Useful Field of Vision and Peripheral Reaction Time in novice drivers – Transfer to a real driving situation after a Perceptual-Motor Training Program

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Abstract

Driving performance can deteriorate and become potentially dangerous when someone pays attention to a secondary task at the expenses of the attention needed to the main driving task.
We wanted to verify if there were differences on the capacity of novice drivers to detect peripheral lights at the left or right over the front panel, according to their status (team-sport players and non-players). To force them to divide attention, there were several marks in the pavement they had to pass over. An experimental group of non-players was submitted to the Peripheral Vision and Reaction Time (PVRT) Training Program, to verify if it would improve significantly more than the control group.
The results show us that team-sport players surpassed in a significant way non-players in the detection of peripheral stimuli, though there were no significant differences on the peripheral reaction time. After the Training Program, the non-players experimental group scored significantly better than the non-trained group, diminishing significantly, also, their peripheral reaction time, showing that it is possible to develop and transfer perceptual skills from perceptual-motor activity to driving that help to diminish the distraction or lack of ability to divide attention between central and peripheral tasks.

Keywords – divided attention, novice drivers, peripheral vision, reaction time, team sport-players, transfer

1. Introduction

When drivers' visual attention is diverted from the primary task of driving, driving performance and safety can be affected, due to longer fixations towards an object or point that can produce impairments of environmental perception [1], reducing useful field of vision. In the majority of the undemanding driving situations, drivers let their eyes wander to objects that are not relevant to driving [2]. As the authors stand, when this attention to irrelevant objects occurs at the expense of processing crucial driving information, it should be called distraction, since it may lead to impairment of driving performance.

If attention is distracted by, e.g., an advertisement during the onset of a sudden hazard, the possibility of occurring an accident gets higher. Studying the prevalence of distracting activities associated with serious crashes [3], investigators found that one-third of all the crashes studied that resulted in hospital attendance by the driver was related to distracting activities. Moreover, a distraction was the only human factor identified among 75% of the drivers that reported a distracting activity when they crashed.

Also, driving experience was negatively associated with the likelihood of having a serious crash involving a distracting activity. Authors emphasize that this association is more important than age per se, concluding that this has important implications for learning drivers', being needed a greater emphasis on the role of driver distraction in crashes, as part of the training requirements of novice drivers.

The aim of this paper is to study the effects of sports prior practice on the capacity of novice drivers to detect peripheral stimuli while driving, as well as to study the efficacy of a Peripheral Vision and Reaction Time (PVRT) Training Program developed by us.

The existence of a positive correlation between team-sports practice and peripheral detection while driving in novice drivers, among with the confirmation of efficacy of PVRT could constitute a positive finding towards driving security, since that might allow us to use physical and perceptual activities, in a safe and controlled environment, that might transfer to real driving situations, at least while drivers have low driving experience.

2. Literature review

Many road traffic crashes appear to be due to driver attentional problems and late detection or lack of anticipation of crucial objects and events [4]. Driving has a high visual and cognitive processing demand. When the information is excessive to driver capabilities, it can divert his visual attention from the primary task of driving, which is known as distraction. Approaching teenage drivers, several studies show that they are overrepresented in crashes, compared to middle-aged ones [5]-[6].

As teenage drivers gain moderate levels of experience, they also tend to have greater crash risks related to driver distraction when compared to drivers in other age groups [7], probably because, as they become more confident in their driving abilities, they may tend to overestimate their multitask ability to make use of in-vehicle devices while driving.

