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# *Fooled by numbers: Why people think that 24 months takes longer than 2 years*

**BY MARIO PANDELAERE**

***Don't miss the trial consultant responses at the end of this article from Bradley Hower and Paul Roberts!***

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People often use numerical information and even prefer it to more relevant non-numerical information (Hsee, Yang, Gu, & Chen, 2009). This preference may reflect the belief that numerical information is more objective, reliable and precise. However, the way quantitative information is specified often alters the judgments and decisions people make based on that information.

The current article first describes two large classes of biases: context and framing effects. It then shows how people's tendency to engage in relative number processing creates such biases. At the same time, some more recent lines of research have identified biases that occur when relative differences between numbers are held constant. I discuss in more detail the effects of expanding a scale (e.g. multiplying all numbers by 10) on people's perceptions of differences. I end with some implications of research on number processing for dealing with people's biased interpretation of quantitative information.

## *Context and Framing Effects*

***Context effects*** occur when people try to make sense of quantitative information by relating it to other numbers. In that situation, the same number often leads to different perceptions and evaluations, depending on the background information they receive. For instance, the difference between a 4 year and a 5 year warranty looks more substantial when people are told that most warranties in that product category vary from 3 to 6 years than when they are told that these vary from 1 to 9 years. This is because people relate a difference between the entire range, which is the maximal difference that could occur (range effect; Parducci, 1965).

***Framing effects*** occur when specifying quantitative information in a different type of units alters perceptions and evaluations. For instance, people find the same ground beef tastier when it is labeled as '75% lean' than when it is labeled as '25% fat' (Levin & Gaeth, 1988). One of the most robust findings is that people react differently to information when it is represented as a loss rather than as a gain. For instance, if people have to choose between a program that saves 200 people (out of 600) or a program that has a 33% chance to save all and a 67% chance to save no one (both programs focus on the gains), the majority of people prefer the former (saving a guaranteed 200 people). However, when the same information is specified in losses, these programs become: a program in which 400 will die for sure and a program that offers 33% chance that nobody will die and 67% chance that all will die, the majority of people prefer the latter program (Asian disease problem; Tversky & Kahneman, 1981).

## *Sensitivity to Relative Differences*

Studies on number representation have shown that the same objective difference is perceived as subjectively smaller when it involves higher numbers (Dehaene, 2003). For instance, the difference between 100 and 101 seems smaller than the difference between 1 and 2. As a result, people often pay more attention to relative attribute differences than to absolute attribute differences (cf. Hsee et al., 2009), which renders them susceptible to various context and framing effects.

For instance, people are more likely to drive an extra couple of miles to visit a store that offers a $5 USD discount on a $10 USD item than a store that offers a $5 USD discount on a $200 USD item (cf. Thaler, 1980; Tversky & Kahneman, 1981). Also, people are willing to pay more for an intervention that would prevent 5 deaths of the estimated 50 to occur than for an intervention that would prevent 50 deaths of the estimated 1000 to occur because the former intervention saves 10% of the people at risk, while the latter saves "only" 5 % of the people at risk (e.g., Baron, 1997; Fetherstonhaugh, Slovic, Johnson, & Friedrich, 1997). In both cases, people's decisions are influenced by relative comparisons while they should not be: a $5 USD discount is the same amount of money, irrespective of the original product price. Similarly, preventing 50 deaths should be viewed as saving 5 deaths, irrespective of the number of people at risk.

Recently, several lines of research have documented various biases that do not involve a preferential focus on relative differences. These lines of research have focused on so called numerosity effects demonstrating that the use of alternative units leads to different evaluations, although different mechanisms may operate depending on the specific setting.

## *Ratio Bias*

A first line of research has focused on *probability information.* This type of information is often given in a numerator-denominator format. For instance, the probability of something happening may be specified as "1 in 5" or, alternatively, "20 out of 100". Various studies have shown that people exhibit a ratio bias: equivalent odds or probabilities are perceived more favorably when expressed in higher numerators (and obviously also higher denominators). This is because people pay insufficient attention to the denominator (5 vs. 100) and are overly sensitive to the numerator (1 vs. 20). So, because 20 is bigger than 1, 20% looks bigger as "20 out of 100" than as "1 out of 5". Correspondingly, people prefer drawing from a bowl containing 10 winning and 90 non-winning possibilities to drawing from a bowl containing 1 winning and 9 non-winning possibilities (Kirkpatrick & Epstein, 1992). Yamagishi (1997) even found that cancer was incorrectly rated as riskier when it was described as `kills 1,286 out of 10,000' than as `kills 24.14 out of 100'.

