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Developing Intuition for Prices in Euros: Rescaling or Relearning Prices?

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This article examines how numerical intuition for prices develops after a major change in currency. University students in Portugal (Study 1) and Austria (Study 2) made price estimates for 40 different items from November 2001 to June 2002, surrounding the time at which these countries switched to the euro. Overall results are more in accordance with a relearning hypothesis, considering that price estimates become progressively more accurate by a process that is related to buying frequency and, hence, is faster for frequently bought items. An alternative global rescaling hypothesis received mixed support. Results also suggest that price estimations in euros have not yet reached a level of accuracy comparable with estimations in the former national currency.

Everyone as a consumer carries in his or her mind a reasonable price for most products. Given a product name, he or she can quickly provide a price, expressed in a familiar currency. This price knowledge is not stored in the form of exact declarative knowledge but involves an inherently variable and approximate component. This component is related to market price characteristics and to the nature of consumers' representations of numerical quantities including prices.

Marketing and consumer research studies have provided abundant evidence of the general nature of price knowledge and market price characteristics. For example, Dickson and Sawyer (1990) questioned shoppers just after they selected a product from the supermarket shelf and observed that less than half were able to state the correct exact price. Recalled prices varied greatly and, on average, fell lower than the actual price. Some of the shoppers even had in mind a price that was not only inaccurate but was higher or lower than all of the actual prices in the brand choice set. Other experimenters have suggested that price knowledge is not random, but obeys Weber's law (Webb, 1961), so that the standard deviation of price estimates increases in direct proportion to the item's absolute price (i.e., larger prices are increasingly less discriminable). For instance, Lambert (1978) presented participants with partially modified advertisements for products and asked participants to detect "anything that differed from the brand you usually buy" (pp. 143–144). The frequency with which participants noticed a change in price did not depend on the absolute size of the price change but only on its ratio to the price of the item. Likewise, Grewal and Marmorstein (1994) demonstrated that people do not perceive the value of a proposed saving in absolute terms but only in terms relative to the mean price of a product.

In a more recent study, Dehaene and Marques (2002) showed that price estimations across a wide range of prices followed Weber's law. More specifically, they observed that the standard deviation of price estimates increased in direct proportion to the item price being estimated, a property called more generally *scalar variability*. The proportionality constant is then called the Weber fraction and corresponds to the standard deviation of price estimates for an item divided by the mean estimated price for the same item.

Scalar variability was initially demonstrated in animals' perception of numerosity (Mechner, 1958; Meck & Church, 1983) and also in humans for both numerosity perception and production tasks using simple stimuli such as light flashes and chips (Whalen, Gallistel, & Gelman, 1999). Dehaene and Marques (2002) extended these results to price estimation, a task not subjected to perceptual or motor biases, and confirmed that scalar variability adequately describes price knowledge and hence the internal structure of mental representations of numerical quantities. Moreover, Dehaene and Marques (2002) also showed that price estimates were 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. The latter was demonstrated by comparing the ability to estimate prices in a national familiar currency to the ability to estimate prices in an "at the time" unfamiliar currency—the euro (the study was carried out in France, Portugal, and Ireland in 1999–2000, before the switch to the euro). In fact, when participants estimated prices in euros, although estimates still followed the basic scalar variability rule observed for the national familiar

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currency, the Weber fraction of estimates tended to be higher than for the same items in the former national currencies. As such, the Weber fraction gives us a measure of the accuracy of price estimates. This difference shows that estimation was less precise in euros, in the sense that participants showed less agreement in their price estimates for this currency (i.e., higher standard deviation of estimates in euros). Estimates in euros also took longer to produce probably reflecting the use of explicit calculations when making price judgments in an unfamiliar currency (Dehaene & Marques, 2002).

Having shown that the numerical representations that people form for prices are only valid once a currency is fixed, the transition to euro offers the opportunity to study what happens when this reference changes. Millions of Europeans are currently involved in such an experiment in 11 member states of the European community. Since January 2002, they were forced to use a new currency, the euro, in all aspects of their daily life. To facilitate the transition, since January 1999 the euro had begun to be introduced alongside the local currency in price tags, bills, and bank forms, and this double pricing still remains in some cases.

