discrimination (Grondin & Rammsayer, 2003). This might account for some inconsistency, but does not explain why discrimination is better with filled intervals in Experiment 1.

The second critical factor is the fact that in both methods, there is a succession of signals marking two intervals to-be discriminated, and one extra interval, i.e., the ISI. Confusion in processing a series of time intervals is probably increased if the intervals to-be discriminated are close in duration to the value of the ISI (Rammsayer & Lima (1991)`s misassignment hypothesis). There is no such problem with filled intervals but in Experiment 1, the risk of confusion with empty intervals is very high. Thus, any potential advantage of empty intervals is probably masked by confusion

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Acknowledgements.

This research was made possible by a Scholarship awarded by the Canadian Institutes of Health Research to MP, by a Scholarship awarded by the Natural Sciences and Engineering Council of Canada (NSERC) to PLG, and by a research grant awarded to SG by NSERC: marilyn.plourde.1@ulaval.ca ; simon.grondin@psy.ulaval.ca

A PERCEPTUAL-COGNITIVE DIVIDING MODEL FOR THE INTEGRATION OF VELOCITY AND TRAVELED DISTANCE OF A MOVING TARGET BY LOCALIZATION RESPONSES

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Abstract

Differently from phenomenological responses, Representational Momentum (RM) offers a continuous response measure in the field of dynamic representations and naïve physics. This property is taken here as a basis for the use of Information Integration Theory in a field where one-dimensional approaches are the rule and integration results are entirely lacking. The present work establishes a psychological multiplying/dividing model in a data pool obtained from a full factorial design Velocity (4) × Traveled Distance (3) with forward displacement error of the last seen position of the target as the measured response. Besides compliance with standard criteria (Anderson, 1982; Weiss, 2006), the model was tested for additional algebraically derived predictions concerning the relations of the intercept c_0 *to interval and ratio-scale functional measures of the stimuli (Anderson, 1982; Masin, 2004). Implications of the findings are discussed, with an emphasis on estimation of* c_0*, which opens the way to the functional measurement of both stimulus dimensions on a common ratio-scale.*

When a moving target that suddenly disappears is presented to subjects who are required to locate its vanishing point, an error in the direction of motion is typically found. Originally reported by Freyd & Finke (1984), this error was coined Representational Momentum, calling upon a "mental analogue" of physical momentum. Partly in agreement with the proposed analogy, RM was shown to increase with the target's velocity for both implied (Freyd & Finke, 1985) and smooth motion presentations (Hubbard et al., 2001; Hubbard & Ruppel, 2002), although no effect upon RM was apparent for the target's mass (Hubbard, 2005). In an attempt to merge the existing evidence, Hubbard surmised that RM expresses a second order-isomorphism between mental representations and environmental invariants applying to the dynamics and kinematics of physical objects. Support for this view was provided from several displacement effects consistent, for instance, with the internalization of principles of friction, centripetal force, or gravity (Hubbard, 2005).

One important feature of RM is that, being a continuous variable, it makes it possible to address the issue of the integration of its contributing factors. Although many such determinants have been studied in isolation, they have seldom been considered in acting jointly. Anderson's Information Integration Theory (IIT: Anderson, 1981; 1982; 1996) is taken here as an appropriate framework for the study of RM multidetermination. Specifically, the present work focuses on the integration of the target's velocity and travelled distance by RM magnitude. In line with IIT methodology, all variables were fully crossed in factorial integration tasks, requiring a localisation response. As a supplementary between-subjects factor, two kinds of localisation response, either indirectly through a mouse cursor, or directly through a pointer, were used.

Method

Subjects

Twenty undergraduate (19 female and 1 male) students at the University of Coimbra volunteered for the experiment. All of them had normal or corrected to normal vision and were unaware of the purposes of the experiment.

Stimuli

A set of avi-type animations (40 fps) that depict a 1 cm^2 black square travelling horizontally across a white background, at constant speeds of 6, 8, 10, 12, 14, 16 or 18 cm/s were used. The target emerged from either the left or right edge of the screen and suddenly vanished at 2, 4 or 6 cm ahead of the centre of the screen. All animations were created with *Interactive Physics 2000* and edited with *VirtualDub*.

