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INDIVIDUAL DIFFERENCES IN STARTING POINT LOCALIZATION OF MOVING OBJECTS: DATA ANALYSIS USING MULTILEVEL/HIERARCHICAL MODELS.

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Abstract

When observers are asked to localize the starting point (SP) of a moving target, the perceived position is reported both in and opposite to the direction of motion. It is still not clear under which conditions the perceived SP is mislocalized back or forth. Although research has shown a remarkable inter-individual variability, only few studies mentioned this aspect, which seems to be crucial to understanding whether the observers used different evaluating systems on judging the SP or it is due to methodological aspects. In the present study, we used multilevel models to choose between these two alternatives analyzing individual variability in localizing SP as a function of both velocity and direction. Results showed an individual variability, suggesting that observers used different evaluating systems when asked to localize the SP of a moving target.

A wide body of research has focused interest on the perceived position of a moving stimulus (e.g. Fröhlich, 1923; Mac Kay, 1958; Freyd & Finke, 1984; Hubbard & Bharucha, 1988; Nijhawan, 1994; Müsseler & Aschersleben, 1988; Thorton, 2002; Actis-Grosso & Stucchi 2003). This interest is based on the observation that there are small but consistent errors, here defined as spatial dislocations, when a position judgement is required for a moving object at both its starting point (SP) and vanishing point (VP) or when a flash is presented aligned with the moving object (Flash-lag effect, FLE). With respect to the SP, the first perceived position of a moving target is typically mislocalized. A localization error in the direction of motion (i.e., a forward mislocation) was firstly reported by Fröhlich (1923), whereas more recent studies also revealed a reverse error, that is an error opposite to the direction of motion (i.e. a backward mislocation; Actis-Grosso, Stucchi & Vicario, 1996). Several explanations have been proposed, however, many questions concerning the nature of these errors remain unanswered.

Regarding the FLE, several studies report individual variability (Baldo & Klein, 1995; Lappe & Krekelberg, 1998; Krekelberg & Lappe, 1999; Patel et al, 2000; Kreegipuu & Allik, 2003). In particular, Baldo and Klein (1995) report that one observer out of five did not perceive any spatial dislocation on FLE, whereas two studies (Lappe & Krekelberg, 1998; Patel et al, 2000) report that some observers showed the opposite effect (i.e. flash-lead). In other research (Lappe & Krekelberg, 1998; Krekelberg & Lappe, 1999) a great variability in the magnitude of the FLE between subjects was present. However, little is known about whether or not different populations exhibit similar levels of individual variability: despite the observation that there is variability between subjects in the perception of the FLE, there are no studies to date that try to analyse whether this difference reflects different strategies in judgment or whether it is due to a different "calibration" of the perceptual mechanism. In fact, it is possible that when an observer is required to judge the position of a moving object, he/she perceives this position with a fixed bias that could differ between subjects. In other words, in principle, it is possible that observers could be divided into three different categories, depending on their precision in the

perceived localization of moving objects: (i) no bias at all; (ii) a bias in the direction of motion (the one which is reported by the two studies mentioned above as "Flash-lead") and (iii) a bias opposite to the direction of motion (the one which is reported by the majority of papers on FLE as "Flash-lag"). The third "category" of observers could simply be the most common one, and this would explain why FLE is often reported.
In the last 5 years our research group has carried out several experiments on spatial dislocations. From a qualitative point of view, we have observed a remarkable individual variability across subjects for both the event's boundary (SP and VP, Bastianelli et al. 2004) and FLE (Scocchia et al., 2006).

The present work focuses on individual variability since during these years a great amount of data has been collected. In this research Multilevel models (MLMs) were used for analysing the data of one experiment reported by our group (Bastianelli et al., 2005). In this experiment, the observed individual variability seemed to be due to a qualitative difference across subjects, rather than to simple chance or methodological issues.