In this context of currency change our present objective is to evaluate how people adapt their price knowledge when currency changes. This is a situation that is familiar to all who travel and have to adapt to a foreign currency but, in the case of the euro changeover, it is a long-term adjustment. There is other evidence beyond precision of price estimates that show that a currency change involves much more than an adaptation to new coins and banknotes. The fact that prices in the former national currency have to be converted in a new common currency that, in general, corresponds to lower quantitative values (the only exception is Ireland) has a clear influence on price perception. One effect corresponds to the "money illusion" (Shafir, Diamon, & Tversky, 1997), or in this case the "euro illusion" (Gamble, Garling, Charlton, & Ranyard, 2002). The money illusion corresponds to a biased tendency to assess the real value of transactions considering primarily their nominal values (Shafir et al., 1997). Translated to this context, it would correspond to a tendency to assess the same real prices as lower when expressed in euros than when expressed in the former national currency in all countries entering the euro, with the exception of Ireland where the reverse would be expected (the Irish punt is the only currency that corresponds to a larger money unit than the euro). This illusion was demonstrated for price evaluation (Gamble et al., 2002), job attractiveness as a function of salary (Jonas, Greitemeyer, Frey, & Schulz-Hardt, 2002), and price estimation (Jonas et al., 2002). However, the illusion was not present in all situations, depending on how the new money unit (not only the euro but others) was presented (Gamble et al., 2002) and how the judgment context was framed (Jonas et al., 2002). In fact, some of the results could be explained in terms of an *anchoring bias*, corresponding to the assimilation of a judgment to a previous salient standard of comparison (Tversky & Kahneman, 1974). Susceptibility to this bias is higher in situations of uncertainty, and this would have led participants to use their familiar reference prices in the former national currency as anchors to judgments made in euros (Jonas et al., 2002). Moreover, Mussweiler and Englich (2003) in a study involving data collection before and after the introduction of the euro coins and banknotes (all other studies mentioned were done before January 2002) showed that susceptibility to this bias was higher for anchors in euros as compared with anchors in German marks (DM) in Winter 2001, but this was reversed by Summer 2002. Mussweiler and Englich only used one item (the price of a new German midsize car), which seems a very limited (and maybe biased) set to conclude for a rapid adaptation to the new currency. Moreover, even if this is the case, it may just reflect that people passed from a situation in which the conversion of euros to DM was harder to a situation in which this conversion is easier as compared with the reverse calculation (i.e., from DM to euros).

The present study addresses the questions of whether and how the price representations in the former national currencies changed to price representations in euros. This is an important question for the understanding of the judgment biases reported, as, in fact, they can be partly ascribed to a context of uncertainty regarding an unfamiliar currency. Understanding if and how reference prices are built in euros can thus inform researchers about situational and context variables that can make these biases more or less salient.

Considering that citizens of the countries adopting the euro will eventually build reference prices in the new currency, how will they achieve this? Will they rescale their previous map of prices, or do they have to relearn and form an internal price representation for each product?

The first alternative corresponds to a rescaling hypothesis in which a global change affects all price knowledge at the same time. The idea is thus one of a translation of price knowledge expressed in a particular scale (i.e., the former national currencies) to a new scale, all prices being rescaled (i.e. transformed) at the same time. The evidence collected by Dehaene and Marques (2002) gives some support to this hypothesis because estimates in the national currencies and in euros had the same general structure, only the latter were globally less accurate. The anecdotal evidence that we seem to adapt at a general level when shopping abroad with an unfamiliar currency could also argue in favor of this hypothesis, although this type of adaptation may only correspond to a general conversion–calculation strategy. However, with respect to the available empirical data from Dehaene and Marques, as the euros were still not physically introduced at the time, it could be argued that the situation was in some sense artificial and, as such, not a crucial test for the rescaling hypothesis.

The second relearning hypothesis concerning the different prices for the different items derives from 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-based solutions (i.e., the prices in euros). Automatic performance is thus based on memory retrieval. Whereas novices must solve problems with deliberate thought 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 database 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 of exemplar-based theory of memory.

Following these principles, we can consider that price intuition in the novel currency should develop by a slow process of asso-

ciation that requires exposure to many product-price pairs (indeed, such a process is presumably the only way that price intuition could develop in the first place for the initial currency or for entirely novel products). Reliance on the calculation algorithm should 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 price estimates in euros to show a faster improvement for more frequently bought products. In a related view, many authors have shown that both humans and animals are very sensitive to frequency information (see Gigerenzer, 1998, for a review), and this could also explain the expected difference between estimations as a function of buying frequency.

To test these hypotheses, we collected monthly price estimates in euros for different items from the year 2001, before the introduction of euro coins and banknotes, to mid-2002, to evaluate whether and how price representation in euros develops. We collected data using a between-subjects design, although both hypotheses concern within-subject changes. This choice was motivated by the fact that it was easier to match participant samples over the data collection period, which in turn allowed us to test the same set of items every month, a crucial aspect in evaluating the possibility that price estimations become more accurate. A within-subjects design would involve selecting different items each month that would constitute comparable sets in terms of buying frequency, a design that proved to be extremely difficult to implement. The fact that a between-subjects design was chosen instead is considered in data interpretation.

Finally, similar to Dehaene and Marques (2002), data collection was carried out in different countries to further evaluate whether different conversion rates could have an impact on this development. Study 1 was carried out in Portugal, and Study 2 was carried out in Austria (for Portugal, 1 euro (U.S.$1.20) = 200.482 escudos; for Austria, 1 euro = 13.7603 schillings).

