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Drivers rely on passing and stopping possibilities when deciding to cross an intersection

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INTRODUCTION

Several decades before the publication of the Theory of Affordances (Gibson, 1977), Gibson & Crooks already imagined an application of this framework, especially capable of explaining driver behavior while approaching an intersection (Gibson & Crooks, 1938). In this seminal paper, safe driving behavior was hypothesized as the response to the driver's simultaneous perception of the boundaries of two spatio-temporal regions, called *"Field of Safe Travel (FST)"* and "*Minimum Stopping Zone (MSZ*)", specifying his "passing" and "stopping" possibilities, respectively. Although ubiquitous in everyday-life, such a paradigm obliging an agent to perceive several action possibilities seems to have faded from the literature and the study of affordances has been restricted to the perception of a unique action possibility (Fajen et al., 2005). We attempt to formalize Gibson & Crooks' theoretical ideas of *FST* and *MSZ* into equations and experimentally investigate the contributions of *FST* and *MSZ* to the driver's behavior while approaching an intersection.

METHODS

In a driving simulator, participants moved at constant velocity on a two-lane road crossed by a perpendicular intersection while a vehicle coming from the left threatened their safe passage. Participants were instructed to pass the intersection before the obstacle, if deemed possible, by putting into action their maximum acceleration capability. Otherwise, they had to stop before the intersection by putting into action their maximum braking capability. They could finally bail-out on the road bank, as a last resort. Participants were spread into 3 groups ("low", "high" and "inf" groups) corresponding to the manipulation of their maximum braking capabilities as between group variable (5, 10 and ∞ m/s², respectively) whereas maximum accelerating capabilities were kept constant (2 m/s²). "Passing" and "stopping" possibilities have been manipulated as within group variables by changing the critical times before safe passing became no longer possible (3 t_{FST}) and the critical times before safe stopping became no longer possible (6 t_{MSZ}, depending on the between-groups manipulation of braking capabilities). This gave rise to 18 intersection-crossing situations.

RESULTS

Between groups comparisons firstly revealed that each group responded to a given t_{FST} value by different "passing" frequencies. Moreover, within group comparisons also revealed that "passing" frequencies evolved with t_{MSZ} values even though t_{FST} remained constant. Indeed, the "inf" group, which could stop at any time before the intersection given its infinite braking capabilities, responds to the increase of t_{FST} values by increasing its "passing" frequency

irrespective of changes in t_{MSZ} values. Such a behavior can be modeled as a linear function of the between-trial manipulation of t_{FST} (Figure 1, bottom panel). In contrast, the "low" and "high" groups, which could stop at a limited time before the intersection given their limited maximum braking capabilities, respond not only to the increase of t_{FST} values by increasing their "passing" frequency, but also to the combined increase of t_{MSZ} by decreasing their "passing" frequencies. This behavior can be modeled by completing the "inf" group's model with a t_{MSZ} component (Figure 1, top and middle panel).

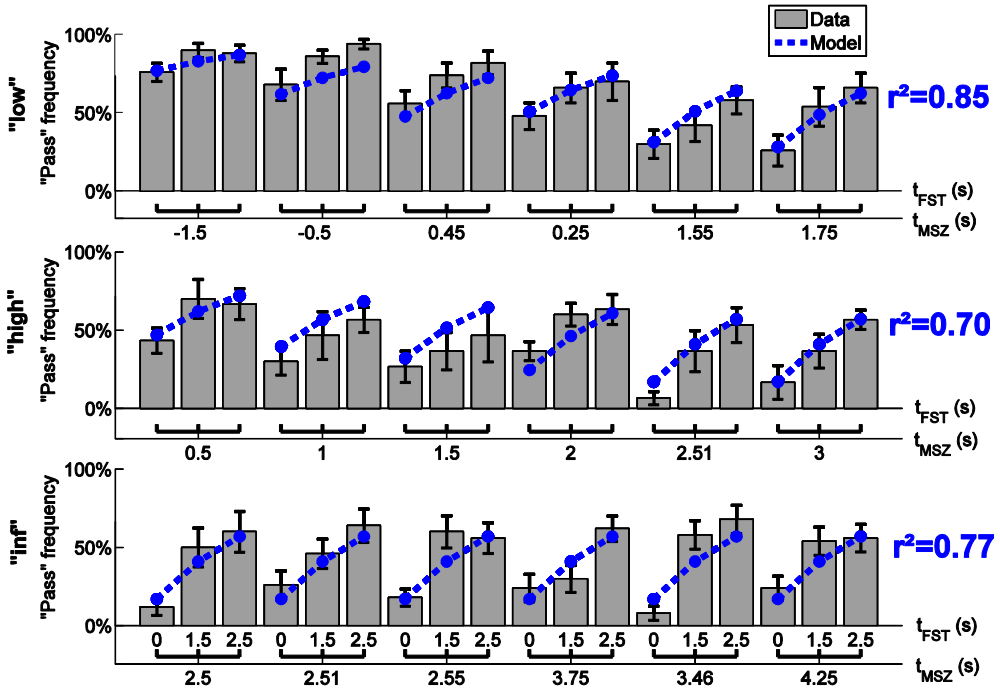

Figure 1. "Passing" frequencies plotted as a function of t_{MSZ} and t_{FST} for the "low", "high" and "inf" groups (from top to bottom). r^2 provided by our model are noticed on the right

CONCLUSION

We formalized the *FST* and *MSZ* affordances, as critical times t_{FST} and t_{MSZ} specifying the limits at which putting into action the driver's maximum accelerating and braking capabilities do not guaranteed a safe passing or stopping. Our results, supported by a behavioral model, showed that drivers simultaneously relied on t_{FST} and t_{MSZ} to judge their "passing" possibilities, even though t_{MSZ} is only assumed to specify "stopping" possibilities. Confirming Gibson & Crooks' intuitions, our study empirically highlights the competition between two affordances, simultaneously acting on the driver's "passing" decision.

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