

Role of Environment Complexity and of Individual Variability in the Perception of Object Motion During Self-Motion

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INTRODUCTION

To the displacement of an observer through a stable environment corresponds a global optical flow (Gibson, 1979; Cutting, 1986); which specifies spatio-temporal properties of the observer's trajectory with respect to the environment. It has been shown that human subjects are able to perceive their direction of heading from the optic flow with a precision sufficient for a safe control of locomotion, in a wide range of trajectories and environments (Warren, Mestre, Blackwell, & Morris, 1991). On the other hand, object motion triggers a local optical flow, which delivers information concerning characteristics of the object's displacement through space and relative to the observer (Tressilian, 1994).

However, little is known about the visual bases of the perception of object motion during self-motion, in situations where the observer has to

control his/her trajectory from a global optical flow while estimating the motion of objects from a local flow, in order to catch or avoid them. This situation corresponds, by example, to a driver approaching an intersection where another vehicle is arriving.

EXPERIMENTAL RESULTS

We tested perceptual judgments made by drivers in simulating such situations (Berthelon & Mestre, 1993). In this case, two main sources of perceptual difficulty arise. First, the vehicle's visual motion is the resultant of the visual consequences of its own movement and of the driver's displacement. The perception of the vehicle's motion appears to be dependent on local visual cues, such as its visual trajectory itself and on the relative motion between the vehicle and static reference elements in the environment like a road sign placed near the intersection. A second source of difficulty may arise from the global optical flow itself. So, previous experiments have shown that perceptual thresholds for object motion detection were significantly elevated during visually induced self-motion (Probst, Brandt, & Degner, 1986). Our own experiments also suggested that a global optical flow impaired the

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perception of a moving vehicle's trajectory. So, perceptual judgments were more perturbed when the driver's/observer's trajectory was curvilinear (due to the rotational component of global optical flow) than when it was rectilinear, notably when the radius of curvature was small (Berthelon, & Mestre, 1990, 1993).

The level of realism of the simulated scenario also influenced drivers' judgments. When visual scenes were abstract, presenting only the visual information necessary to evaluate the motion of the approaching vehicle (no surrounding environment therefore no peripheral stimulation, vehicle and road sign represented by colored spheres) judgments were very accurate. The addition of texture on the ground surface of these abstract scenes (spheres generating a global flow field) increased the quantity of visual motion that seemed to mask relevant information, impairing the evaluation of the local flow field generated by the vehicle's motion. Finally, with realistic scenes (complex visual scene close to a real driving environment) the addition of texture on the ground surface improved the perceptual judgments as found by Kleiss and Hubard (1993) in plane simulation. So, the additional texture might be included within a three-dimensional perceptual framework, increasing information quality and the «virtual reality» of the display (Berthelon, Mestre, & Taramino, 1995). Thus, there would be a functional representation of the road context. This representation would be difficult to be elicited in abstract scenes which seem to refer to other visual processing mechanisms or which don't contain as much local information than road scenes.

Level of expertise influenced performance mainly with complex scenes. Non-drivers were «impaired» in perceiving future events from predictive visual information, notably when the radius of curvature of their trajectory was small. In this case, the optical flow resulting from the curved self-motion was more important which suggests that non-drivers might be highly sensitive to this optical flow. It might then be that the multiple elements of a realistic image have a dual effect on non-drivers performance. So, they would have difficulties in selecting the pertinent cues in a complex visual scene and in correctly anticipating the outcome of a situation from early predictive information.

Expert drivers presented better performances. They evidently selected the correct and useful cues in a complex environment and were able to correctly and rapidly anticipate the evolution of the situation. Expert drivers were also better in using the road sign with realistic scenes than with abstract ones, that was to use local cues in a meaning road context or/and to use supplementary cues of the complex road scenes.

Consequently, experience of driving seems to be related to an increased ability to quickly select relevant cues in a complex environment and to perceive correctly the characteristics of the trajectory of a moving vehicle during self-motion, so to be less dependent to global or local induction effects due, respectively, to the global optical flow resulting from self-motion and to local relative optical motion between the vehicle and environmental elements (Neboit, 1974; Berthelon, Mestre, & Taramino, 1995).

Finally, the capacities of drivers to analyse the visual motion of another vehicle during self-motion seemed to be link to their perceptual style. Field independent subjects preferentially treat proprioceptive information and have an analytic approach of the visual input. Inversely, field dependent subjects preferentially treat visual information and have a global approach of the visual input (Huteau, 1985; Goodenough, & Cox, 1985). So, we showed that field-independent subjects were significantly better than field-dependent subjects in analyzing the motion of another vehicle when approaching an intersection but were not more rapid, suggesting that they were better at picking-up dynamic relevant information in a complex environment in the same temporal delay (Berthelon, Mestre, Pottier, Pons, & Cavallo, to be published).

CONCLUSION

In these researches, we clearly showed that the optical motion resulting from a moving vehicle during self-motion contained predictive information concerning the trajectory of another vehicle, in relation with the trajectory of the observer, which is of major importance for collision avoidance in vehicle driving. Though the utilization of visual cues was modulated by the complexity and the meaning of the visual scenes,

the fact that observers were able to correctly perceive the evolution of such a situation with abstract as well as with realistic scenes enables us to think that such visual analysis also occurs during real driving.

In addition, the influence of driving experience suggests that the difference between non-drivers and drivers resides less in their «basic» visual capacities than in their ability to correctly and rapidly analyse complex visual scenes. Inversely, the fact that drivers' perceptual style also modulated visual information treatments suggests interindividual differences for a same level of driving experience.

One further step will be to approach the issue of the interaction between the driver and the environment. Indeed, since vehicle driving cannot be reduced to simple perceptual mechanisms, it is necessary to devise situations in which the «drivers» must make emergency maneuvers (breaking, avoiding an obstacle, etc.) to avoid an accident. This would provide interesting information for the development of driver training methods which are more suited to real-life situations.

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ABSTRACT

Little is known about the perception of another vehicle during self-motion. This situation occurs, for instance, when a car's driver approaches an intersection with ongoing traffic. By graphic visual simulations, we showed that the perception of the other car's trajectory relies both on global visual information, such as the optical flow field, and on local visual information, such as the optical motion of the moving object and the relative optical motion between the moving object and fixed elements in the environment. We also showed that environmental factors (presence of a road sign, level of realism of visual scenes), driving experience (novice versus experienced drivers) and perceptual style (field dependence versus field independence) contributed to perceptual judgments.

RESUMO

Pouco se sabe actualmente sobre a percepção de um outro veículo quando o sujeito está simultaneamente em movimento. Por exemplo, esta situação ocorre quando num cruzamento o condutor se confronta com outros veículos em aproximação. Através de simulações gráficas mostramos que a percepção da trajetória de outro veículo depende quer da informação visual

global, tal como a do campo de fluxo óptico, quer da informação visual local, tal como a do movimento óptico do outro veículo e a do movimento óptico relativo entre este e objectos fixos no ambiente. Mostramos também que os factores ambientais (presença

de um sinal de trânsito, nível de realismo das sequências visuais), a experiência de condução (condutores iniciados versus condutores experientes) e o estilo perceptivo (dependência versus independência de campo) contribuem para as avaliações perceptivas.