If a rescaling hypothesis is correct, we can expect price estimations to become more accurate (as expressed by decreasing Weber fractions) conjointly for all items, including those that are infrequently bought. If, instead, a relearning hypothesis formulated on the basis of the acquisition of automaticity is correct, we can expect price estimations to become more accurate with a significant difference between items as a function of buying frequency. Price estimates in euros will show a faster improvement in accuracy for more frequently bought products.

Study 1: Portugal

The first study evaluates the rescaling versus the relearning hypotheses for Portugal.

Method

Participants and design. A total of 174 university students participated in the study and were divided by the month of participation from November 2001 to June 2002. Students either participated on a voluntary basis or to obtain credit for partial fulfillment of an introductory psychology course requirement. Data for 5 participants were not considered, as their country of origin was not Portugal. A final total of 169 participants were considered for analysis. Samples varied from 18 participants in November to 25 participants in May ($M = 21$ participants). Mean age was 19.1 years (there were no significant differences between monthly samples), and all samples were composed of approximately 80% female participants and 20% male participants. The experiment involved an 8×40 mixed factorial design, with month as a between-subjects variable and item as a within-subjects variable.

Materials. 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"). A full list of items is presented in the Appendix. The items were also rated in terms of their buying frequency by a group of students ($n = 24$) that did not otherwise participate in the study. For each item, participants were asked to estimate the frequency with which they buy it, on a scale ranging from 1 (*very rarely*) to 7 (*very frequently*).

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 thought 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?" and "Can you estimate your degree of intuition for prices in euros, on a scale ranging from 1 (*no intuition*) to 7 (*excellent intuition*)?"

Results and Discussion

Price estimations produced in each month were pooled in four periods: before the transition (i.e., November and December 2001), early transition (i.e., January and February 2002), medium transition (i.e., March and April 2002), and late transition (i.e., May and June 2002). For each item (i) in each period, we calculated the mean (M_i) and the standard deviation (SD_i) of the estimates across participants and we obtained a Weber fraction by item defined as $w_i = SD_i/M_i$.

To evaluate the hypotheses, we divided the items in terms of buying frequency (rare and frequent) considering the medium point of the scales (i.e., 3.5) and the ratings previously obtained. Using these criteria, 28 items were classified as rare and 12 were classified as frequent. Mean Weber fractions by transition period are presented in Figure 1, including data for escudos from the year

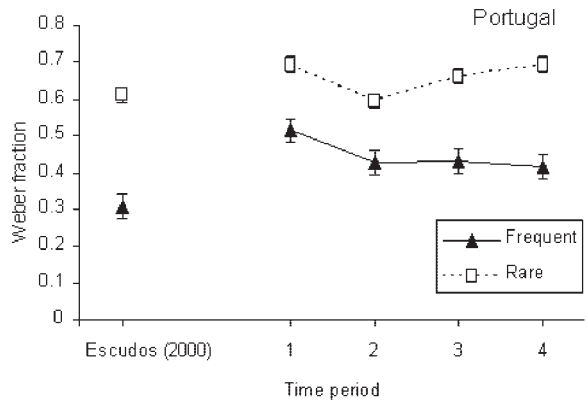

Figure 1. Mean Weber fractions by buying frequency (frequent, rare) and transition period in euros and for escudos in the year 2000 (Portugal). Error bars represent standard error of the means.

2000 as a comparison data point (from Dehaene & Marques, 2002).

To evaluate the two alternative hypotheses, we performed the following two planned comparisons: a comparison between the periods before the transition (Period 1) and early transition (Period 2) and a comparison between the periods medium transition (Period 3) and late transition (Period 4). The comparisons were performed separately by buying frequency to assess whether there was only an overall gain in estimation accuracy (as predicted by the rescaling hypothesis) or whether accuracy gains were observed sooner for frequently bought items (as predicted by the relearning hypothesis). Unilateral tests were performed in each case and an alpha level of .05 was considered for all comparisons. Cohen's *d*s (Cohen, 1988) for paired observations were also calculated to estimate effect size. Results are presented in Table 1.

In the cases of both frequently bought items and rarely bought items, there is a significant gain in accuracy (i.e., lower Weber fractions) corresponding to a large effect size from Period 1 to Period 2, with no significant gains observed after. As also apparent from Figure 1, mean Weber fractions were smaller for frequently bought items, which shows that price estimations were overall more accurate for these items.

Considering that for Portugal we have results with escudos from previous price estimations experiments (Dehaene & Marques, 2002) with student samples equivalent to the ones used here, we further compared price estimation accuracy for Period 4 with a similar set of data obtained with escudos in the year 2000 (excluding item 37 that is different from the one used in Dehaene & Marques, 2002; $N = 39$). A mixed 2×2 analysis of variance (ANOVA) by currency (between-subjects variable) and buying frequency (within-subjects variable) was performed. Main effects were found for currency, with more accurate estimations in escudos, $F(1, 37) = 5.40$, $MSE = 0.019$, $p < .05$, Cohen's $f = 0.37$, and for buying frequency, $F(1, 37) = 6.95$, $MSE = 0.124$, $p < .05$, Cohen's $f = 0.41$, with more accurate estimations for frequently bought items. The interaction of Currency $\times$ Buying Frequency was nonsignificant, $F(1, 37) = 0.001$, $MSE = 0.019$, *ns*, Cohen's $f = 0.00$.

