Developing Euro Intuition for prices: Are we there yet?

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Abstract
The present paper continues a previous research carried out before the Euro transition (Dehaene & Marques, 2002) where the ability to estimate prices in a national familiar currency was examined and compared to the ability to estimate prices in an ‘at time’ unfamiliar currency – the Euro. Results showed that estimations in both cases followed Weber’s law, but that Weber fractions were significantly higher for the Euro (i.e. less accurate). Estimations in Euros also took longer to produce reflecting the use of algorithms from automated estimations in the national currency to calculated estimations in Euros. Price estimates were also correlated with buying frequency and price variability, which means that a part of the observed variability comes from the properties of the mapping from items to prices that is currency specific. In the present study we examined how the mapping from items to prices developed for the Euro considering that price intuition in the novel currency will develop by a slow process of association that requires exposure to many product-price pairs. Following Logan’s (1988) theory on the acquisition of automaticity we consider that the estimation of prices in Euros will involve a strategic shift from reliance on an initial algorithm (Dehaene & Marques, 2002) to reliance on memory for past solutions (i.e. prices retrieved from memory). We thus hypothesize that price estimates in Euros will show a faster improvement for more frequently bought products. This hypothesis was tested by collecting euro prices estimates in Austria and Portugal for 40 different items and with different monthly samples from November 2001 to June 2002. Overall results seem to show that price estimations in Euros have not yet reached a level of automatization comparable to estimations in the former national currency, but there is some sign of automatization for frequently bought items. Results are discussed, considering also reference price research literature.

Keywords: Price Estimation, Scalar Variability, Automaticity

Introduction

Price Estimation, Scalar Variability and the Euro

Our interest in price estimation and in the euro switch departs from the opportunity this task and this transition offers to study the organization of the mental representation of numerical quantities (Dehaene & Marques, 2002; Marques, 1999). Adult humans appear to possess a semantic representation of numerical quantities, which helps to evaluate proximity relations between numbers. Two characteristics constitute the signature of this representation (Dehaene, Dehaene-Lambertz, & Cohen, 1998). First, the distance effect reflects the fact that, when subjects have to discriminate two numbers or to decide which of two numbers is the larger, their reaction time and error rate is inversely related to numerical distance. For instance, subjects are faster in deciding that 9 is larger than 2 than in deciding that 6 is larger than 5. Second, the number size effect reflects the fact that, for an equal distance between the numbers, reaction time and error rate increase with number size. Thus, subjects are slower in deciding that 9 is larger than 8 than in deciding that 2 is larger than 1, although the distance is one unit in both cases (Moyer & Landauer, 1967).

The theoretical interpretation of those effects is that the mental representation of numbers is fuzzy and obeys Weber’s law, so that larger numbers are increasingly less discriminable. The mathematical formulation of this property corresponds to the fact that the standard deviation of numerical estimates increases in direct proportion to the number being estimated, a property called scalar variability (the proportionality constant is then called the Weber fraction). Assuming that numerical discrimination is hindered by overlapping internal representations, numbers that are closer in size are increasingly more confusing, explaining the distance effect, and also that this effect of proximity worsens as the numbers get larger, explaining the number size effect.

Scalar variability was demonstrated in both animals and humans’ perception of numerosity (Mechner, 1958; Meck & Church, 1983; Whalen, Gallistel, & Gelman, 1999) using simple stimuli such as light flashes and chips, where the standard deviation of the subjects’ estimation responses increased linearly with number size, indicating scalar variability compatible with Weber’s law. However, these findings are limited to a situation in which one of the two quantities was non symbolic, and hence perceptual or motor errors could have contributed to the observed response variability. We reasoned that, if the semantic representation of numerical quantities is Weberian, then scalar variability should be observed whenever this representation is accessed, even when both
the input and output stimuli are symbolic rather than perceptual or motor. Price estimation appeared as an ideal task to test this hypothesis.

Given a product name, we can quickly provide a reasonable number, expressed in a familiar currency. If the underlying representation of numerical quantity is Weberian, the variability in the estimated price should increase in direct proportion to the price of the item to be estimated. Because this task involves well-defined symbolic inputs and outputs (the name of the product and the numerical answer), variability in the input-output function cannot be attributed to perceptual or motor factors, but must reflect the internal structure of the mental representations involved.

Previous marketing and consumer research suggested that price knowledge is not stored in the form of exact declarative knowledge, but involved an inherently variable and approximate component, suggest that price estimations and representation have scalar variability (e.g. Grewal & Marmorstein, 1994; Lambert, 1978). However they had not directly verified it by measuring the Weber fraction across a large range of prices. And this was our motivation to begin our study. Moreover, approaching the transition to the Euro at that time, offered a first opportunity to study the impact of a currency change in a task that is currency specific as the numerical representations that subjects form for prices are only valid once a currency is fixed.

In our first study (Dehaene & Marques, 2002) we thus tested the ability to estimate prices in a national familiar currency and compared to the ability to estimate prices in an ‘at time’ unfamiliar currency – the Euro. Participants evaluated prices for different items either by selecting the most appropriate price from a set of alternatives (in a timed or not timed version) or by directly producing a price estimate and the study was carried out both in France, Portugal and Ireland.