Apparatus

The experiment was implemented with *Super Lab 4.0*. Animations were presented on a PC equipped with a flat touchscreen LCD monitor, at a refreshing rate of 120 HZ and with screen resolution of 1024 x 768 pixels. Half the subjects responded by displacing a "plus sign" cursor controlled by an optical wireless mouse; the other half by directly touching the screen with a Softpoint Pen (pointer).

Design and Procedure

The experiment was a full factorial 7 (*velocity*) x 3 (*travelled distance*) x 2 (*direction of movement*) repeated measures design, with two replications. Half the subjects used the mouse for responding and the other half the pointer. Subjects sat at 60 cm from the screen, and were requested to hold a steady position. They were asked to attentively observe the randomly presented videos and, the moment these were over, to immediately locate the point where the target had vanished (corresponding to its geometrical centre). Subjects responding with the wireless "mouse" had to displace a "plus sign" cursor from the centre of the screen, where it appeared, to the desired position. Those responding with the pointer simply touched the screen at the last perceived location of the target. Practice trials were given beforehand to ensure good understanding of the instructions and familiarity with the task.

Results

Magnitude of RM was gauged by the difference in pixels between the *x*-coordinate of the target's centre when it vanished, and the *x*-coordinate of the point where the subject remembered seeing it for the last time. Both these measures were analysed using mixed ANOVAs with response modality as a between-subjects factor.