A final analysis looked at the participants' evaluation of their judgments for the percentage of price estimates done exclusively on intuition and for the degree of intuition by transition period. Results are presented by transition period in Figure 2 for intuition use and in Figure 3 for degree of intuition, including data for escudos from the year 2000 as a first data point. A one-way ANOVA by transition period was performed on each case. In terms of intuition, the main effect of transition period was nonsignificant, $F(3, 165) = 0.78$, $MSE = 631.59$, *ns*, Cohen's $f = 0.12$, showing that participants did not feel that they relied only on their intuition more often as the transition advanced. In terms of degree of intuition, the main effect of transition period was significant, showing that participants felt that their degree of intuition for prices in euros increased as time advanced, $F(3, 165) = 6.58$, $MSE = 1.33$, $p < .05$, Cohen's $f = 0.35$. Again, comparing these results with similar data obtained with escudos in the year 2000 (Dehaene & Marques, 2002) showed that both intuition, $F(1, 72) = 13.44$, $MSE = 526.39$, $p < .05$, Cohen's $f = 0.40$, and degree of intuition, $F(1, 72) = 5.27$, $MSE = 1.14$, $p < .05$, Cohen's $f = 0.27$, were higher in escudos than in euros in the last transition period evaluated, as is apparent from Figures 2 and 3. Overall, these results show that there is some improvement in price estimates and degree of intuition for prices in euros as a function of time and that price estimates vary as a function of buying frequency.

With respect to the two opposing hypotheses for the development of reference prices in euros, comparisons from estimates in euros are more in accordance with a rescaling hypothesis. Data analysis shows that there is an early improvement in estimates that appears simultaneously for frequently and rarely bought items and

Table 1
Planned Comparisons for Estimation Accuracy (Weber Fraction) as a Function of Buying Frequency and Time Period (Portuguese Data)

	Comparison 1: Periods 1 and 2		Comparison 2: Periods 3 and 4	
Buying frequency	*t*	*d*	*t*	*d*
Frequent ($n = 12$)	1.81*	0.84	0.24	0.16
Rare ($n = 28$)	3.15*	0.83	0.98	0.37

* $p < .05$.

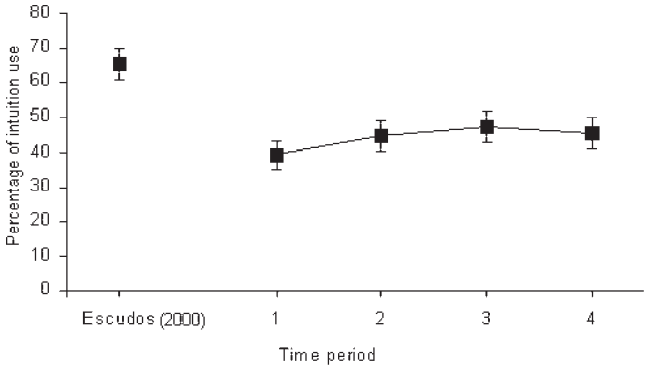

Figure 2. Percentage of intuition use for estimations in euros by transition period and for estimations in escudos in the year 2000 (Portugal). Error bars represent standard error of the means.

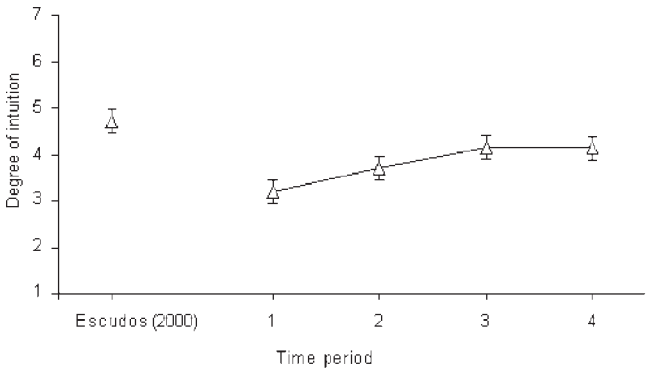

Figure 3. Degree of intuition for estimations in euros by transition period and for estimations in escudos in the year 2000 (Portugal). Error bars represent standard error of the means.

that further corresponds in both cases to comparable large effect sizes.