The core aim of the present work is thus to understand if the individual variability in judging the SP of a moving target is due either to different evaluating systems between subjects or to methodological considerations. Different from the traditional approach involving repeated measures ANOVA, in the present work the multilevel models (also known as hierarchical linear models or general linear mixed models) were used. A multilevel model is a regression-based approach that addresses hierarchical data structures. An example of hierarchically structured data occurs when the same individuals are measured on more than one occasion. A common example occurs in studies of visual perception. In this case the occasions are nested within individuals that represent the level 2 units with measurement occasions the level 1 units. Such structures are typically strong hierarchies because there is much more variation between individuals in general than between occasions within individuals. When repeated measures are taken, responses provided by each subject are not, in most cases, independent. Ignoring dependence of responses within subjects can lead to biases in the estimates of the standard errors corresponding to fixed parameter estimates (see, e.g., Raudenbush & Bryk, 2002). Multilevel models address this dependency by partitioning variance in the responses into two levels: a within-subjects level and a between-subjects level. At the first level, the within-subjects errors represent variation in responses after important predictor variables have been taken into account. At the second level, the effects (regression coefficients) of one or more of the predictors that enter the model at the first level are allowed to vary across subjects. These effects are commonly known as random coefficients or random effects. This means that the effect of a predictor at the first level can affect the outcome differently for individual subjects.

Method

Data were collected in Experiment 1 reported in Bastianelli et al. (2005). In that experiment, 10 subjects were asked to judge the position of SP of a moving target in the 4 directions with 5 possible accelerations. The experimental design included two factors: Direction (4 levels) x Acceleration (5 levels) for a total of 20 stimuli. Each stimulus had five replications, for a total of 100 trials (total observations = 1000). The Euclidean distance between judged starting point and actual starting point is referred to as displacement.

As first step data were inspected for the presence of outliers. Based on both statistical and theoretical considerations, an outlier was defined as an observation larger than 200 pixels. One subject was removed whose response bias was larger than 200 pixels in most trials. The total observations obtained were 892, balanced across subjects.

Figure 1 shows all observations (raw scores) for the four directions (Left-Right, Right-Left, Top-Bottom, Bottom-Top).

