	3.71	5.76	2.05
2	8.08	11.42	3.34
3	11.09	15.31	4.22
4	13.83	18.26	4.43
5	16.23	20.75	4.52
6	18.56	23.14	4.58
7	20.87	25.49	4.62
8	23.16	27.81	4.65
9	25.48	30.14	4.66
10	27.82	32.49	4.67
sum	168.83	210.57	41.74

When the green light is on, the total time it takes for vehicles numbered at each location to pass through the stop line is the total delay for the fleet to dissipate. Take the 10 cars in line: 41.74s is the difference in the cumulative consumption of the top 10 vehicles, which is the difference in total delay, indicating that the total delay in the first 10 vehicles in the case of a red countdown is 41.74s less than in the countdown without a red light, a decrease of 19.8percent. The above results show that the red light countdown can effectively improve the traffic efficiency of the cross-line vehicles and reduce the delay at the intersection.

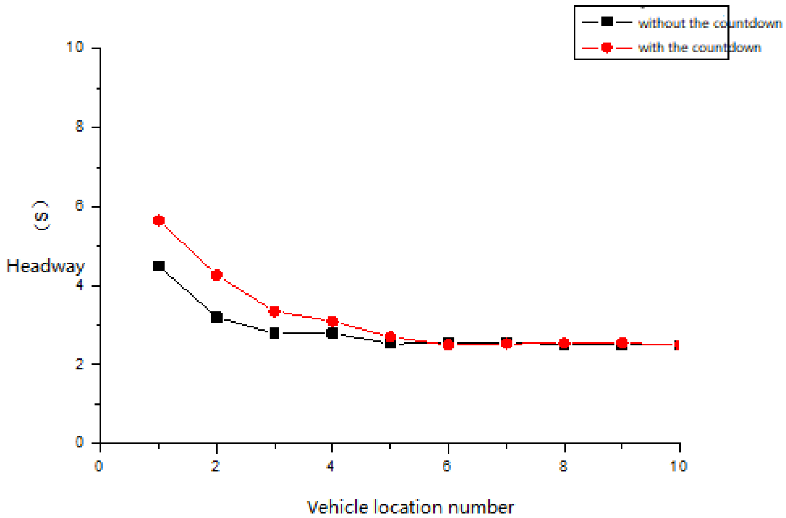

Figure 1: There is no countdown to the head time distance of each vehicle

1.3. Head time distance

In the same direction of a train team, two consecutive vehicles head through the stop line of the interval, for the head time distance. With the parking line as the coordinate origin, the vehicle position number is horizontal, and the head time margin is drawn with the head time range value as the ordinate coordinates, as shown in the figure. As can be seen from Figure 1, the head distance of the first 3 cars under the red light countdown conditions is smaller than the red light countdown conditions, the reason is that the driver according to the red light countdown time in advance to do the preparation of the vehicle start, reducing the vehicle start loss time. After the 4th car, there is a small difference in head time distance in the absence of a red light countdown, indicating that the red light countdown mainly affects the head time spacing of the first 4 cars in line.

2. The effect of signal countdown on the safety of traffic flow

2.1. Speed

Through video detection, speed changes of vehicles with the intersection stop line by the driver at the end of the green light (i.e. 3 seconds before the green light turns yellow and during the yellow) are, and the effect of the vehicle green light countdown signal on the driver's behavior is quantitatively analyzed, as shown in the figure. From the end of the green light through the stop line vehicle speed comparison can be, compared to the countdown signal , no countdown situation of the vehicle through the stop line speed is significantly , and more distributed between 10to 15m/s; This shows that a considerable number of drivers at the end of the countdown to the green light of the vehicle will choose to speed up past , rush through the intersection before the end of, green light, resulting in the, of speeding, because this part of the vehicle speed is, a little careless may cause serious traffic accidents.