Since human beings have limited attentional resources, it becomes very important the way they allocate their attention when they should manage, simultaneously, several tasks while driving. Some prior studies have tried to identify differences on the capacity to deal with central and peripheral stimuli on driving, according to experience and other features. Distinct differences were found, in terms of search patterns, between novice and experienced drivers, especially in high cognitive and visual workload situations [8]. Others [9]–[10] noted narrower visual search patterns among novice drivers. It was also found that more experienced drivers enlarge their visual search of the traffic scene [11]–[12]. Other studies showed that when there was an increase in the environmental complexity during driving, the detection of peripherally presented stimuli was negatively affected. Increasing the visual workload in a driving situation (e.g., more pedestrians, cyclists, crossing traffic) decreased residual attentional capacity available for peripheral stimuli detection [13] – [14]. The most prevalent pattern of visual search in driving is in the horizontal plane, since relevant environmental information has a greater distribution along it than along the vertical plane. Straight ahead gets the majority of fixations, and when drivers look somewhere else in the traffic scene, there is a greater probability that their gaze will return to this focus of expansion before looking at any other stimulus [12]. The Peripheral Detection Task (PDT) was used [15] to measure the workload of driver support systems while driving in different traffic scenarios.

Investigators argued that measuring the detection of stimuli in the peripheral visual field was a possibility for assessing workload or attentional distraction, since the functional visual field decreases with increasing workload. Results showed that performance on the PDT proved to be sensitive to variations in driving primary task demand, and, also, that PDT measures the variations in selective attention, in which the selectivity of attention increases with workload (cognitive tunnelling). PDT method was used in another study [16] in a real-life driving context. Half of the participants were the experienced driver group and the other half the inexperienced one. Like in the previously referred study, the peripheral stimuli were presented to the left side of the drivers' line of forward sight. There was a limited time for drivers to detect the stimuli, which they would do by pressing a micro switch. Participants' performance was recorded according to PDT miss rate and mean reaction times, in milliseconds (ms). The inexperienced drivers had, on average, approximately 250 ms longer reaction times. Also, the most experienced drivers missed significantly less peripheral stimuli. Authors concluded, among others, that the more experienced drivers had more available mental resources that could be allocated to peripheral information, and that the visual/cognitive tunnelling effect appeared to be greater for the less experienced, when performing the same task. When dealing with a cognitive demanding secondary task, drivers narrowed their inspection of the outward view, spending more time looking straight ahead and less looking at areas to the periphery, among with a reduction of their inspection to instruments and mirrors [17].

Participants also reduced their glances to traffic signals and their monitoring of the area around the intersection. An increase in the hard breaking events was also evident, reflecting a reduction in the visual monitoring of the driving environment.

In another study [18], investigators examined drivers' ability to detect a decelerating car ahead when their visual attention was focused on a display located at different positions around the interior of the vehicle.

Results got poorer when the eccentricity of the task, relatively to the normal line of sight, increased. A forced peripheral vision driving paradigm was used, requiring subjects to focus solely (and continuously) on a LED display. Interestingly, at similar eccentricities, detection thresholds were higher in vertical locations than in horizontal ones, which, perhaps, can be explained by the eye not being spherical. Since it is somewhat squashed in the vertical plane, it appears to reduce the resolution available for such detection in the vertical plane. According to this, they also found a better detection when drivers use lower visual field for the detection, that is, when looking up, as, for instance, when checking the rear inside view mirror, peripheral detection of decelerating cars was easier than when adjusting the radio volume, at a lower position, if at the same eccentricity.

Relating driving to sports experience, literature gives us several examples of better visual information processing of expert compared to novice players [19]-[20]-[21], better peripheral vision of people engaged in sports compared to those who are not [22]-[23]-[24], better reaction times [25] and, probably, some advantage in certain aspects of driving performance [26]-[27]. These also concluded that there was an evident transfer from sport engagement to some features of driving, namely at a *tactical* level. Should our study reflect this?

3. Method

Since we wanted to find if there were differences between team-sport players and non-players, we decided to choose novice drivers, so that accumulated driving experience wouldn't mask eventual early differences.

Fig. 1 - Inside the car, with the right leds on (left's are covered by left hand)

Because of that, we only allowed subjects with a maximum of one and a half years after getting their driving license (non-players: *m*= 0,78 years, *sd*= 0,47; team-sport players: *m*= 0,72 years, *sd*= 0,38). Team-sport players had, at least, three years of sports practice.