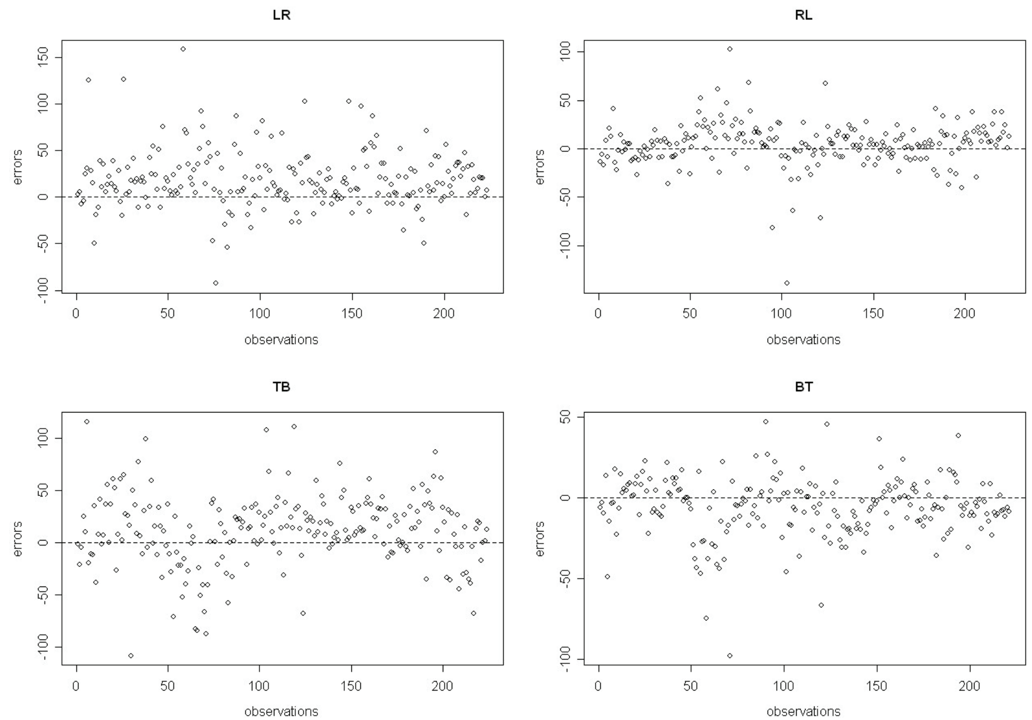

Figure 1. A schematic representation of the errors (pixels) for the four directions. The dotted lines represent the overall median in each condition. For horizontal motion, only the x displacement and, for vertical motion, only the y displacement are shown.

For the two experimental conditions, Direction and Acceleration, data were aggregated using two different statistics: i) median and ii) coefficient of variation (CV), both reflecting important theoretical features of the data: the first measured the magnitude of the errors, the second considered the response variability. In this way, each dataset was composed by 180 observations.

Analyses were performed separately for each dataset using the package lme4 (Bates, 2007) of the software R version 2.6.0 (R Development Core Team, 2007).

Results

- Dislocation: analysis of medians
As first step a random intercept model was estimated. Results indicate that 24% of the variance ($F_{(8,171)}$=6.899; $p < .001$) in any individual response can be explained by the properties of the individual who provided the rating (see Figure 2).

The second step included modeling the fixed relationship between direction and acceleration and the dependent variable. The results showed a significant effect for direction ($\chi^2(3) = 8.619$; $p = .034$) whereas both acceleration and interaction between acceleration and direction proved to have no significant effect.

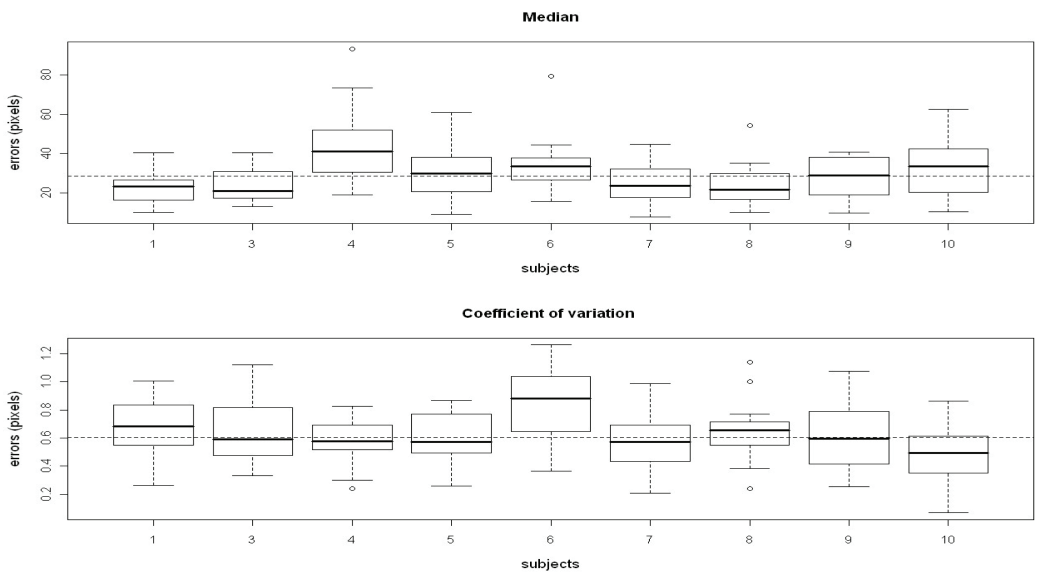

Figure 2. A schematic representation of errors for each subjects using the median and the coefficient of variation respectively. The dotted lines represent the overall median for medians and coefficients of variation, respectively.

