Trait-anxiety dependence of movement time performance in a bimodal choice task in subjects exposed to moderate anxiogenic conditions

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Abstract

Recent studies have provided insight into the interdependence between state-anxiety, trait-anxiety and motor performances. In the present study, we investigated in very low trait-anxiety (VLTA) and normal trait-anxiety (NTA) subjects, the effects of moderate state-anxiety induced by the video-recorded Stroop color word interference test, on reaction time and movement time in bimodal choice response time task providing either visual or auditory modality. We found that in anxiogenic condition, movement time performances were improved in visual modality in NTA subjects, and in auditory modality in VLTA subjects. Our results show that depending on their trait-anxiety level, individuals exposed to anxiogenic condition would allocate attentional resources towards a specific relevant modality. Such attentional resources would influence movement time, but not reaction time.

Keywords: Trait-anxiety; State-anxiety; Reaction time; Movement time; Response time; Crossmodal task

Studies have shown a complex relationship between state-anxiety and motor performance [2,4,7,9,12]. Effects of state-anxiety seem to be different according to the motor task complexity. On the basis of the inverted-U hypothesis [17], Oxendine [11] has suggested that simple motor task requiring rapidity or strength would be maximized at high level of state-anxiety, whereas complex motor skills would be altered.

Alternatively, recent studies have provided insight into the interdependence between state-anxiety, trait-anxiety and motor performances [1,5,10]. Trait-anxiety could favour the processing of information of stimulus-response tasks in anxiogenic condition, but not that of complex motor skills requiring strategic processes [1]. In a previous study, we investigated the relationships between state-anxiety, trait-anxiety and simple response time including reaction time and movement time to visual and auditory stimuli given separately. We showed that normal trait-anxiety (NTA) subjects improved visual response time performances in anxiogenic condition, while very low trait-anxiety (VLTA) subjects improved auditory response time performances [5].

In the present study, we have assessed in subjects possessing different levels of trait-anxiety whether moderate state-anxiety influences reaction or movement time in visual and auditory modality in a bimodal choice task. In contrast with our previous work, we used a crossmodal choice response time task that could be closer to daily life situations in which attention must be coordinated between auditory and visual modalities.

Forty-two potential subjects (17 women, 25 men) studying for a degree in Sport Sciences at the University of Metz were recruited. All of them declared to possess normal hearing and vision. All gave their full inform consent. Trait-anxiety was assessed using the Y2 form of the Spielberger's State-Trait Anxiety Inventory (STAI, [15]). After sorting by sex, the right-handed subjects whose scores were at the extremes of the distribution were assigned in two separate groups. According to the Spielberger's classification [15], individuals were shifted as subjects with a very low trait-anxiety (VLTA) level (score range: 22–36; mean score: 31.6 ± 3.9, mean age: 20.1 ± 1.4; female ($n = 7$) mean score: 32.6 ± 5.3, mean age: 19.7 ± 1.1; male ($n = 7$) mean score: 30.6 ± 1.5, mean age: 20.4 ± 1.6) and as subjects with a normal trait-anxiety (NTA) level (score range: 44–60; mean score: 51.4 ± 5.5, mean age: 19.8 ± 1.4; female ($n = 7$) mean score: 52.4 ± 5.8, mean age: 19.1 ± 1.2; male ($n = 7$) mean score: 50.4 ± 5.5, mean age: 20.4 ± 1.4).

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State and trait-anxiety were assessed, respectively, using the STAI Y1 and the Y2 forms [15], which are two self-evaluation questionnaires about the subjects' feelings. These questionnaires consist of 20 items each scored on a four-point scale and are well known to possess a high internal consistency and test-retest reliability.

The subjects' performances in response time were assessed using a bimodal choice task providing either visual or auditory modality. The visual stimulus consisted of a red circle appearing in the middle of a computer screen placed in front of the subject (approximately 60 cm). The auditory stimulus was a pure tone of 1000 Hz presented binaurally. The task was reduced to 20 signals (10 auditory stimuli and 10 visual stimuli given in a random order), because state-anxiety induced by the anxiogenic condition used in the present study is moderate and transitory. The subjects had to keep a finger on the home button placed between the response buttons located 7 cm to the left (auditory) and 7 cm to the right (visual) until the stimulus occurrence. Each signal occurred in a random delay of 1.4–2 s after positioning a finger on the home button. Then, the subjects were required to press as quickly as possible the response button corresponding to the stimulus. Response times were distinguished for two components: (i) reaction time, i.e. the time spent from the stimulus occurrence to the release of the home button, and (ii) movement time, i.e. the time spent from the release of the home button to the subject's subsequent press of the response button [6]. All tests were programmed with E-prime (Psychology Software Tools, Inc.) and performed on a serial response box. Response time performances for auditory modality and visual modality were assessed in milliseconds by calculating the median value for 10 responses.