However, comparisons with data from escudos may contradict this straightforward interpretation. In fact, as price estimates in euros are still less accurate than in escudos, this may show that an adaptation to the euro is still unfinished and, as such, one cannot discount the alternative possibility of relearning. In fact, the comparisons with escudos may be called on to defend the relearning hypothesis, considering that the transition period for relearning (even for the more frequently bought items) is still in progress and that, in a task like the one proposed here, participants still rely on a calculation algorithm (i.e., the mental calculation of the price in euros from the estimated price in the former national currency). Although this was a post hoc comparison between two studies, the fact that the items were the same and the samples were very similar (they were both student samples from the same university, from the same age group, and with similar sex distribution) ensures that the significant and medium size effect between escudos and euros is not mainly the result of other differences between studies. Moreover, the interpretation that an adaptation to the euro is still unfinished is also supported by the estimations of use of price intuition and degree of intuition, which show some improvement but are still lower in comparison with escudos. The two hypotheses are further evaluated in Study 2 with another country.

Study 2: Austria

The second study evaluates the rescaling versus the relearning hypotheses for Austria.

Method

Participants and design. A total of 164 university students participated in the study on a voluntary basis and were divided by the month of participation from November 2001 to June 2002. Data for 10 participants were not considered, as their country of origin was not Austria. Also, 8 participants were detected as having responded in different months to the questionnaire, so their second set of data were also disregarded. A final total of 146 data sets were considered for analysis. Samples varied from 16 participants in February to 22 participants in December ($M = 18$ participants). Mean age was 25.6 years (there were no significant differences between monthly samples), and all samples were composed of approximately 72% female participants and 28% male participants. Similar to Study 1, the experiment involved an 8×40 mixed factorial design, with month as a between-subjects variable and item as a within-subjects variable.

Materials. The same list of 40 familiar products or services used in Study 1 was used for Study 2 (items are presented in the Appendix). The items were also rated in terms of buying frequency by a group of Austrian students ($n = 25$) who did not otherwise participate in the study.

Procedure. Procedure was the same as in Study 1 with respect to general instructions and answer mode.

Results and Discussion

Similar to Study 1, price estimations produced in each month were pooled in four periods: before the transition (i.e., November and December 2001), early transition (i.e., January and February 2002), medium transition (i.e., March and April 2002), and late transition (i.e., May and June 2002). For each item (i) in each period we calculated the mean M_i and standard deviation SD_i of the estimates across participants and obtained a Weber fraction by item defined as $w_i = M_i/SD_i$.

To evaluate the hypotheses, we divided the items in terms of buying frequency (rare and frequent) considering the medium point of the scales (i.e., 3.5) and the ratings obtained previously. Using these criteria, 27 items were considered rare and 13 were considered frequent. Although there are some items classified differently between countries, the buying frequency correlation between countries was .79 ($n = 40$; $p < .01$). Also, mean buying frequency was slightly higher in Austria than in Portugal, although this difference was not significant, $t(40) = 0.80$, *ns*, Cohen's $d = 0.17$.

Mean Weber fractions by transition period and buying frequency are presented in Figure 4. Similar to Study 1, the two alternative hypotheses were evaluated using the following two planned comparisons: a comparison between the periods before the transition (Period 1) and early transition (Period 2) and a comparison between the periods medium transition (Period 3) and late transition (Period 4). The comparisons were performed separately by buying frequency to assess whether there was only an overall gain in estimation accuracy (as predicted by the rescaling hypothesis) or whether accuracy gains were observed sooner for frequently bought items (as predicted by the relearning hypothesis). Unilateral tests were performed in each case, and an alpha level of .05 was considered for all comparisons. Cohen's *d*s for paired observations (Cohen, 1988) were also calculated to estimate effect size. Results are presented in Table 2.

In the case of frequently bought items, there was a significant gain in accuracy (i.e. lower Weber fractions) between Period 1 and Period 2 and between Period 3 and Period 4, corresponding in both cases to medium effect sizes. In the case of rarely bought items, there was only a significant gain in this last comparison between Period 3 and Period 4, corresponding to a large effect size. As also apparent from Figure 4, mean Weber fractions were smaller for frequently bought items, which shows that price estimations were overall more accurate for these items.

A final analysis looked at the participants' evaluation of their judgments for the percentage of price estimates done exclusively on intuition and for the degree of intuition by transition period. Results are presented by transition period in Figure 5 for intuition use and in Figure 6 for degree of intuition. A one-way ANOVA

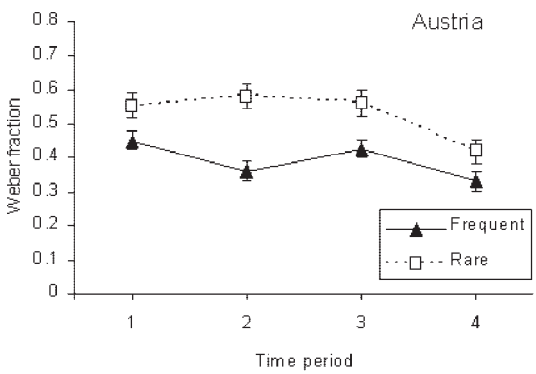

Figure 4. Mean Weber fractions by buying frequency (frequent, rare) and transition period for Austria. Error bars represent standard error of the means.