The existence of a ratio bias is linked to experiential processing: people can more easily simulate (or visualize) drawing a winning possibility (or contracting a disease) as the number of possibilities increases. In fact, Denes-Raj and Epstein (1994) found that a significant portion of their participants preferred a gamble with 9/91 odds of winning to a gamble with the higher odds of 1/10 of winning, even though they knew that the objective probability of winning is larger in the second case. It just didn't feel right!

### *Currency Numerosity Effects*

A second line of research has investigated people's valuation of money when it is specified in alternative currencies. In this situation, ease of simulation cannot operate because the quantities involved do not refer to probabilities. Raghubir and Srivastava (2002) found that people may spend less in a foreign country if the value of the foreign currency is lower per unit than the value of one's own currency (e.g., American people spend more in Great Britain as 1 U.S. dollar is less than 1 British pound, and spend less in Mexico as 1 U.S. dollar is greater than 1 Mexican peso). Interestingly, when people's budgets or income are also translated into the foreign currency, the opposite phenomenon is observed (Wertenbroch, Soman & Chattopadhyay, 2007).

These currency numerosity effects result from *inexact translation* from one currency to another. Confronted with prices and budgets in foreign currencies, people try to estimate the corresponding prices and budgets in their own currency. In this estimation process, however, people try to adjust the posted, foreign prices and budgets to their own currency. This typically results in anchoring: estimates are too close to the posted numbers than they should be. So, while 185 Mexican pesos equal 15 U.S. dollars, people overestimate it to be 20 U.S. dollars or more (a value closer to 185). In contrast, while 9 British pounds also equal 15 U.S. dollars, people underestimate the equivalent as 12 U.S. dollars or less (a value closer to 9). As a result, prices seem larger in Mexico than in Great Britain (e.g., a blouse seems more expensive when it costs 185 pesos than when it costs "only" £9). At the same time, the residual budget after spending seems larger in Mexican pesos than in British pounds.

Although this line of research has exclusively focused on specifying prices and budgets in unfamiliar currencies, the anchoring mechanism is relevant for any setting where people are confronted with quantitative information in unfamiliar units that they can *translate* to a familiar unit. For instance, when American citizens prepare for a European summer trip, they may underestimate the temperature at their destination when they view these temperatures in Celsius (because in summer, temperatures in Celsius use lower numbers than temperatures in Fahrenheit). Conversely, Europeans may overestimate the temperature in the U.S. if they view temperature information in Fahrenheit. A similar logic applies for translations between miles and kilometers, gallons and liters, and so on.

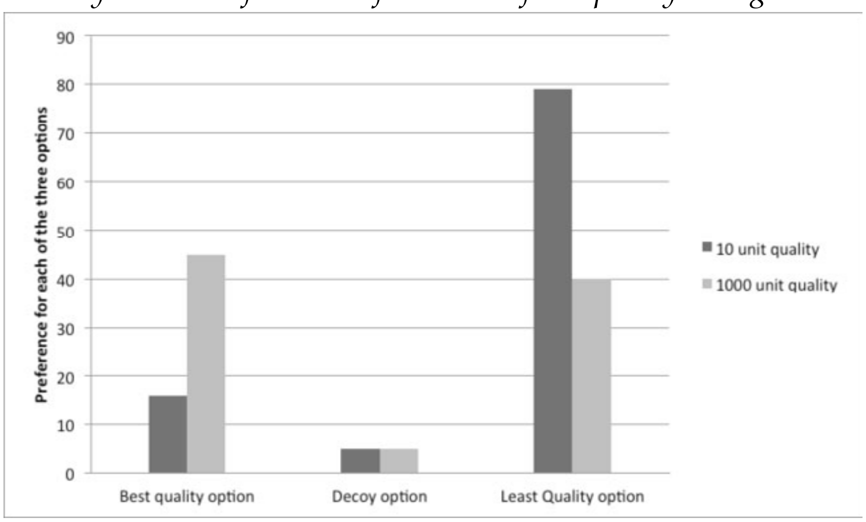
### *The unit effect – overview of our findings*

In many cases, people are confronted with quantitative information that they feel perfectly comfortable with and have no problem making sense of the numbers they receive. Hence, no translation occurs. For instance, people can rate the quality of a service or product on a scale from 1 to 5 (as Amazon.com uses in customer reviews) or on a scale from 0 to 100 (as Robert Parker uses in wine ratings). Although one can translate ratings on a 5-point scale to ratings on a scale from 0 to 100, people would not feel the need to do so. In fact, this translation issue probably does not even enter their minds as they can easily interpret the ratings. Similarly, companies can specify warranties in years or in months. Because people are equally accustomed to both measurement units, again they readily interpret the numbers they receive.