In the anxiogenic condition, state-anxiety was induced by using a Stroop color word interference test of 2-min maximal duration, strident sound for indicating errors or hesitations, and video monitoring. Each subject had to say as quickly as possible and in the sequence presented the color of the ink used to print a color name, not the color designated by the words. In the control condition, the subjects were given a Stroop color word-like test with no interference, which consisted of congruent color words and ink colors. Each subject had to name the ink colors that appeared in the sequence. There was neither time limit nor video recording in performing the test.

All subjects performed the control condition first, and then the anxiogenic condition. In each condition, the subjects had to (i) name the first 50 words of the Stroop test, (ii) execute the response time task, and (iii) name the last 50 color words. Before the beginning of the experiment, subjects performed a training session for the response time task. Before, between and after each condition, the subjects were allowed to stay at rest for 5 min. State-anxiety was evaluated before the beginning of the experiment, and immediately after the control condition and the anxiogenic condition, using the Y1 form of the Spielberger State-Trait Anxiety Inventory (STAI; [15]).

Two-way ANOVAs were applied to state-anxiety with moments (baseline, control condition, anxiogenic condition) and group (NTA and VLTA subjects) as factors. Response time performances were analyzed with a four-way ANOVA using group (NTA and VLTA subjects), condition (control and anxiogenic), modality (visual and auditory) and sequence of response time (reaction time and movement time) as factors. Following a significant *F*-value, *post-hoc* comparisons were performed to determine pair wise differences using the Tukey's test.

Table 1
State-anxiety (mean ± S.D.) for the two groups measured in the first rest period (baseline), in the control condition and in the anxiogenic condition

	Baseline	Control condition	Anxiogenic condition
VLTA group	28.4 ± 5.2	31.3 ± 6.7	34.4 ± 10.6**,†
NTA group	40.8 ± 10.6	42.9 ± 12.3	49.4 ± 15.9**,†

State-anxiety was evaluated by the STAI [15].
** Significantly different from baseline ($p < 0.001$).
† Significantly different from control condition ($p < 0.05$).

Changes in state-anxiety are shown in Table 1. Statistical analysis on state-anxiety showed main effects for moment ($F(2,52) = 9.45$; $p < 0.001$) and group ($F(1,26) = 13.15$; $p < 0.01$) factors, but no interaction between factors. *Post-hoc* analysis carried out on both groups showed a significant higher level of anxiety in the anxiogenic condition as compared to the baseline ($p < 0.001$) and control ($p < 0.05$) period.

Analysis of performances for response time tasks revealed a significant interaction between group, condition, modality and sequence of response time factors ($F(1,26) = 4.76$; $p < 0.05$). Therefore, we compared anxiogenic condition to control condition in each group, modality and sequence of response time. No significant differences between conditions were found in reaction time for VLTA subjects (Fig. 1A), and NTA subjects (Fig. 1B). Concerning movement time, performance of VLTA subjects was significantly improved in the anxiogenic condition for the auditory modality ($p < 0.05$), but not for the visual modality (Fig. 1C). Conversely, in NTA subjects, performance in movement time was significantly improved for the visual modality ($p < 0.05$), but not for the auditory modality (Fig. 1D). No significant effect for gender was observed for response times and psychological changes. Therefore, this factor was excluded in analyses.

The purpose of this study was to assess in subjects possessing different levels of trait-anxiety whether moderate state-anxiety influences reaction or movement time in visual and auditory modality in a bimodal choice task. Changes in state-anxiety were induced by exposing the subjects to the video-recorded Stroop color word test with interference [13,16]. As previously reported [5,8], this procedure results in a moderate but significant increase in state-anxiety whatever the subjects' trait-anxiety.