Results with the different manipulations currencies and samples showed in all cases that estimations followed Weber’s law, as expressed by the fact that there was a linear relation between standard deviation and mean price estimations whether this was calculated by simple regression or by using their logarithmic scale transformation. This was also apparent more simply when plotting the Weber ratio for each item against its mean price. In fact, although ratio varied somewhat across items, no systematic linear or non-linear relation with price was found, suggesting that the Weberian relation provided a good description of price estimation. It should be noted that Weber’s law does not test for preferences only for discriminability.

When participants estimated prices in Euros, an unfamiliar currency at the time (1999-2000), they still followed the basic scalar variability rule. However, the Weber fraction tended to be higher, suggesting that estimation was less precise in the unfamiliar currency. Estimations in Euros also took longer to produce reflecting the use of algorithms from automated estimations in the national currency to calculated estimations in Euros. Moreover, price estimates were also correlated with buying frequency and price variability, which means that a part of the observed variability comes from the properties of the mapping from items to prices that is currency specific.

Developing price intuition and automaticity

In the present study we examined how the mapping from items to prices developed for the Euro considering the framework of Logan’s (1988) theory on the acquisition of automaticity. In general terms, the theory assumes that automatization involves a strategic shift from reliance on an initial algorithm that is sufficient to perform the task (i.e. the mental calculation of the price in Euros from the estimated price in the former national currency) to reliance on memory solutions (i.e. the prices in Euros). Automatic performance is thus based on memory retrieval. Whereas novices must solve problems with deliberate though and conscious algorithms, skilled performers simply retrieve solutions from memory. This also means that people will not rely on memory retrieval until it is faster than computing solutions with an algorithm. The theory assumes that the data base is built up by encoding each encounter with a stimulus separately. Later, when the stimulus is encountered again, each of the stored representations is potentially retrieved independently and, in this sense Logan’s theory is an instance or exemplar theory of memory.

Following these principles we consider that price intuition in the novel currency will develop by a slow process of association that requires exposure to many product-price pairs. Reliance on the calculation algorithm will continue as long as this new mapping is being established and direct retrieval of the prices in Euros is not possible or simply takes longer than computing them from the estimated price in the former national currencies. As prices for products and services in Euros are accumulated and retrieved we may begin to observe more accurate and faster price estimates and as such, we can expect that price estimates in Euros will show a faster improvement for more frequently bought products. Moreover, considering that our data also shows that estimated price variability also seems to contribute to subjects price estimations, automatization will be more rapid for items with less variable prices in the market.
To test this hypothesis we collected monthly price estimates in Euros for different items from 2001, before the introduction of euro coins and banknotes, to mid-2002, to evaluate if and how price intuition in Euros develops. Data collection was carried out in Portugal and in Austria, to further evaluate if different algorithms could have an impact on acquisition of automaticity. Results were also considered as a further evaluation of the characteristics of price estimations and representations established in our first study (Dehaene & Marques, 2002).

Method

Participants and Design

A total of 338 students participated in the study divided in terms of country (n=164 for Austria; n=174 for Portugal) and month of participation from November 2001 to June 2002 (about 20 subjects per month in each country). Data for 15 participants was not considered as their country of origin was not either Austria or Portugal. In the former case 8 participants were also detected as having responded in different months to the questionnaire and their second data was also disregarded. A final total of 315 data (n=146 for Austria; n=169 for Portugal) was considered for analysis.

The study involved a 2x8x40 mixed factorial design, with Country and Month as between subjects variables and item as a within subjects variable.

Stimuli

The same list of 40 familiar products or services used in Dehaene and Marques (2002) was selected with only one item replaced (“a consultation fee for a general practitioner” replaced by a “haircut”) and some small adaptations (e.g. package of yogurt) to have an equivalent set of items for the Austrian and Portuguese samples. The items were also rated in terms of their buying frequency and estimated price variability in both countries by a group of students did not otherwise participated in the study (n=25 for Austria; n=24 for Portugal). For each item, participants were asked, to estimate the frequency with which they buy it, on a scale from 1 (very rarely) to 7 (very frequently) and the variability of the items’ price in different shops or stores, on a scale from 1 (very constant) to 7 (highly variable) – half the participants doing one or the other estimation first. Between country correlations were .79 for buying frequency and .75 for estimated price variability (p<.01).

Procedure

Participants were told that they would be presented with various familiar products or services. They were asked to write down the price in Euros that they fell would be the typical price of each item. They were asked to answer quickly, intuitively, and without calculating. The following two questions were asked after completion of the test: What percentage of trials do you think that you answered based only on your intuition, without calculating? Can you estimate you degree of intuition for prices in Euros, on a scale from 1 to 7 (1=no intuition ; 7=excellent intuition)?