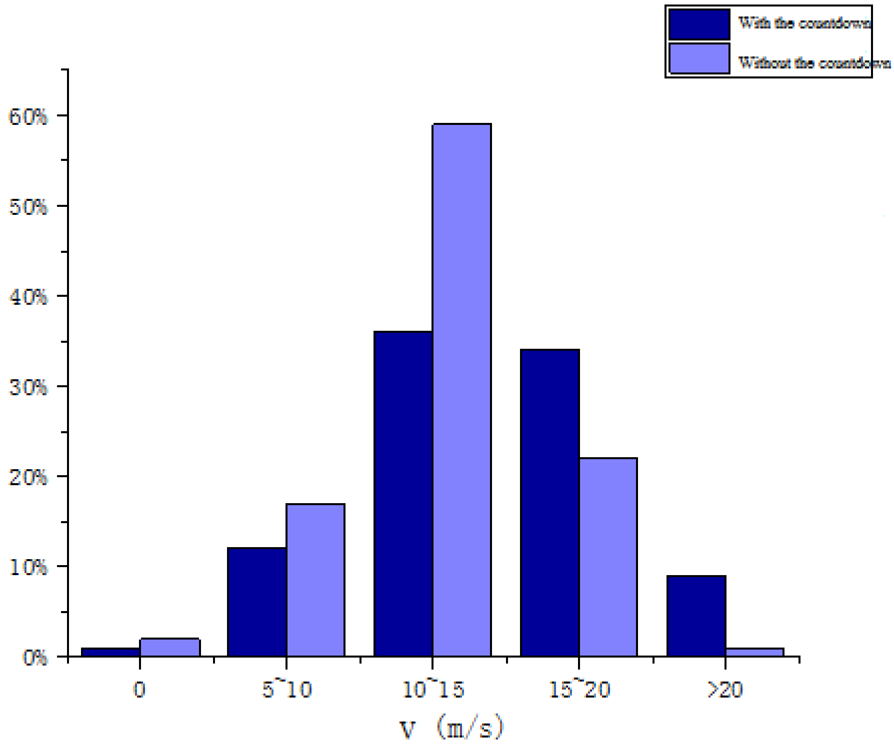

Figure 2: Point speed to reach the stop line

2.2. Run a red light

According to the statistics of driver behavior at the beginning of the red light, a total of 4.5% of the drivers at the countdown signal intersection reached the intersection stop line when the red light was on, and the driver ran a red light at the intersection without a countdown signal, accounting for about 8.3%. From the data, it can be seen that the countdown signal intersection than the countdown signal intersection run a red light behavior decreased by 3.8%, the driver's red light behavior improved, greatly improve the traffic safety at the intersection.

2.3. Violation of the diversion

Violation of lane change is a common bad driving behavior at intersections. In this paper, two traffic conditions with signal countdown and no signal countdown and similar environmental conditions were selected for observation, the number of illegal diversion behavior at the two types of intersections was analyzed statistically during peak and peak hours, and the statistics of the violation were obtained by adding statistics for 5 days for each 30min group during the daily survey period, and obtaining the statistics of the violation of the diversion, as shown in the figure.

Comparing the mean with the data in Figure 3 shows that the mean number of irregular changes at the intersection of the peak-hour countdown signal and the non-countdown signal is 31.8 and 23.8, respectively. The above two types of intersections during peak hours are 51 and 25.8 times, respectively, the difference is larger, and the number of countdown-free signal control intersections has approximately doubled. It can be seen that due to the high traffic flow during peak hours, vehicles interfere with each other to a greater extent, can not travel freely in addition to traffic police on-site command, so that the two types of intersections of the number of illegal diversion behavior is basically equivalent, and the peak period, the number of countdown signal intersection of the violation of the change of lane behavior is significantly higher than the non-countdown signal intersection, which shows that the green light countdown signal on the violation of the lane change behavior has a certain impact.