In Figure 3, it can be seen that subjects reported a smaller amount of errors in the left-right direction.

In the third step, a model that allowed the direction effect to vary randomly across subjects was performed and compared with a model including only the fixed effect of direction. No significant difference emerged, indicating that the direction effect could be considered to be constant across subjects.

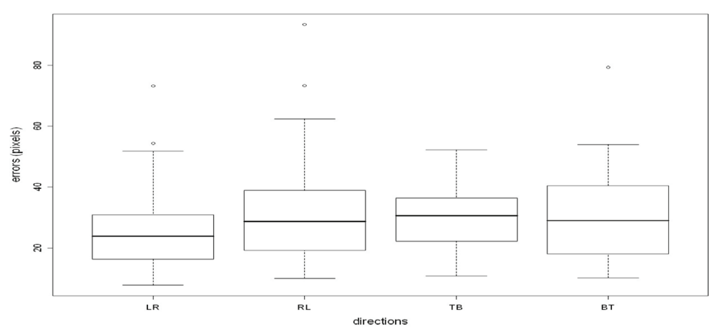

Figure 3. A schematic representation of the errors for the four directions.

- Dislocation: analysis of CVs

As the first step, a random intercept model was estimated. Results indicated that 14% of the variance ($F_{(8,171)}$=4.533 ; p < .001) in any individual response can be explained by the properties of the individual who provided the rating (see Figure 4).

The second step involved the construction of a model including the direction and acceleration in a fixed relationship with the dependent variable. The results show a significant effect for direction ($\chi^2(3) = 9.251$; p = .026) and acceleration ($\chi^2(4) = 12.641$; p = .013). No significant interaction emerged. As can be seen in Fig. 4, for acceleration there is high

variability in the Left-Right direction, whereas for acceleration there is low variability at the highest acceleration (i.e., 2) .

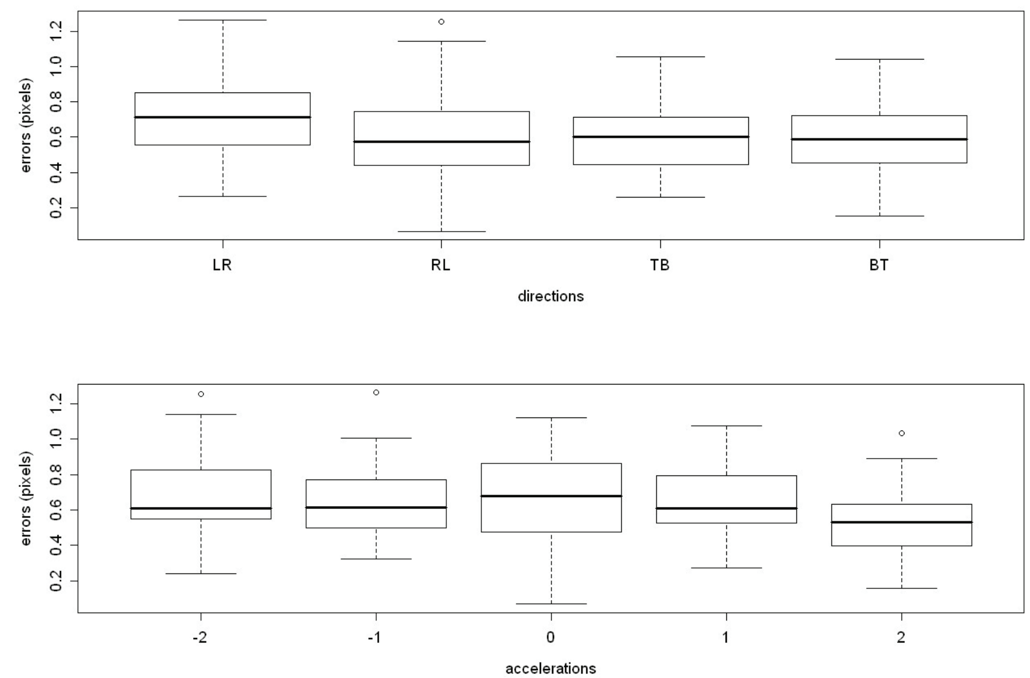

Figure 4**. A** schematic representation of the effect of direction (top panel) and accelerations (bottom panel) of the error using the coefficient of variation.