Table 2
Planned Comparisons for Estimation Accuracy (Weber Fraction) as a Function of Buying Frequency and Time Period (Austrian Data)

	Comparison 1: Periods 1 and 2		Comparison 2: Periods 3 and 4	
Buying frequency	*t*	*d*	*t*	*d*
Frequent ($n = 13$)	1.89*	0.78	1.93*	0.68
Rare ($n = 27$)	0.89	0.25	4.16*	1.07

* $p < .05$.

was performed on each case. In terms of intuition, the main effect of transition period was significant, $F(3, 142) = 3.99$, $MSE = 849.42$, $p < .05$, Cohen's $f = 0.29$, showing that participants felt that they relied only on their intuition more often as the transition advanced. In terms of degree of intuition, the main effect of transition period was significant, showing that participants felt that their degree of intuition for prices in euros increased as transition advanced, $F(3, 142) = 2.93$, $MSE = 2.65$, $p < .05$, Cohen's $f = 0.26$.

With respect to the two opposing hypotheses for the development of reference prices in euros, results are more in accordance with the relearning hypothesis. In fact, there is a medium and significant improvement in price estimate accuracy from Period 1 to Period 2 in the case of frequently bought items but not in the case of rarely bought items. For the latter, significant accuracy gains are only observed for Period 4, also with similar (although smaller) gains for frequently bought items. It thus seems that people made an adaptation to the euro by first relearning the prices for the items that they frequently bought and only later for the items that they rarely bought.

If this conclusion is correct, how can the different pattern of results observed in Austria and Portugal be explained? One possible explanation is that the adaptation to the euro is more advanced in the former country. From the different figures it seems apparent that overall accuracy is higher for Austria than for Portugal, but it is true that in the former case we do not have data for schillings, which makes this comparison incomplete. Moreover, as was already mentioned, although correlated between countries, buying frequency classifications were not identical. When only the items that were similarly classified in the two countries are considered, we end up with reduced and very unbalanced samples that do not allow us to explore these differences without introducing further biases (21 rare items vs. 6 frequent items). Regarding price intuition, where the two countries are comparable, Austrian participants felt they relied on their intuition more often than did the Portuguese participants, $F(1, 307) = 20.00$, $MSE = 732.35$, $p < .05$, Cohen's $f = 0.25$, and no significant differences were found in terms of degree of intuition, $F(1, 307) = 0.15$, $MSE = 1.94$, *ns*, Cohen's $f = 0.00$.

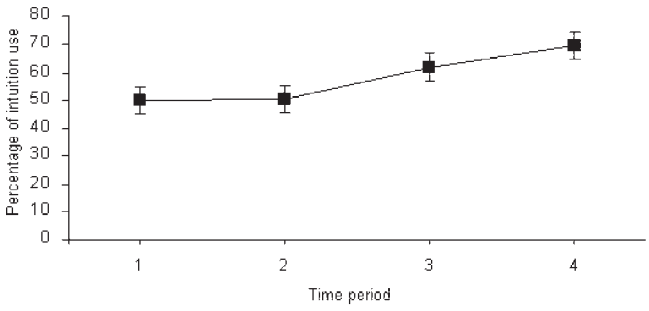

Figure 5. Percentage of intuition use for estimations in euros by transition period for Austria. Error bars represent standard error of the means.

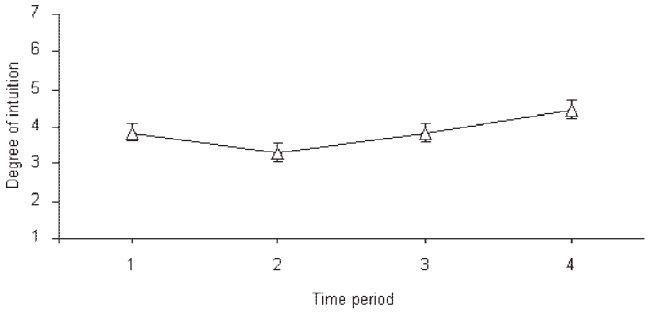

Figure 6. Degree of intuition for estimations in euros by transition period for Austria. Error bars represent standard error of the means.

General Discussion

The present study evaluated the development of price intuition for a novel currency, the euro, and compared two alternative hypotheses to explain this development, namely, the rescaling hypothesis and the relearning hypothesis based on automatization. Results are more in accordance with the second hypothesis, although support is clearer in the case of Austria (Study 2) than in the case of Portugal (Study 1).