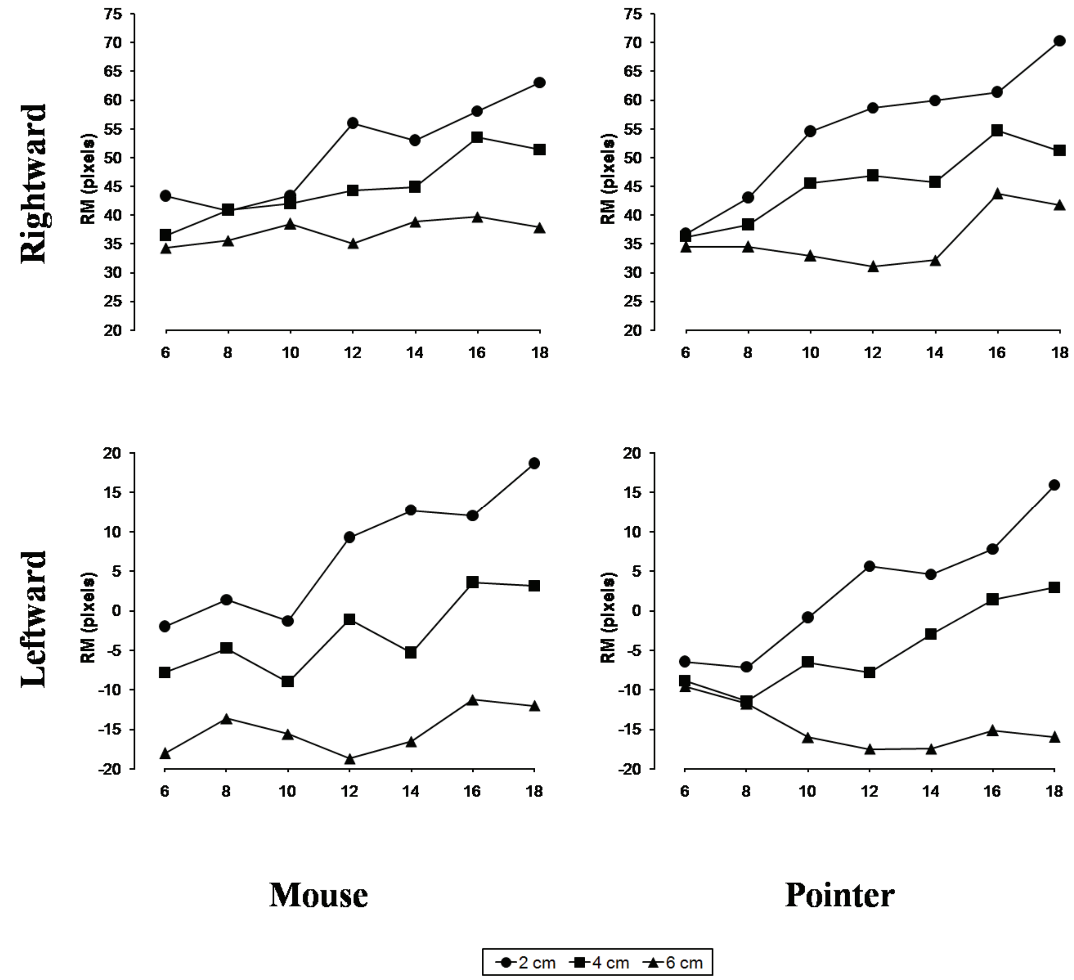

Figure 1 – Factorial plots of *velocity* (abscissa) × *travelled distance* (curve parameter) across *response modality* (columns) and *motion direction* (rows).

Figure 1 illustrates the factorial diagrams of *velocity* × *distance* for both mouse and pointer responses and across directions of movement - rightward (top row) and leftward (bottom-row). A clear trend for higher RM with greater velocity is denoted by the lines' positive slopes, while the vertical separations among them illustrate an effect of distance. The fan-like pattern observed overall suggests a strong interaction between factors, with larger (and decreasing) effects of *travelled distance* for higher levels of *velocity*. RM for leftward motion is consistently lower than the one for rightward motion and exhibits in many instances negative values.

Concurring with the visual inspection, statistically significant main effects were found for *travelled distance* ($F(1.636, 29.44) = 92.697$, $p < 0.01$) *and velocity* ($F(2.921, 52.576) = 26.394$, $p < 0.01$), together with a significant *velocity * distance* interaction ($F(12, 216) = 9.86$, $p < 0.01$). No further interactions of second or higher order (relative to either *motion direction* or *response modality*) were observed involving these factors.

Integration model

On the whole, the results appear compatible with an overall dividing model whereby *velocity* is divided by *travelled distance* (the dividing model is formally equivalent to a multiplicative one, except that increasing levels in one factor decrease the overall response, just as it happens with *travelled distance*). As established in IIT, the statistical signature of a multiplying model is a significant bi-linear component of the interaction term which leaves only non significant (null) residuals behind (Anderson, 1981; 1982). This was tested with the CALSTAT program (Weiss, 2006): a significant *linear* × *linear* component of the *velocity* * *distance* interaction for both response modalities [Mouse: ($F(1, 9) = 23.01$, $p < 0.01$); Pointer ($F(1, 9) = 65.3$, $p < 0.01$)] was indeed found and no significant residuals were left in both cases ($F < 1$).

Following on earlier work by N. Anderson, S. Masin has derived two additional predictions from the IIT algebraic multiplying model, which conjoins a linear response function $R_{ij} = c_0 + c_1 r_{ij}$ and a multiplicative operation $r_{ij} = s_{Ai} s_{Bi}$ (s_{Ai} and s_{Bi} the subjective counterparts of stimuli A_i and B_i). Those predictions concern the orderly relations of the intercept c_0 to interval (marginal means of the levels of the factors: $\overline{R}_j, \overline{R}_i$) and ratio-scale measures (differences with minimum relative error: $D_j = \left|R_{1j} - R_{Ij}\right|, D_i = \left|R_{i1} - R_{iJ}\right|$) of the stimuli (for details of the algebraic derivation see Masin, 2004; for ratio-scale measurement allowed for by the multiplying model see also Anderson, 1982). Specifically, prediction (1) states that, if mean ratings are plotted as a function of interval-measures of the levels of one factor, using interval-measures of the other as the curve parameter, c_0 will be negative whenever intercepts with the ordinate increase with parameter values, and positive otherwise. Prediction (2) states that when similar plots are done with ratio-measures in the abscissa (e.g., D_j) and as curve parameter (e.g., D_i), intercepts with the ordinate will be essentially invariant.

As can be seen from Figure 2, both predictions are verified for both response modalities (panel rows), with the qualification that the marginal means in prediction (1) actually refer to the reciprocal of stimuli functional values (e.g., $1/s_{Bi}$), due to the underlying dividing (rather than multiplying) operation. In particular, invariance of the positive intercept in the right panels, as foreseen by prediction (2), is clearly illustrated by an almost perfect convergence of the fan on a single point of the ordinate, which provides an estimate of c_0.