We began by testing team-sport players (ten subjects, five females and five males, being seven handball players, one indoor soccer player, one soccer player and one basketball player - *m*= 19,97 years, *sd*= 1,29), and non-players (twenty-two subjects, twelve females and ten males - *m*= 19,82 years, *sd*= 1,28) in a closed circuit driving task (fig. 1), in which they had to perform a defined trajectory, passing over several marks (40x40 cm square pillows, filled with sand) without stepping on them. Whenever subjects stepped over the marks, the researcher could easily feel it.

From time to time (intervals between a minimum of 2 and a maximum of 5 seconds) they were asked to detect the random onset of lights (in a total of 72 stimuli), manually activated by the researcher, seated at the backseat of the car. Those lights were located at the left and right of the central staring line of vision of the driver, at an angle of approximately twenty five degrees, for each side. With a wireless microphone connected to a Biopack hardware, every time a subject said "*vi!*", which, in Portuguese, means "*I saw!*", a wave sound was registered at Acq*knowledge* 3.8.1 software, allowing us to, after the task, detect how many stimuli had not been detected, if their detection was lately registered (more than a second after the light onset) and the time between light onset and answer (reaction time).

After testing all subjects, which took two weeks, we trained half of the subjects of the non-players group, using a training program (PVRT), developed by us, of six sessions of forty-five minutes each, one per week, in which, basically, they had to use, consistently, their peripheral vision, dividing attention between central and peripheral stimuli, while performing motor tasks like, for instance, trying to catch a stick dropped by the colleague in front, who holds two of them and only drops one at an unexpected moment; avoiding rolling balls while in the middle of a circle, surrounded by colleagues who throw the balls (fig. 2), and, at the same time, not stepping on objects that are in the floor; juggling with three scarves; keeping two balloons in the air, using two hands, while naming loudly which arm ("left!"; "right") his partner puts up in the air, in front of him, among others. At the end of the Training Program, every subject was tested again, so that performance between the two moments could be compared, looking for the efficacy of the Perceptual-motor Training Program.

Fig. 2 - Trying not to be hit by two rolling balls and not to step on the objects on the floor, using peripheral vision (one of the PVRT exercises)

Tab. 1 - Mean results of Non-players and Team-sport players on PDT

Subjects Group	**ND**	**LD**	**SO**	**ND+LD**	**ND+LD+SO**
Non-players	6,7	6,0	10,0	12,7	22,7
Team-sport players	3,9	2,5	3,8	6,4	10,2
Mann-Whitney U	,047	,008	,000	,009	,000

4. Results

Pre-PVRT data (table 1 and fig. 3) show that team-sport players were significantly better than non-players at Peripheral Detection Task (PDT) while driving, since they missed significantly less stimuli (ND), as well as they had much less ND + late-detected stimuli (LD) and + stepped over (SO) objects on the ground of the circuit.

Fig. 4a and 4b and Table 2 show us the results in the Peripheral Detection Task (PDT) before and after submitting a sub-group of the non-players (named experimental group) to the PVRT. As can be seen, the Experimental group increased exponentially its performance, from the first testing to the second.

It is especially remarkable since this group even surpassed the team-sport players in all parameters of the PDT test.

The control group and the team-sport players only changed slightly their results, with the control one getting poorer in one of them, but the experimental group improved in a significant way all of them, as can be seen by Wilcoxon Test.

Though there were no significant differences on reaction time between non-players and team-sport players before PVRT Training Program (respectively 562,32ms/537,94ms), after it the results (table 3) show significant improvements in the experimental and in the team-sport players groups, but not in the control one.

The experimental group results can be attributed to the Training Program, while the team-sport group ones are, somehow, intriguing, since they did not improve, as we stressed before, on the other parameters of the test.