In fact, in the case of Austria, as predicted by the relearning hypothesis, estimates in euros seem to show a significant and medium size improvement in accuracy that appears earlier for frequently bought items than for rarely bought items. In the case of Portugal, this hypothesis receives mixed support, as there is an early overall improvement in accuracy, but accuracy is still lower than in escudos, which may contradict a straightforward interpretation of the overall gain.

This different pattern of results may be due to a slower adaptation to the euro in the case of Portugal, a conclusion that is supported by several other data. First of all, accuracy in price estimations is still overall lower for euros in the final transition period assessed than for escudos before the transition. Second, this same superiority of escudos in relation to euros happens for the comparison between the degrees of intuition in the two currencies, which is higher for escudos than for euros. Finally, intuition use for estimating prices in euros was higher for Austrian participants than for Portuguese participants, which may mean that the latter continued to use a calculation algorithm for the estimation task (i.e., the mental calculation of the price in euros from the estimated price in the former national currency). One possibility is that this longer reliance on a calculation algorithm is related to the different conversion rate factors, which seem to provide an easier calculation in the case of Portugal than in the case of Austria (for Portugal 1 euro = 200.482 escudos; for Austria 1 euro = 13.7603 schill-

ings). Portuguese participants preferred a simpler computation algorithm but were more prone to biases, whereas Austrian participants used more intuition and price memory. However, only further research can adequately test this possibility, as we do not have comparable price estimation data in the Austrian former national currency.

The need for further research to evaluate the two hypotheses also extends to the fact that the present items are not sufficiently representative of the buying frequency categories. It is obviously true that the 40 items evaluated do not constitute a representative sample of all items that consumers buy. Moreover, each consumer may have particular buying habits. As such, these results merit further evaluation with other items and samples. Moreover, the automatization hypothesis from which the relearning hypothesis was derived was established at a within-subjects level, whereas the comparisons made in the present studies were between-subjects (although with similar characteristics). The fact that this limitation did not prevent the predicted relearning effect to emerge in the case of Austria seems to show that it is sufficiently strong. However, confirmation should also be obtained with a within-subjects design. This type of design along with other measures, such as response times, are also important to evaluate other theoretical models that may support the relearning hypothesis. One example is Siegler's model (Siegler, 1988), which asserts that retrieval of the answer is attempted in a first phase, followed by a sophisticated guessing phase, and, when the second retrieval attempt fails to provide an answer with a certain strength, it is followed by calculation of the answer using an algorithm. Although our relearning hypothesis was based on Logan's (1988) race between strategies model, it is also possible that the sequential strategies model proposed by Siegler (1988) is more adequate to explain the relearning process. Only other research designs and the analysis of response time will allow us to evaluate these alternative possibilities.

Considering the different studies that previously showed that price estimations in euros are subject to different biases, especially in situations of uncertainty (Gamble et al., 2002; Jonas et al., 2002; Mussweiler & Englich, 2003), a within-subjects design could also be implemented to evaluate the relation between uncertainty and the relearning hypothesis. From both Logan's and Siegler's models (Logan, 1988; Siegler, 1988), one can expect that retrieval of prices in euros from memory would be more established for frequently bought items than for rarely bought items, the latter presenting a situation of higher uncertainty and more prone to bias. Jonas and Frey (2003) have recently shown that before the euro switch, the at the time unfamiliar currency caused decisions framed in euros to have more uncertainty and risk than the same decisions framed in DM. If the relearning hypothesis is correct, it is possible that uncertainty would still occur for rarely bought items.

The present data further show that relearning is remarkably slow and, that at least for Portugal, it may not be effective even for more frequently bought items. In fact, the 6-month period from the physical introduction of the euro in January 2002 to our last data collection in June 2002 was not sufficient to establish Weber fractions in the unfamiliar currency comparable with those observed in the familiar currency prior to the switch. If the development of price knowledge in a new currency is a slowly learned process, this also has important implications.

One implication is that when someone travels abroad and has to use a new currency he or she will probably use calculation algorithms to estimate and compare prices. If relearning takes as long as it seems, the adaptation in short trips can only be one on the basis of calculation algorithms with very few memorized prices. As such, the introduction of the euro will increase price comparability between countries adopting this currency, a result that was already empirically supported (Jonas et al., 2002; Mussweiler & Strack, in press).

Another important implication is that the study of the adaptation to the euro is not yet finished. In this context, it will be important to evaluate which factors promote or hinder this process. Naturally, many political and sociological factors can also be expected to affect the ease with which people in different countries switch to the euro (Marques, 1999), and these may be associated with individual and group differences. Lemaire and collaborators (Lemaire & Lecacheur, 2001; Lemaire, Lecacheur, & Ferréol-Barbey, 2001) have shown that participants use different strategies to convert prices, and these may also be related to the amount of time participants are willing to rely on conversion rather than memory for price estimation.

We hope that further testing will allow us to check whether the participants' evaluation of their increasing degree of intuition for prices in euros really has a higher correspondence in terms of a qualitative change in how they make their price estimations.

