Effects of Age and Stimulus Velocity in the Performance of a Complex Coincidence-anticipation Task by Children and Adults

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Abstract: This study investigated the effect of stimulus velocity in a complex coincidence anticipation task performed by children and adults. Participants were required to throw a ball to hit the luminous stimulus of a Bassin Anticipation Timer in coincidence with its motion, and they performed five 24-trial blocks with the target speeds of 0.36 m/s, 0.71 m/s, 1.61 m/s and 3.21 m/s. Results showed more accurate and consistent performance for adults at all target speeds, as well as a deterioration in the measures of AE and VE with increasing stimulus speed. Furthermore, a dominant linear trend was found to explain performance changes in adults and children at the various target speeds. The discussion focuses on the constraints of complex coincidence anticipation tasks related to perceptual and motor demands.

1 INTRODUCTION

The coincidence-anticipation capacity is a major and determinant competence in performing sports skills, such as receiving, intercepting or batting a moving object, but also in many daily actions in someone's life like driving a car, crossing a street, handling of domestic appliances or the action to divert the body from a moving object. Coincidence-anticipation tasks require anticipatory prediction, that is, the capacity to anticipate the trajectory of a stimulus moving in space and time and to tuning and synchronization motor actions. This capacity involves a complex combination of perceptual and motor demands, depending on the task characteristics and particular constraints.

Simple coincidence-anticipation tasks have a limited motor component, since the required response is restricted to pressing a button. On the contrary, complex tasks involve the production of a motor action to intercept a moving target, either using a segment of the body or an external object. Several works on complex coincidence timing tasks indicate that the performance error increases at the slower speeds of the visual stimulus presentation (e.g., Coker, 2004); (Williams, 2000); (Williams et al., 2002); (Wrisberg et al., 1982); (Wrisberg and Mead, 1983). In opposition, Coker (2005), Rodrigues et al., (2011a) and Williams (1985, exp. 1) noticed more accurate responses on coincident timing performance at the lower stimulus speed. The main goal of the present work is the examination of the influence of constraints, such as the different speeds of the visual stimulus motion, in the performance of a coincidence-anticipation task calling for a propulsive action. Another goal of the study is to analyze the effect of stimulus velocity on coincident timing performance by children and adults under the same experimental design.

2 METHODS

2.1 Participants

Twenty-four right-handers equally distributed for both genders, 12 children (9.48 ± 0.79) and 12 undergraduate students (21.61 ± 1.46), volunteered to participate in the study. They were unaware of the purpose of the study and none had previous experience on the experimental task.

2.2 Apparatus and Task

The apparatus consisted of an adaptation of the Bassin Anticipation Timer of the Lafayette Co., and

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it simulates a moving target with a runway of 43 sequentially illuminated LEDs (270 cm long), which creates the perception of a luminous stimulus in motion (Figure 1). The device also included a curtain of photoelectric cells throughout the light runway, which allowed the precise detection of the hitting point of a ball. The LEDs and the photoelectric cells were protected by a transparent acrylic panel (270 x 60 cm), which corresponded to the reception area of the balls. An automaton, with an internal chronometer, was also incorporated into the device and has been connected to a computer. Specifically designed computer software was used to edit the automaton program, which allowed the control of preprogrammed sequences of different target speeds, as well as the duration of the intertrial interval, the supply of visual information to the executants on the performance results, and the storage of data relative to motor performance measures.

Figure 1: Apparatus used for the gathering of the data.

The task consisted of throwing a mini-tennis ball over the shoulder to hit the luminous target in coincidence with its motion, and the participants were required to produce the response as soon as they were ready to take a decision about the displacement of the luminous target along the runway. Every time the ball intercepted the acrylic panel, the movement of the luminous stimulus was interrupted at a point of its trajectory. At the end of each practice trial, it was possible to collect two measures for the evaluation of the response: (a) the place where the ball intercepted the light runway; (b) and the position of the target when the ball intercepted the light runway. The data collected on performance measures were subsequently transferred to the PC and transcribed into an excel file.