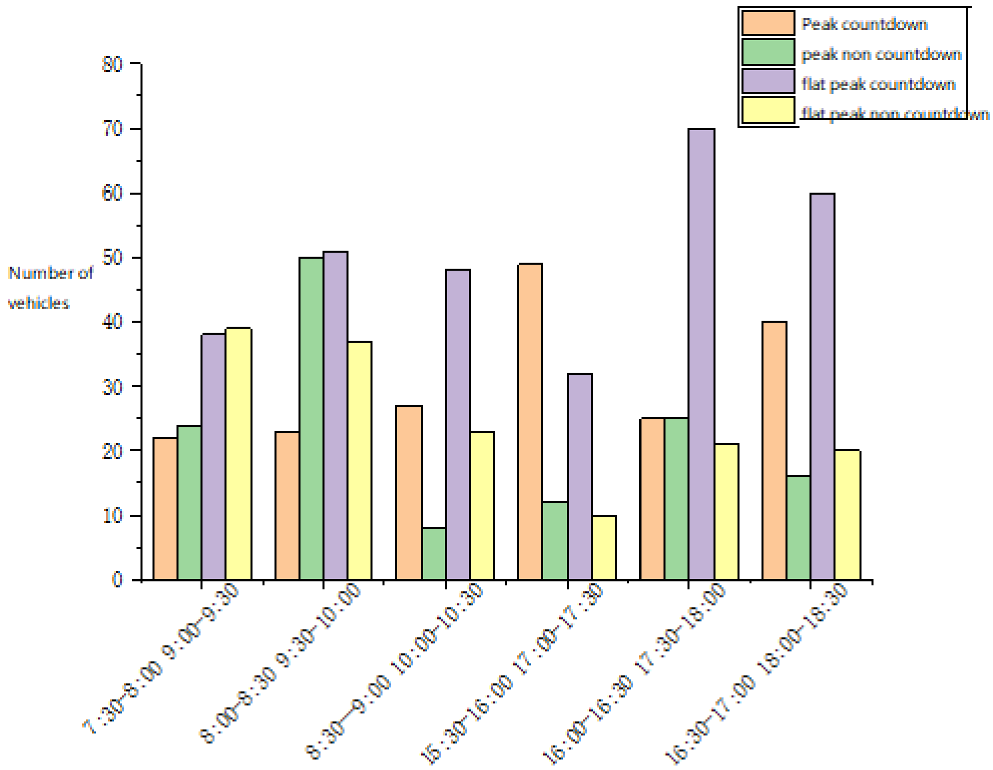

Figure 3: A comparison of the number of violations

3. Analysis of the applicable conditions for the countdown installation

By analyzing the efficiency and safety of the traffic flow with or without the countdown, it can be seen that the intersection with countdown increased the speed by 3%,reduced the head time distance of the first three vehicles, and reduced the total delay at the intersection by 19.8% (10vehicles in line), while in terms of traffic : the speed of the intersection with the countdown The number of vehicles larger than 15m/s is significantly higher than the no countdown intersection, about 18%more than the no countdown intersection, and the increase in high-speed vehicles poses a great safety hazard to the intersection, while the number of illegal diversions during peak hours has roughly doubled, with little impact during peak hours, but the number of red light violations has decreased by 3.8%.

Comprehensive analysis, in the case of small traffic flow, low saturation, the mutual interference between vehicles is small, the speed is faster, although there is a countdown signal intersection than the countdown intersection head distance, delay will be reduced, but its reduced time, in the later stage did not make efficient use of the intersection capacity has not been improved, but make the violation of the road change behavior increased, the number of high-speed vehicles increased, the intersection of the safety has had an extremely adverse impact. So don't mind installing signal countdowns on sections with low traffic or peak hours. In the case of large traffic flow, the intersection with the countdown signal will improve the speed of vehicles through the intersection to a certain extent, reduce the total delay at the intersection, the first three vehicles in line time distance, while its saving delay time is the follow-up queue vehicles efficient use, improve the traffic capacity of the intersection; Therefore, it is suggested to set up countdown signal device at intersections or peak hours to improve cross-crossing capacity, and the safety impact on intersections is weak, but it is necessary to install certain monitoring equipment to monitor and capture violations in real time, and further improve cross-crossing safety.