The third step consisted, in the first part, of applying a model that allowed the direction and acceleration effects to vary randomly and, in the second part, of comparing it with a model including only the fixed effects for both direction and acceleration. No significant differences emerged, indicating that direction and acceleration effects could be considered to be constant across subjects.

Discussion

These results seems to indicate that both dislocation magnitude (using the medians) and the dislocation variability (using the coefficients of variation) are affected by individual characteristics.

With respect to dislocation magnitude, a lower error dislocation was found in the left-right direction. On the other hand, with respect to dislocation variability, effects of both direction and acceleration were seen. This means that, different from our previous results (Bastianelli et al., 2005) using the coefficient of variability an effect of acceleration is observed on SP. This result highlights the relevance of studying spatial dislocations not only from the point of view of their magnitude, but also from the point of view of their variability.

In general, these results seem to suggest that each subject has a specific starting bias for both the magnitude of error dislocation and variability of the errors, and the response pattern of each subject seems to be coherent with his the starting bias level. However, it is necessary to perform further analysis in order to verify the existence of specific profiles of response.

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PRACTICE MODULATES THE EFFECT OF EXPECTING A GAP IN TIMING

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Abstract

In previous studies on time production with gaps, participants were asked to interrupt and then to resume timing during a time interval production. Produced intervals consistently lengthened as the gap occurred later, revealing temporal underestimation related to pregap duration. This effect was explained by referring to two main mechanisms: 1) attention sharing between timing and monitoring for the gap signal, and 2) preparation to interrupt timing while the gap is expected. In the present study, two participants were tested in a 2.5-s time production task with gaps in 20 experimental sessions. Produced intervals lengthened with increasing value of gap location as in previous studies, but this effect was clearly modulated by practice: the slopes of functions relating produced intervals to gap location generally increased during the first 10 experimental sessions, and then stabilized. In contrast, the intercepts of these functions were unaffected by practice. These results suggest that practice specifically influences processes related to gap expectancy, namely, attention sharing and/or preparation to interrupt timing.

When timing has to be interrupted and then resumed during a gap in time interval production, an effect of varying gap location is consistently found: produced intervals are longer when the gap occurs later during the interval (Fortin & Massé, 2000; Fortin, Bédard & Champagne, 2005). This effect is explained by attentional time-sharing between timing and monitoring for the gap signal when a gap is expected, which shortens perceived time and thus delays the reach of the target interval. This interpretation is supported by results showing that a) in trials where a gap is expected but does not occur, produced intervals are even longer and b) when participants are forewarned of the gap absence, the effect is almost abolished. Another factor contributing to the effect is that when the gap occurs later, participants are better prepared to interrupt timing as soon as the gap signal is presented, which also results in relatively shorter perceived durations, hence longer productions (Bherer, Desjardins & Fortin, 2007). The present experiment tested whether the effect of varying gap location would be influenced by extensive practice of time production with gaps. Although attentional time-sharing failed to reduce interference under dual-task conditions when one of the two tasks was a timing task (Brown, 1998), practice usually improves performance in time-sharing situations (T. L. Brown & Carr, 1989). Besides, if temporal uncertainty concerning the possible values of gap location is reduced through practice, better preparation to interrupt timing when the gap signal occurs might amplify the gap location effect.

Method

Two participants (2 women, 20 and 23 years old) first practiced producing a 2.5-s interval, which was the target interval that had to be produced throughout the experiment, in practice sessions. They were then tested in 20 experimental sessions, in which they produced the