2.3 Procedures

The participants stood behind a straight line drawn on the ground, in the centre and in front of the apparatus, and were positioned at 270 cm of distance from the target. The motion of the light sequence was presented from left to right, at a height of 140 cm from the ground for both age groups. All individuals practiced 120 trials (five 24-trial blocks) with the target speeds of 0.36 m/s, 0.71 m/s, 1.61 m/s and 3.21 m/s, and they performed 30 trials for one target speed before the presentation of another one. There was a two-minute rest interval between consecutive blocks of practice. The order of presentation of the different target speeds was counterbalanced for each group and it was similar for both groups. At the moment of the ball interception, visual information of knowledge results (KR) related to the direction and spatial magnitude of the response error was automatically supplied. This information was presented for a period of 5 sec at the end of each practice trial. A constant foreperiod of 1500 msec was used for all trials, and the post-KR interval and intertrial interval had the duration of 5 sec and 10 sec, respectively.

3 RESULTS

The magnitude and the direction of the response error were recorded for each trial. For the analysis of the response error, absolute error (AE) and variable error (VE) measures were calculated for each age group. The AE and the VE measures were converted to the symmetry (base 10 logarithms) in order to ensure the conditions for normality and homoscedasticity of the data. A 2 (groups) x 4 (stimulus speed) analysis of variance with repeated measures on the last factor were respectively performed, one for each dependent variable. Also, the extension of the One-way ANOVA was used for studying the dominant trend in the observed results for the different target speeds. This has been accomplished through polynomials orthogonal contrasts. For the statistical analysis the assumed significance level was $\alpha = 0.05$.

For the AE and VE measures (Table 1), the results showed a better performance for the adults in all target speeds as it was expected [$F(1, 88) = 81.95$, $p<.001$ and $F(1, 88) = 41.10$, $p<.001$, respectively].

Main effects for stimulus velocity were also found [$F(3, 88) = 33.26$, $p<.001$ and $F(3, 88) = 20.46$, $p<.001$, respectively, for AE and VE], while the interaction Groups x Stimulus Speeds failed to reach significance [$F(3, 88) = .17$, $p\geq .05$ and $F(3, 88) = .58$, $p\geq .05$, respectively, for AE and VE]. Further examination of the main effects of stimulus speed indicated a significant decrement for AE and VE from the faster speed to all other target speeds, and a decrease in AE and VE performances between the target speeds of 1.61 m/s and 0.71 m/s was also found (Figures 2 and 3). Moreover, the results showed a linear trend for the decrease of the AE and VE values as a function of the declining of the target speeds [*One-Way ANOVA's*: $F(3,44) = 24.57$ and $F(3,44) = 26.52$, ps<.001, respectively in adults and children for the AE; $F(3,44) = 28.38$ and $F(3,44) = 12.41$, ps<.001, respectively in adults and children for the VE]. The linear effect has proved being the dominant effect to explain the performance variability at the various target speeds, both in children and in adults.

Table 1: Mean (M) and standard deviation (SD) for the absolute and variable errors at the different target speeds. Mean values were converted to the symmetry using logarithms of base 10.

	Absolute Error		Variable Error	
Speeds	M	SD	M	SD
	Adults			
0.36 m/s	1.81	0.50	1.42	0.38
0.71 m/s	1.70	0.26	1.42	0.19
1.61 m/s	2.13	0.45	1.81	0.37
3.21 m/s	3.75	2.33	3.45	2.60
Total	2.35	1.45	2.02	1.54
	Children			
0.36 m/s	3.12	1.34	2.47	1.18
0.71 m/s	2.84	0.57	2.40	0.42
1.61 m/s	3.69	0.83	2.97	1.41
3.21 m/s	6.70	2.62	4.04	1.09
Total	4.09	2.16	2.97	1.25

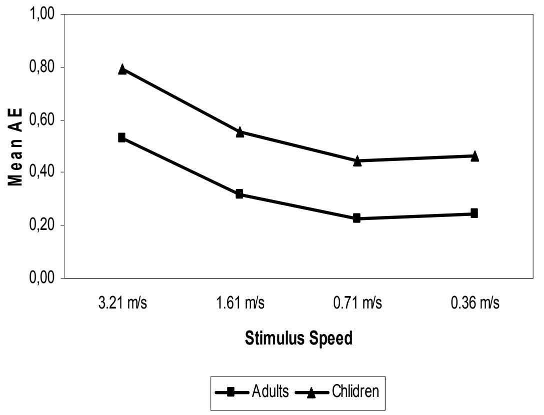

Figure 2: Mean absolute error in adults and children as a function of stimulus speed. Values converted to the symmetry through the use of base 10 logarithms.