Invariance of c_0 was also statistically tested, by extracting the intercept values on an individual basis from plots with both D measures of *velocity* and D measures of *travelled distance*, respectively, as a parameter, resulting in a total of 10 estimates for each subject (7 for velocity levels and 3 for distance levels). A mixed repeated-measures ANOVA was performed treating those estimates as a within-subjects factor and response modality as a between-subjects factor. No main effects were found either for the estimates or for response modality, nor was there an interaction, a result which supports c_0 invariance.

The finding of c_0 invariance therefore opens the door to the derivation of ratio-scale functional measures of *velocity* and *travelled distance* by means of the equation $R_{ij} - c_0 = c_1 \rho_{ij}$, provided by the linear response function which is an integral part of the multiplying model.

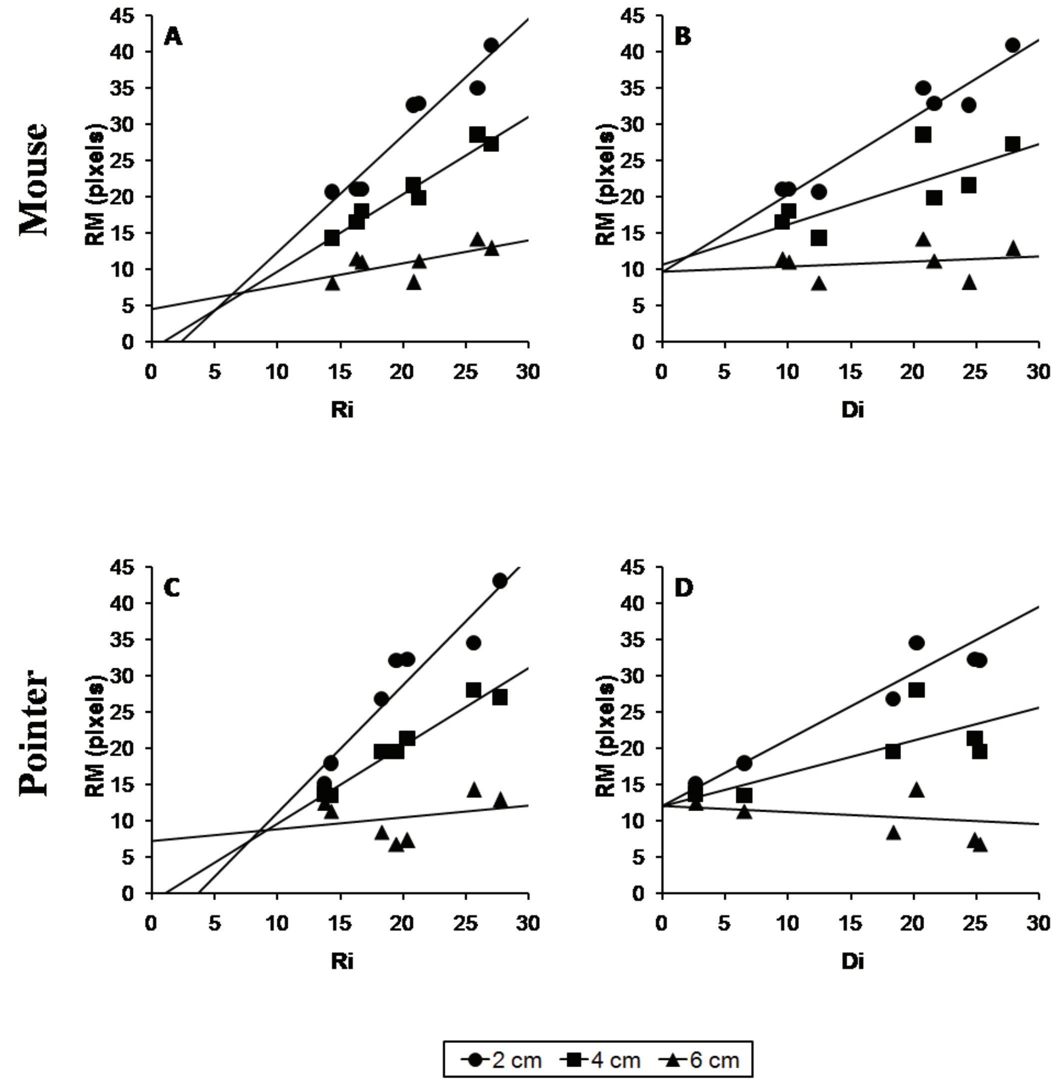

Figure 2 – Average RM magnitude plotted as a function of the marginal means of distance (panel A: Mouse; panel C: Pointer) and of "differences with minimum relative error" for the distance factor (panel B: Mouse; panel D: Pointer). Interval-scale and ratio-scale measures of *velocity* are used as parameters.