Statistical analysis did not show any main effect of condition on response time task performance, but revealed a significant interaction between all factors. We found that moderate state-anxiety improves movement time performances in visual modality in subjects with normal trait-anxiety, as well as movement time performances in auditory modality in subjects with very low trait-anxiety. This confirms our previous work on the relationships between state-anxiety, trait-anxiety and response time to visual and auditory stimuli given separately [5]. Taken together, these studies suggest that, whether or not a

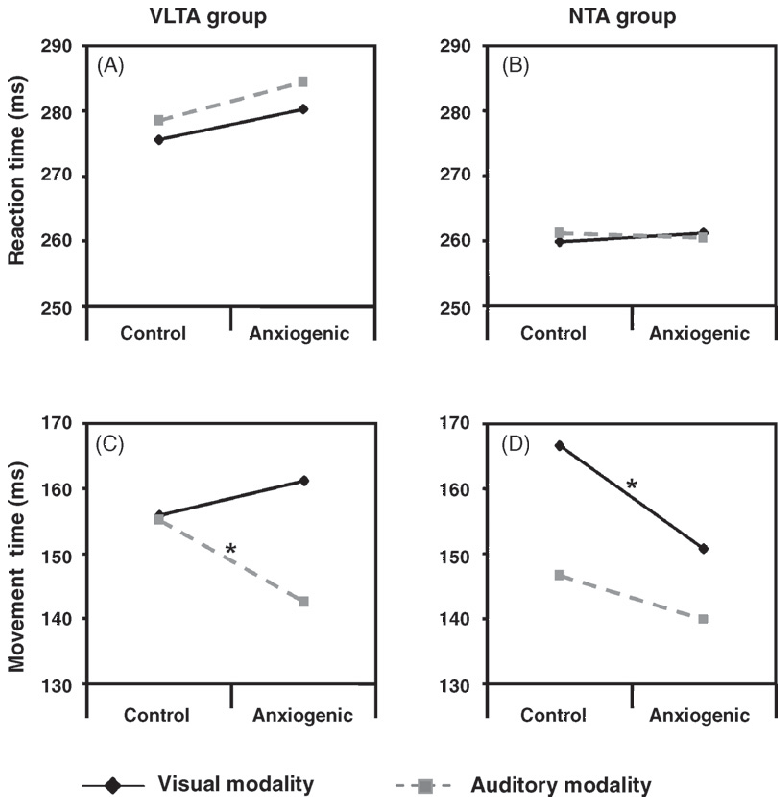

Fig. 1. Differences of reaction time and movement time performances (mean in ms) between the control condition and the anxiogenic condition for the very low trait-anxiety group (VLTA; $n = 14$; A, C) and the normal trait-anxiety group (NTA; $n = 14$; B, D). $^{*}p < 0.05$, significant difference between the control condition and the anxiogenic condition.

decision-making is required, individuals exposed to anxiogenic conditions could favour the information processing of a specific "relevant" modality, either visual or auditory, depending on their trait-anxiety level. As such, NTA subjects would focus their attention towards visual stimuli, and VLTA subjects towards auditory stimuli. It should be noted that in similar tasks where attention is divided between visual and auditory modalities, Driver has shown that subjects mainly attend to one modality versus another [3]. Given our findings, we suggest that this may be related to the subjects' trait-anxiety level. In addition according to the work of Spielberger [14] who has suggested that a specific behaviour would be amplified if it is triggered by an appropriate stimulus, we hypothesise that these effects could be intensified in anxiogenic conditions.

Paradoxically, in anxiogenic condition, improvement of performance in both groups occurred at movement time, but not at reaction time in the preferential modality. According to Driver [3], some crossmodal selection could apparently arise before diffusion of the stimulus. In this way, we suggest that subjects would prepare themselves to react to the expected modality, and thereby could start early motor program for this modality. Thus, this could contribute to facilitate movement execution when the expected modality corresponds to the presented modality, but not when the presented modality differs from the expected modality. However, despite the subjects' oriented attention towards a specific modality, we found no improvement in reaction time. We suggest that this could be due to a stage of verification that the presented modality really corresponds to the expected modality.

In conclusion, our results show that subjects exposed to anxiogenic condition would allocate attentional resources towards a specific relevant modality, either visual or auditory, depending on their trait-anxiety level. Such attentional resources would influence movement time, but not reaction time. Further experiments are needed to determine whether our findings may occur in subjects eliciting high levels of state-anxiety.

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