Results

A general item-based analysis was performed considering for each sample (country x month) the mean $m_i$ and standard deviation $sd_i$ of the estimates across participants, as well as on the Weber fraction defined as $w_i = m_i / sd_i$. Figure 1 shows the linear regression between the mean and the standard deviation of the estimated prices across 40 different products, separately by country.
As shown in Figure 1 there was a linear relation between $sd_i$ and $m_i$. Simple regression by country showed in the case of Portugal that 98% of the variability in $sd_i$ across the forty items could be accounted for by the following equation: $sd_i = .725 m_i \left(t(318)=89.24, p<.000\right)$; and in the case of Austria that 95% of the variability in $sd_i$ across the forty items could be accounted for by the following equation: $sd_i = .651 m_i \left(t(318)=55.79, p<.000\right)$. In both cases, the constant term, when introduced in the regression, was found non-significant, suggesting that a simple proportionality relation between $sd_i$ and $m_i$ accounted for the data. This demonstration of scalar variability of price estimations was also confirmed with a log-log regression that tests more directly linearity. Figure 2 represents the same data on a logarithmic scale.

In this representation, scalar variability predicts that variability estimates should follow a straight line with a slope of 1. Strict linearity was observed with slopes not different from 1 (1.05 and standard error .01 for Portugal and 1.07 and standard error .02 for Austria). These results confirm the with a larger sample including participants from yet another country not tested in the our first study (Austria).

Figure 3 shows the Weber fraction across all items for each month separately for Austria and Portugal.
A two-way ANOVA by month and country showed main effects for country \( [F(1,624)=39.41, p<.00] \) and month \( [F(1,624)=1.99, p<.05] \) and an interaction of the two dimensions \( [F(7,624)=2.41, p<.02] \). Post hoc Tukey HSD tests showed that accuracy of estimates as expressed by lower Weber fractions were more precise for Austrian samples and for June as compared to December. This result was especially related to the June estimates of the Austrian sample that were more precise than the estimates for December, January, March and April for the same country. In the case of Portugal, where we have results with escudos from previous experiments (Dehaene & Marques, 2002), it can also be seen that these estimations are not at the same level of accuracy as in escudos where we had found for the same items Weber fractions of .380 and .375.

To evaluate our hypotheses regarding the development of automatization for frequently bought items that have a more constant price we pooled the data considering these two dimensions and also time, considering only 3 month groups to test this hypothesis more precisely. We first pooled our monthly data in 3 groups: months before the transition (i.e., November and December 2001), first months after transition (i.e., from January to March 2002) and later months after transition (from April to June). We then limited our analysis to items that were estimated as more constant in terms of price variability (i.e., price variability < 3.5) and that correspond to 29 items in the Portuguese sample and 22 items in the Austrian sample. Finally, the analysis was done contrasting frequently bought and rarely bought items. Results are presented by month groups and buying frequency on figure 4. A two-way ANOVA was performed by month and buying frequency and showed an overall main effect of buying frequency \( [F(1,402)=30.21, p<.00] \) but the interaction was not significant \( [F(2,402)=1.48; p<.23] \). The predicted automatization effect was further evaluated by means of planned comparisons, considering that Weber fractions would become more accurate for items frequently bought but not for items bought rarely. In fact, this is what happens when we compare the first two month periods [for frequent items \( t(402)=1.72, p<.05 \), planned comparisons; for rare items \( t(402)=.91, p<.18 \), planned comparisons], although for both type of items there is no significant differences from the second to the third month period [for frequent items \( t(402)=.66, p<.25 \), planned comparisons; for rare items \( t(402)=.82, p<.20 \), planned comparisons].
From these results it thus seems, that some level of automatization in price estimates has been reached in the first months of the transition but only for frequently bought items that have a more constant price.

In terms of the participants evaluation of their own intuition and degree of intuition, Austrian subjects estimate that they rely only on their intuition more often than Portuguese subjects \(F(1,299)=19.28, p<.00\), although no increase is observed in terms of month. The reverse happens for degree, with no differences between countries but instead an slow increase in terms of month \(F(7,299)=2.65, p<.02\), although post hoc analysis did not allow for a further qualification of this tendency and the mean for June (4.38) is still far from the maximum possible (see figure 5, below).

**Discussion**

The results of the present study further validate the hypothesis that price estimations follow Weber’s law. In all samples (including new country Austria), a linear relation is systematically found, across items, between the estimated price and the standard deviation of this price.

In what concerns the hypothesis that price estimates in Euros will show a faster improvement for more frequently bought products that have less variable price, results point to this trend, although they are not significant at a more general level of analysis. Results also show that price estimates are more precise for frequently bought items all over, a result that we had already demonstrated (Dehaene & Marques, 2002) as price estimations are correlated with buying frequency and estimated price variability. One possibility is that this fact makes the improvement in our price estimations in Euros more negligible for frequently bought items, and thus
prevent us to evaluate more clearly if an automatization is already in place for these items in comparison to more rare bough items.

We are presently trying to confirm these results by comparing the evolution of price estimates in Euros and in escudos which may confirm our automatization hypothesis if estimates in Euros are more accurate than escudos for frequently bough items and the reverse happens to more rare bough items. We hope that further testing will allows to check if the participants evaluation of their increasing degree of intuition for prices in Euros has really a correspondence in terms of a qualitative change in how they make their estimations.

References