4. Summary and outlook

In this paper, the main countdown signal device on the intersection of vehicle circulation efficiency and safety quantitative analysis, and finally comprehensive analysis came to the following conclusions: in the traffic flow of large intersections or peak hours, the setting of signal countdown device is more beneficial than harmful, conducive to the setting of signal countdown; In order to deeply understand and quantify the impact of the signal countdown signal device on the efficiency and safety of traffic flow under two different cases of large traffic flow and small traffic flow, it is necessary to choose one at the later stage, and the traffic conditions of these two intersections, road environment and so on are similar, respectively, the above parameters of peak and peak hours are observed, and finally accurately quantify the impact of the countdown on traffic efficiency and safety, so as to draw more accurate conclusions, Provides a strong basis for setting the signal countdown.

References

[1]. Lum K M, Halim H. A before-and-after study on green signal countdown device installation [J]. Transportation Research Part F: Traffic Psychology and Behaviour, 2006, 9(1): 29-41.

[2]. Wu Wenjing, Zhai Zhicai, Jia Hongfei. Driver behavior decisions at the countdown signal intersection. Theory and Practice of Systems Engineering, 2009, 29 (07): 160-165

[3]. Ibrahim M R, Karim M R, Kidwai F A. The effect of digital count-down display on signalized junction performance [J]. American Journal of Applied Sciences, 2008, 5(5): 479-482.

[4]. Limanond T, Chookerd S, Roubtonglang N. Effects of countdown timers on queue discharge characteristics of through movement at a signalized intersection [J]. Transportation research part C: emerging technologies, 2009, 17(6): 662-671.

[5]. Limanond T, Prabjabok P, Tippayawong K. Exploring impacts of countdown timers on traffic operations and driver behavior at a signalized intersection in Bangkok [J]. Transport policy, 2010, 17(6): 420-427.

[6]. Wang Yan, Yang Xiaoguang. Study on the setting of countdown beacons based on traffic safety intersections. China Journal of Safety Science, 2006 (03): 55-59-70-147.

[7]. Cao Yu, Yang Zhongzhen, left. Zhongyi Effect of the green light countdown signal on driving behavior. China Journal of Safety Science, 2015, 25 (02): 77-82.

[8]. Chiou Y C, Chang C H. Driver responses to green and red vehicular signal countdown displays: Safety and efficiency aspects [J]. Accident Analysis & Prevention, 2010, 42(4): 1057-1065.

[9]. Chen P L, Pai C W, Jou R C, et al. Exploring motorcycle red-light violation in response to pedestrian green signal countdown device[J]. Accident Analysis & Prevention, 2015, 75: 128-136.

[10]. Cao Yu, Yang Zhongzhen, left. Zhongyi Effect of the green light countdown signal on driving behavior. China Journal of Safety Science, 2015, 25 (02): 77-82

[11]. Xu Lunhui, Wu Shuai, Hu. Sangen The effect of the countdown traffic signal on the traffic characteristics of the intersection. Highway Works, 2016, 41 (01): 64-69-84.

[12]. Zhu Tong, Guo Chunlin, Xie Chenjiang., Wang Yan The impact of traffic signal countdown on speed and traffic safety. Journal of Chinese Safety Science, 2012, 22 (04): 97-102.

[13]. Zhao Jing, Ma Wanjing, Han. Effect of green light countdown based on measured data on driving behavior. Road Traffic Technology, 2016, 33 (07): 119-124.

[14]. Qian Hongbo, Han Yu. Study on the impact of the green light countdown on traffic safety at intersections. China Journal of Safety Science, 2010, 20 (03): 9-13.

[15]. Jiang Zehao, Yang Xiaoguang, Wang. Tao Green light countdown under the influence of motor vehicle micro-driving behavior analysis and decision modeling. Transportation Systems Engineering and Information, 2018, 18 (02): 66-72.

[16]. Ma Xinlu, Li Bei, Xu Chenlei, Analysis and modeling of traffic flow on imported roads under the influence of signal countdown. Transportation Systems Engineering and Information, 2017, 17 (05): 36-44