We (Pandelaere, Briers & Lembregts, 2011) found that, when people are confronted with numbers they feel they can make sense of, they often do not sufficiently account for the specific unit in which the information is expressed and focus primarily on the sheer number that is communicated. As such, they act as if a bigger number on an expanded scale represents a bigger quantity. Expanding a scale occurs when information in one unit (e.g. years) is translated to a smaller unit (e.g. months). We conducted five studies to test whether and when expressing quantitative information on different scales changes people's judgments and decisions. We were particularly interested in whether people would be biased by the magnitude in which a difference is expressed when this does not alter the objective difference.

In a first study, participants had to compare the warranties of two dishwashers and rated the difference between 84 and 108 months was bigger and more meaningful than the difference between 7 and 9 years. In a second study, we gave participants price (in Euro) and quality information about three home cinema systems and asked which system they would buy. The quality ratings were either expressed on a scale from 0 to 10 or on a scale from 0 to 1000. The price difference between the cheapest and the most expensive model was €50. The quality difference between these two options was .either .5 on the 10 point scale or 50 on the 1000 point scale. While only 16% of the participants indicated they would be willing to buy the most expensive home cinema system when the quality information was expressed on 0 to 10 scale, about 45% of the respondents would be willing to buy the superior system when it was expressed on a 0 to 1000 scale (See Figure 1).

*Figure 1: Probability of selecting each of the three home cinema systems as a function of the scale of the quality ratings.*



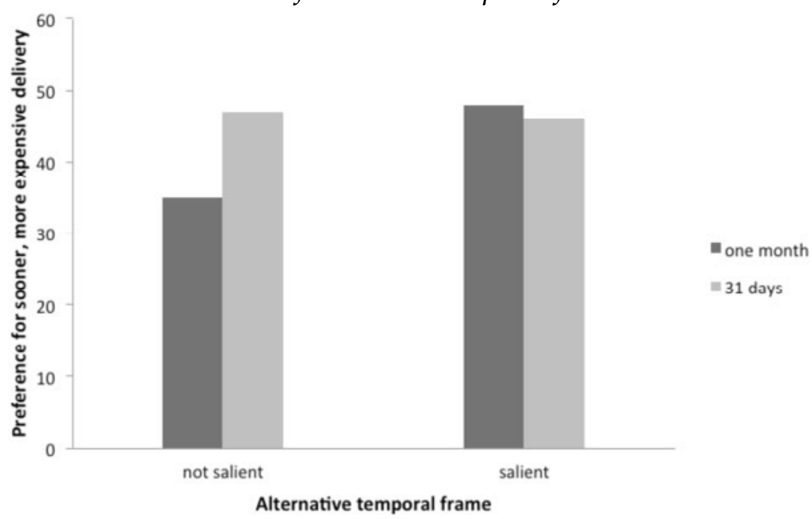

*Note. The decoy option offers the least quality but at a higher price and is therefore selected very infrequently.*

Study 3 tested the unit effect in real life. Students were invited in the lab for a series of experiments in return for course credit. None of these experiments had any bearing on our study. In fact, our study was disguised as a gift at the end of the session. When the students had finished their tasks, they had to come to the front of the lab to indicate they had finished. They were thanked and their name was written down to ensure they would receive their course credit. The experimenter (blind to the hypotheses), then told them that they could also choose a snack to take home. They were presented with two choices: a candy bar and an apple. Before they made their choice, we told them that as consumer researchers we felt it important to inform them on the caloric information of the options so they could make informed choices. We either gave this information in kilocalories (apple = 59 kcal; candy bar = 246 kcal) or in kilojoules, a unit that is approximately four times smaller (apple = 247 kJ; candy bar = 1,029 kJ). Students were more likely to choose the apple when the caloric information was specified in kilojoules (making the difference in calorie content between the two options seem big) than when the caloric information was specified in kilocalories (making the difference in calorie content between the two options seem not so big).