References

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Erlbaum.

Dehaene, S., & Marques, J. F. (2002). Cognitive euroscience: Scalar variability in price estimation and the cognitive consequences of switching to the euro. *Quarterly Journal of Experimental Psychology: Human Experimental Psychology, 55*(A), 705–731.

Dickson, P. R., & Sawyer, A. G. (1990). The price knowledge and search of supermarket shoppers. *Journal of Marketing, 54,* 42–53.

Gamble, A., Garling, T., Charlton, J., & Ranyard, R. (2002). Euro illusion: Psychological insights into price evaluations with a unitary currency. *European Psychologist, 7,* 302–311.

Gigerenzer, G. (1998). Ecological intelligence: An adaptation for frequencies. In D. D. Cummins & C. Allen (Eds.), *The evolution of mind* (pp. 9–29). New York: Oxford University Press.

Grewal, D., & Marmorstein, H. (1994). Market price variation, perceived price variation, and consumers' price search decisions for durable goods. *Journal of Consumer Research, 21,* 453–460.

Jonas, E., & Frey, D. (2003). Searching for information about financial decisions in euros versus DM. *European Psychologist, 8,* 92–96.

Jonas, E., Greitemeyer, T., Frey, D., & Schulz-Hardt, S. (2002). Psychological effects of the euro: Experimental research on the perception of salaries and price estimations. *European Journal of Social Psychology, 32,* 147–169.

Lambert, Z. V. (1978). Differential thresholds in consumer perception of retail prices. *The Journal of Psychology, 100,* 139–150.

Lemaire, P., & Lecacheur, M. (2001). Older and younger adults' strategy use and execution in currency conversion tasks: Insights from French franc to euro and euro to French franc conversions. *Journal of Experimental Psychology: Applied, 7,* 195–206.

Lemaire, P., Lecacheur, M., & Ferréol-Barbey, M. (2001). Strategy use in currency conversion tasks: The examples of euros to French franc and French franc to euro conversions. *Current Psychology Letters, 4,* 39–50.

Logan, G. D. (1988). Toward an instance theory of automatization. *Psychological Review, 95,* 492–527.
Marques, J. F. (1999). Changing "EUROpe": The euro as a new ground for psychological research in numerical cognition. *European Psychologist, 4,* 152–156.
Mechner, F. (1958). Probability relations within response sequences under ratio reinforcement. *Journal of the Experimental Analysis of Behavior, 1,* 109–121.
Meck, W. H., & Church, R. M. (1983). A mode control model of counting and timing processes. *Journal of Experimental Psychology: Animal Behavior Processes, 9,* 320–334.
Mussweiler, T., & Englich, B. (2003). Adapting to the euro: Evidence from bias reduction. *Journal of Economic Psychology, 24,* 285–292.
Mussweiler, T., & Strack, F. (in press). The euro in the common European market: A single currency increases the comparability of prices. *Journal of Economic Psychology.*
Shafir, E., Diamon, P., & Tversky, A. (1997). Money illusion. *The Quarterly Journal of Economics, 112,* 342–374.
Siegler, R. S. (1988). Strategy choice procedures and the development of multiplication skill. *Journal of Experimental Psychology: General, 117,* 258–275.
Tversky, A., & Kahneman, D. (1974, September). Judgment and uncertainty: Heuristics and biases. *Science, 185,* 1124–1130.
Webb, E. J. (1961). Weber's law and consumer prices. *American Psychologist, 16,* 450.
Whalen, J., Gallistel, C. R., & Gelman, R. (1999). Non-verbal counting in humans: The psychophysics of number representation. *Psychological Science, 10,* 130–137.

Appendix

List of Items

1. Car rental (one day)
2. A pack of cigarettes
3. A pocket-sized book
4. A roasted chicken
5. A daily newspaper
6. A bottle of mineral water (1.5 liter)
7. A bottle of champagne
8. A box of cheese (in portions)
9. A head of lettuce
10. One photo film (24 exposures)
11. One coffee at a coffee-house counter
12. One electric bulb
13. A mountain bike
14. An oil change for your car
15. A loaf of bread
16. A deck of cards
17. A folding chair
18. A vacuum-cleaner
19. A movie ticket
20. A bottle of Coca-Cola (1.5 liter)
21. A package of four simple yogurts
22. A standard color TV
23. One kilo of cow meat
24. A pair of tennis shoes (no particular brand)
25. A pair of jeans
26. One kilo of potatoes
27. A stamp for a European Union country
28. A drilling-machine (Black & Decker)
29. A low-cost compact-disc walkman
30. A two-way airline ticket to New York (from Lisbon or Vienna)
31. A box of aspirins
32. A pair of socks
33. One liter of milk
34. A small notebook
35. A low-cost ballpoint pen
36. A fast-food menu
37. A haircut
38. A compact-disc
39. A tooth-cleaning paste tube
40. One liter of unleaded gasoline

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