Discussion

The outcomes lend credence to the usefulness of IIT methodology for RM research. A well-warranted dividing model could be established for the integration of *velocity* and *travelled distance*. A number of advantages can come from that. One is the possibility of comparing performance with RM (involving a motor response) with performance with continuous ratings (involving mostly phenomenology), both regarding the emerging rules and the derivable functional scales of stimuli. Another interesting prospect, resting on the extension of this integration approach to include more *prima facie* cognitive factors (while keeping RM as an integration response), is that analytical insights could be gained about the extent to which high-level cognitive processes impact RM, a central issue of the debate over the very nature of forward displacement bias (Hubbard, 2005; 2006).

The dividing effect found for *travelled distance* is at odds with Hubbard et al.'s (2001) finding that, as opposed to launched targets, isolated targets did not produce a reduction of RM with distance, a disagreement that deserves closer inspection, in particular by considering the possibly confounded effects of travelled distance and vanishing position.

Why the dividing pattern is so much clearer for "pointer" than for "mouse" responses is for the moment unclear, even if, given the rather different latencies in response between these two modalities, it can be plausibly assumed that the time course of representational momentum (Freyd & Johnson, 1987) is playing a role.

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Acknowledgment

This work was supported by grant POCI/PSI/60769/2004, from the *Portuguese Foundation for Science and Technology - FCT/POCI 2010*.

COMPARING TEMPORAL EVENT-CODING IN PATIENTS WITH FIRST-EPISODE PSYCHOSIS AND CHRONIC SCHIZOPHRENIA

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Abstract

Cognitive impairments are a core feature of schizophrenia. It has been suggested that the underlying cause of these impairments is an inability to sequence mental activity in time. Various studies have found increased time windows where patients with schizophrenia judge stimuli to appear simultaneously. However, it is not known if these deficits are already present during first-episode psychosis (FEP) or if they develop gradually over time. This study compares the subjective evaluation of temporal structure between healthy controls, chronic schizophrenic and FEP patients using an experimental approach involving judgments of simultaneity of visually presented stimuli. The results suggest that patients required longer delays between stimuli to detect asynchrony, although FEP patients exhibit shorter windows of simultaneity compared to the chronic sample. These data indicate that FEP patients do not appear to have the same impairments in event-coding in time as do chronic patients but do show substantial variability.

Andreasen (1999, p.784) has suggested that schizophrenia should be defined in terms of cognitive dysmetria, described as "a disruption of the fluid, coordinated sequences of thought and action that are the hallmark of normal cognition." This theory could explain how difficulties with regard to time phenomenology are related to the cognitive impairments typically observed in chronic schizophrenia. It has been suggested that these deficits may be due to disturbed functioning of the basal ganglia and the fronto-thalamic networks, which could also explain the deficits in other cognitive functions such as attention and memory.

Timing is crucial for most cognitive activities and having such impairments has wide ranging consequences. Various studies have shown that people with schizophrenia have problems estimating the duration of events (Davalos et al., 2002) or whether two stimuli appear simultaneously or not (Elliott et al., 2006, Giersch et al., 2008). These results suggest that patients with schizophrenia experience an abnormally large window of time during which two events will be judged to occur simultaneously (Giersch et al., 2008). This could be indicative of an underlying problem in functional coordination at a brain systems level and thereby many of the psycho-cognitive disorders found in schizophrenia. Most research on time perception and estimation has focused on chronic schizophrenia but very little is known if these abnormalities are also present at the onset of illness, i.e. in first-episode psychosis (FEP). Due to their minimal exposure to medication, FEP patients could provide more insight into the nature of the timing abnormalities typically observed in chronic schizophrenic patients.

The aim of the present study was to investigate the nature of time perception deficits observed in chronic schizophrenic patients and to compare them with FEP patients and healthy controls.