A fourth study showed that when people are reminded that the choice of unit is somewhat arbitrary, the unit effect is eliminated. Participants had to imagine having bought a product online and were asked whether they would pay extra to get the product delivered earlier, either specified as 'one month sooner' or as '31 days sooner'. Before making this decision, participants had to indicate whether they thought various lengths of time were very short periods of time or very long periods of time. For half of the participants, all time periods were specified in the unit they would see later on, either specified in only months or in only days. The other half of the participants, however, had to make subjective time estimates for periods specified in months as well as periods specified in days. We expected that for the latter, the alternative temporal frame would be made salient, which would eliminate the unit effect.

Participants in the group who had made subjective time estimates in only days or in only months, corresponding to the time unit used in the expedited delivery service, were more likely to pay for expedited delivery if it referred to '31 days earlier' versus 'one month earlier' – this replicates the unit effect. However, participants who made their estimates in both days and months were not more likely to pay for expedited delivery if it referred to '31 days earlier' versus 'one month earlier' (See Figure 2).

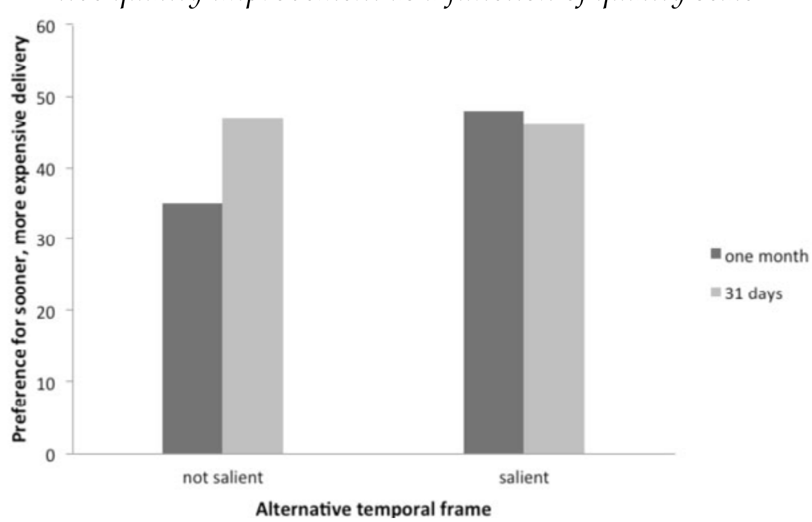
*Figure 2: Probability of paying additionally for earlier delivery as a function of temporal frame and the salience of the other temporal frame.*




So far, all our studies focused on the effect of changing the scale of quantitative information without varying relative differences. For instance, a 9 year warranty is 29% better than a 7 year warranty. Likewise, a 108 month warranty is 29% better than an 84 month warranty. However, in the introduction, I argued that people are very sensitive to relative differences. We therefore investigated whether changing the scale on which quantitative information is specified may alter this sensitivity. Participants had to indicate how much more they would be willing to pay for the perfect home cinema system compared to systems of varying qualities. Quality information was expressed either on a scale from 0 to 10 or on a scale from 0 to 1000.

Our research design allowed us to investigate the willingness to pay for different levels of relative difference between a focal home cinema system and a perfect one. The relation between willingness to pay and relative improvement in quality was much stronger when the quality information was expressed on a 1000 point scale versus on a 10 point scale (see Figure 3). This shows that the sensitivity to relative differences is more pronounced if all quantities are specified as large numbers (i.e. use small units) rather than as small numbers (i.e. big units)

*Figure 3: Willingness to pay for various levels of relative quality improvement as a function of quality scale*



### *Summary of the Findings and Implications*

The most important thing to bear in mind is that while quantitative information may seem objective, biases in how people process numbers may lead to radically different evaluations. The current paper shows that merely altering the scale in which quantitative information is provided affects people's judgments and decisions. In particular, expanding the scale (i.e. increasing the number of units, resulting in higher numbers) increases the perceived difference between options; conversely, contracting the scale (i.e. decreasing the number of units, resulting in lower numbers) decreases the perceived difference between options. This effect is very robust and very general as it is observed for time, quality ratings, probabilities and prices and budgets.

As a lawyer, one can therefore manipulate the perceived differences between two options by changing the scale. For instance, in case of a suspected racial bias in hiring decisions, one could downplay the difference in hiring probability for White Americans versus African Americans by using small numbers (e.g. a 1-in-20 chance versus a 1.5-in-20 chance) or highlight it using large numbers (e.g. a 100-in-2000 chance versus a 150-in-2000 chance).