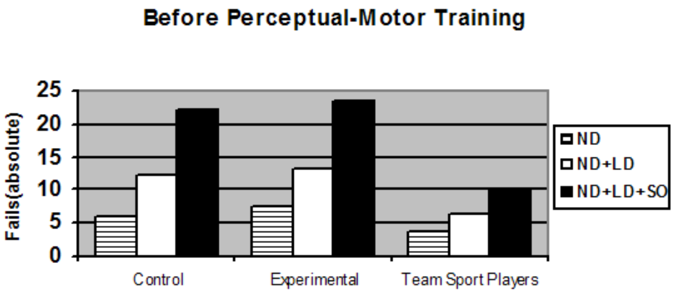

Fig. 4a - Non-Detected (ND) stimuli, ND+Late-Detected (LD) stimuli and ND+LD+Stepped Over (SO) objects, before PVRT, on PDT

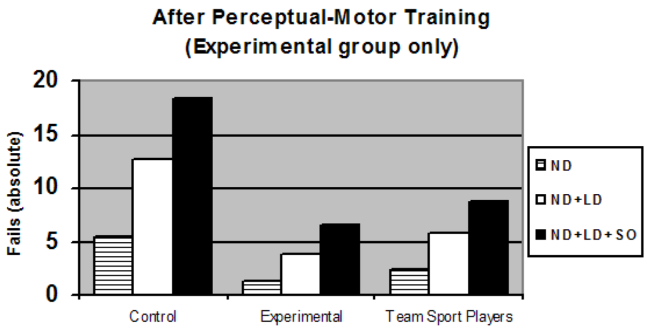

Fig. 4b - Non-Detected (ND) stimuli, ND+Late-Detected (LD) stimuli and ND+LD+Steped Over (SO) objects, after PVRT, on PDT

Tab. 2 - Mean results of Non-players (control and experimental groups) and Team-sport players on PDT

	Experimental			Control			Team-sport players		
	ND	ND + LD	ND + LD + SO	ND	ND + LD	ND + LD + SO	ND	ND + LD	ND + LD + SO
Before	7,6	13,3	23,5	5,9	12,3	22	3,9	6,4	10,2
After	1,2	3,9	6,5	5,4	12,7	18,3	2,4	5,8	8,8
Wilcoxon	,005	,005	,005	,404	,646	,075	,120	,763	,865

5. Conclusion

The application of a Training Program to enhance Useful Field of Vision and Peripheral Reaction Time, though restricted to only six sessions (one each week), was successful. Besides, the detected superiority of team-sport players over non-players, in a Peripheral Detection Task while driving, allow us to predict the existence of a positive transfer between the experience of (team) sports players and driving perceptual skills. This may happen mainly because of the exposure to specific stimuli on sports practice, rather than pre-existing superiority of those players.

Tab. 3 - Mean results of Non-players (control and experimental groups) and Team-sport players on PDT – Reaction time (ms)

	Experimental	**Control**	**Team-sport players**
Before	595,81	534,41	537,94
After	529,75	526,00	490,49
Wilcoxon Test	,005	,530	,017

From these results we can suppose that physical activity practice, especially the one that require subjects to carry on very demanding information treatment, and where event perception is crucial, can be positively transferred to the capacity of using peripheral vision and divided attention in driving situations.

If this is true, our findings can constitute another good reason to promote sports and physical activity practice in youngsters, despite obvious applications in all ages. We think this study can open some important lines in the prevention of traffic sinistrality, since it shows that, among with all the accident causes that are often shown, it may be advised to make some efforts on the teaching and training of perceptual-motor competences, namely on the enhancement of peripheral vision use and capacity of dividing attention between central and peripheral tasks. Future work on this domain should stress on the effects of different kinds of practices on the development of these features, so that their transfer can be maximized using the safest training conditions, as well as investigating the possible benefits of our PVRT Training Program in other age groups, such as old drivers with confirmed perceptual-motor difficulties.

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