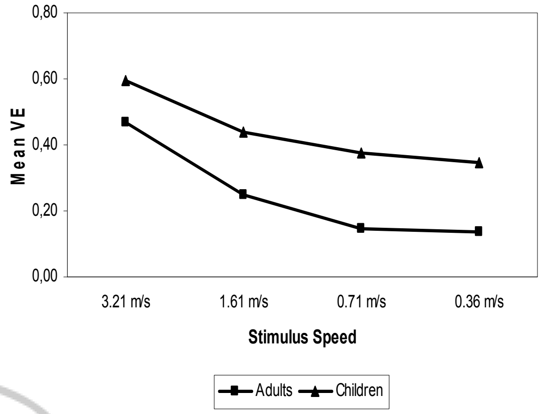

Figure 3: Mean variable error in adults and children as a function of stimulus speed. Values converted to the symmetry through the use of base 10 logarithms.

4 DISCUSSION

The main goal of this study was to investigate the effect of stimulus velocity in a coincidence-anticipation throwing task performed by children and adults. The results revealed a more accurate and consistent performance for adults at all target speeds, as it was expected on the basis of previous research (e.g., Bard et al., 1990); (Dorfman, 1977); (Fleury and Bard, 1985); (Rodrigues et al., 2011b). More important, the results of the study showed an increment of the AE and VE measures as the stimulus speed increases, and a dominant linear trend was encountered to explain performance variability, in terms of accuracy and consistency, at the various target speeds. This pattern of results was observed for both children and adults, with the same visual stimulus sequence and under the same practice conditions. Our findings are in line with the studies of Coker (2005), Rodrigues et al., (2011a) and Williams (1985, exp. 1), where less accurate responses at the faster stimulus speed were found. In opposition, Bard et al., (1981), Coker (2004), Williams (2000), Williams et al., (2000), Wrisberg et al., (1992) and Wrisberg and Mead (1983) observed lower values for the responses error at the faster target speed. Côrrea et al., (2005) found no differences among stimulus speeds. All the above mentioned studies have investigated complex coincidence-anticipation tasks, even though different motor skills were used: (a) a segmental arm movement (Coker, 2004; 2005); (Wrisberg et al., 1982); (Wrisberg and Mead, 1983); (b) pushing a certain number of buttons sequentially (Corrêa et al., 2005); (Rodrigues et al., 2011a); (c) a propulsive action, namely a throw at a moving target (Bard et al., 1981), a soccer pass (Williams, 2000) and a tennis stroke (Williams et al., 2000). One plausible explanation for this discrepancy of results may be tied to the nature of the task, that is, to the unique and particular configuration of task's perceptual and motor constraints. This idea is reinforced by the results of the present study, where similar results were encountered for children and adults, with regard to the influence of the visual stimulus velocity on coincident timing performance.

In the present study, it was noticed a significant decrement in AE and VE performances from the faster speed (i.e., 3.21 m/s) to all other target speeds, as well as between the two lowest speeds (1.61 m/s and 0.71 m/s). A possible explanation for these findings may be related to differences in processing time information at slower and faster stimulus speeds. With the increase in target speed, the stimulus duration and the time available for the information processing become progressively shorter. As coincident timing performance requires fast decision operations, this could lead individuals to automatically respond, or use stereotypic movements by a "default" processing at the faster stimulus speeds based on the subliminal perception and pre-programming of movement (cf. Rodrigues et al., 2011c; Williams, 1985). On the contrary, the longer viewing time provided by slower stimulus speeds could improve perceptual estimates, decision making and planning of movement (cf. Rodrigues et al., 2011a).

Overall, the results of this study indicated that the stimulus speed plays a major role on coincident timing performance. Further research is needed to investigate the influence of stimulus velocity on the visual processing information and control of anticipatory tasks. This research should focus on different developmental levels, as well as on real-world tasks and sport skills that have rarely been used in previous studies.

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