When the information refers to probabilities, the framing effect is partly due to differences in mental simulation. One can try to diminish the impact of mental simulation by appealing to people's rational side. When people engage in rational processing rather than in experiential processing, the ratio bias decreases. When the information involves units that people are unfamiliar with, the framing effect occurs because people engage in a quick-and-dirty estimation of the corresponding value in a unit they are familiar with. To reduce the framing effect, one should give people an exact translation to the familiar unit and not leave this calculation to them.

Our research shows that framing effects even occur when people think they can readily interpret the quantitative information they receive. This is important because people are not aware that they may exhibit a bias and it may also be very difficult to persuade them of that fact. I would therefore recommend that lawyers should not make people explicitly aware of this bias – it may be hard to believe and trigger reactance effects. However, our research does show that merely reminding people that the information they receive could have been specified in alternative units may eliminate the unit effect. Reminding people of this fact should be very subtle by referring to some alternative units in one's argumentation.

It is important to recognize the fact that our studies use a between-subjects design. That is, the unit effect is demonstrated as a difference between the perceptions between some people who receive information in one unit and other people who receive the same information but in a different unit. Reminding people of alternative units eliminates the effect. That is, it eliminates the difference between the two groups. It does not directly specify what decision people will make after being reminded of alternative units. Our studies do not speak to this issue.

So, eliminating a bias does not necessarily mean that the interpretation has become more congenial to one's case. For instance, in a case where people sue a restaurant because it made them fat by providing high-calorie food, one could specify caloric information in kilojoule to exaggerate the quantities in comparison with some healthy standard. Opposing counsel could remind the judge and jury by using kilocalorie information. It is not clear, however, what information judge and jury will ultimately use in their decisions. Even when reminded of kilocalories, they may still think in terms of kilojoules. All our studies show is that reminding people of different units is sufficient to eliminate differences due to specifying information in alternative units. On the other hand, it is possible that judge and jury may base their decision on the newly provided numbers – the kilocalories. As it is not clear a priori which type of information will be most important, one could investigate this in a mock jury. Also note that even if reminding people of the alternative unit might not always work in one's favor, there is likewise no evidence that it might backfire. As such, reminding people of alternative units is a safe, though possibly not always effective, strategy.

Finally, it is also important to be aware of the fact that both absolute differences and relative differences play a role in the interpretation of quantitative differences. So, the difference between a 100-in-2000 chance versus a 150-in-2000 chance looks big in both absolute (difference of 50) and relative sense (a 50% difference). While a 1-in-20 chance does not differ much from a 1.5-in-20 chance in an absolute sense (only a difference of .5), it still does represent a 50% difference in relative sense. So changing from the first frame (in 2000) to the second frame (in 20) will definitely alter perceived differences, but it may not necessarily render the differences meaningless! However, it is possible to reduce the relative difference by changing what the numbers refer to. In the example, shifting from 'how many people are hired' to 'how many people are not hired' changes the numbers to 19-in-20 versus 18.5-in-20. This decreases the relative difference from 50% to below 3%.

To conclude, while people often feel that they can readily interpret numerical information, their interpretation is often susceptible to context and framing effects. Our research shows a very basic but robust framing effect: merely altering the scale in which quantitative information is specified can lead to different evaluations. Such numerosity effects are likely to be observed in many different situations.

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***We asked trial consultants who specialize in visual evidence to respond to this article. Below Bradley Hower and Paul Roberts give their perspectives.***

## *Bradley Hower responds:*

*Bradley Hower is the founder and principal of Insight Design LLC. Insight Design is a demonstrative evidence design firm with an international practice based in Maryland. He has been concentrating on intellectual property and complex business litigation for 21 years.*

Dr. Pandelaere raises a number of important points in his paper, the impact of which should be thoroughly explored by both lawyers and their demonstrative evidence experts. In my response I will attempt to extrapolate these into usable practices for the preparation and critique of demonstrative evidence.

1. **Use native units.** Just as you would not expect an American jury to understand you if you spoke Russian or Tagalog, do not expect them to translate from Yen or kilograms to US units, unless it is your purpose to confuse them. Dr. Pandelaere's paper concludes that individuals are not likely to perform conversions accurately. Conversion information for virtually any unit is readily available on the Internet. Just because counsel may provide data in unfamiliar units does not mean it should be presented that way. Check with counsel and testifying experts to make sure that they agree with your conversions.

2. **Use small units to emphasize the impact of quantities, large units to diminish.** Consider the following fictitious damages demonstratives. Exhibit 1 is presented in small units, dollars, to maximize the extent of damages suffered. Exhibit 2 is stated in millions of dollars, minimizing the impact of the numbers. At first blush, we might assume that the Plaintiff would present exhibit 1 and the defendant would present exhibit 2. But the situation calls for more critical consideration.

   The plaintiff who wants to say "Look how badly the defendant has hurt me" might use something like exhibit 1. But if he wanted to say "My demands are modest and reasonable" he might use exhibit 2. Similarly, the defendant who wants to trivialize the damages might use exhibit 2, but if he wants to say that the plaintiff's demands are unreasonable, he might use exhibit 1. We must examine very closely the intent of each and every demonstrative in light of the teachings of Dr. Pandelaere.

**Damages**

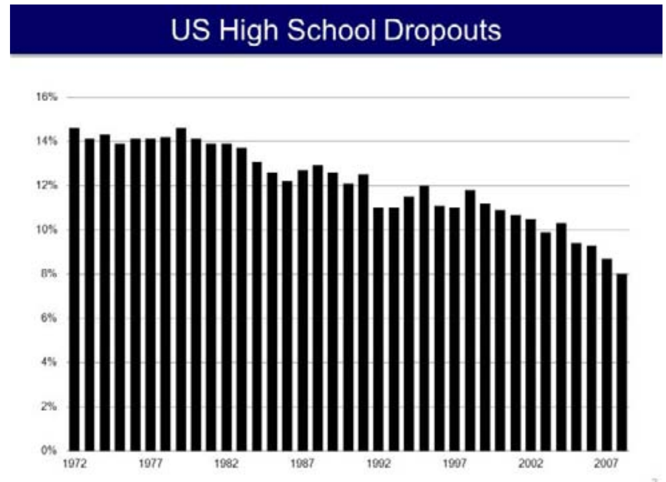
| *Type of Loss* | *Loss Amount* |
|---|---|
| Lost clients still with Defendant | $ 6,388,515 |
| Lost clients no longer with Defendant | 1,737,428 |
| Future loss: class A clients | 3,365,539 |
| Future loss: class B clients | 411,745 |
| Free premiums for class A clients | 4,608,851 |
| Other Defendant revenue not above | 20,081,366 |
| TOTAL | **$36,593,444** |

**Damages**

| *Type of Loss* | *Loss Amount (millions)* |
|---|---|
| Lost clients still with Defendant | $ 6.39 |
| Lost clients no longer with Defendant | 1.74 |
| Future loss: class A clients | 3.37 |
| Future loss: class B clients | 0.41 |
| Free premiums for class A clients | 4.61 |
| Other Defendant revenue not above | 20.08 |
| TOTAL | **$36.59** |

3. **Look at the other side of the coin.** There is always another way to look at the message to be delivered. We can look at failure rates or success rates, parts per billion of contaminant or percent purity. Consider the following statistics.



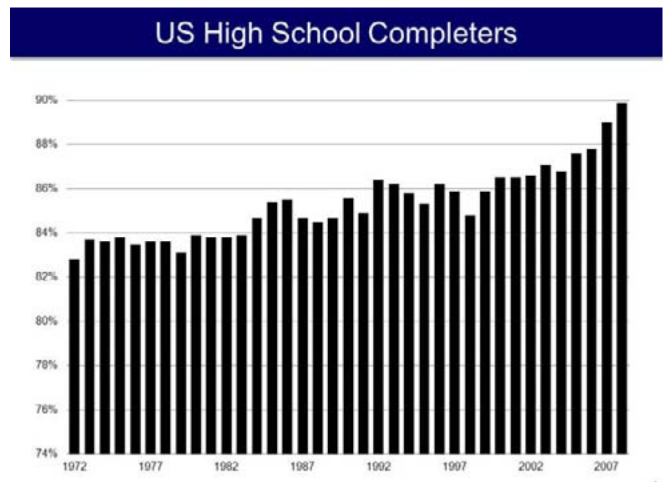




Exhibit 3 illustrates high school dropout rates while exhibit 4 quantifies high school completers. Which graph to use is, again, a function of examining critically and deciding clearly what point is to be made. If the objective is to criticize the educational system then exhibit 3 illustrates failure. If the objective is to praise the educational system, then exhibit 4 celebrates success. Litigation is frequently a rather acrimonious battle of egos, something the jury is not likely to miss. Framing in the positive gives you a chance to take the high ground and look reasonable, perhaps even generous. Be clear about what you intend to say.

4. **Analyze the whole story.** Perhaps the biggest lesson to be drawn from Dr. Pandelaere's work is the critical need to do a detailed analysis of the complete story to be presented. Only with a thorough understanding of the nuance of the message can we apply these principles to design. Anything less risks lack of clarity and continuity. It is not enough to blindly prepare a chart with data provided by counsel; we need to know the objective of each and every demonstrative and how it fits into the overall story.

5. **Retain experts and use them well.** Lawyers are trained in the law and verbal argument. Graphic designers, specifically those with long experience preparing demonstrative evidence, are trained and experienced in the visualization of information. Counsel should not have to look for the visual nuance implied by Dr. Pandelaere's research, that is the job of the demonstrative evidence expert. Designers should bring these details to the attention of Counsel during preparation of demonstratives. Also, counsel would do well to have their designer review opposing demonstratives with an eye toward "impeachment."

We would be foolish to ignore the work of Dr. Pandelaere and his colleagues. As design criteria, it is very useful, but perhaps the most important thing to be learned is the critical nature of the upfront story analysis that must be employed before we can make use of what he teaches us here.

## *Paul Roberts responds:*

*Paul Roberts is a senior case manager at The Focal Point based in Oakland, California. He works with the country's top trial teams on a wide variety of cases ranging from complex intellectual property litigation to commercial disputes and class-action lawsuits.*

Dr. Pandelaere's article offers a useful survey of several different types of perception biases in relation to how people interpret quantitative information. While his studies do not deal directly with courtroom or juror behavior, he quickly makes a connection between the quantitative biases that people exhibit and the potential for those biases to be exploited in the courtroom in order to influence a jury's evaluation of numerical information.

Dr. Pandelaere's studies seem to confirm the prior literature on the subject rather than push new boundaries, although he does explore the breadth of the unit effect by documenting it in a series of different contexts (units of time, quality ratings, and calories). While his primary conclusion is fairly straightforward (changing the unit scale can serve to emphasize or deemphasize differences) its implications for juror decision-making are murkier.

In positing ways to apply his conclusions to trial situations, Dr. Pandelaere suggests that a lawyer might downplay a difference by expressing a probability with a smaller numerator and denominator (1 in 20 instead of 100 in 2000) or emphasize a difference in caloric content by using a higher number expressed in kilojoules instead of a lower number of kilocalories. However, he immediately notes that someone translating the probability for jurors or making jurors aware of alternate unit options "may eliminate the unit effect." Therefore, it seems that as long as opposing counsel does not adopt the same "manipulated" scale (which would be unlikely), the unit effect would not have much bearing on a juror's evaluation of the numeric information.

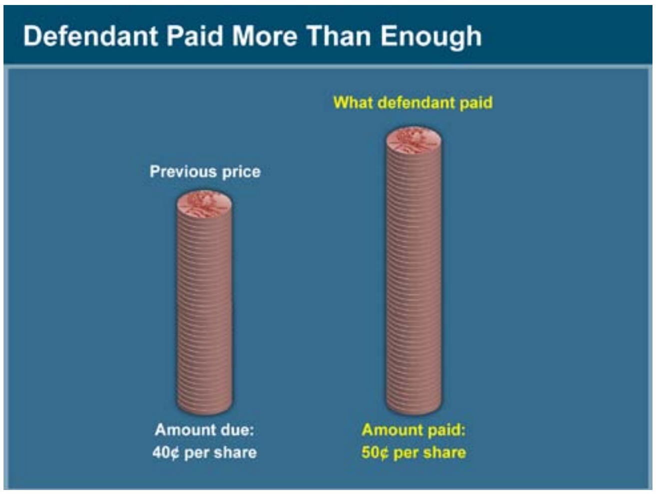
Furthermore, all of Dr. Pandelaere's studies involve individual decision making in the absence of group discussion. If the same numerical information is evaluated by a group of jurors during deliberations, it would likely increase the chance that at least one person would point out the unit discrepancy, thereby mitigating the unit effect for the group.

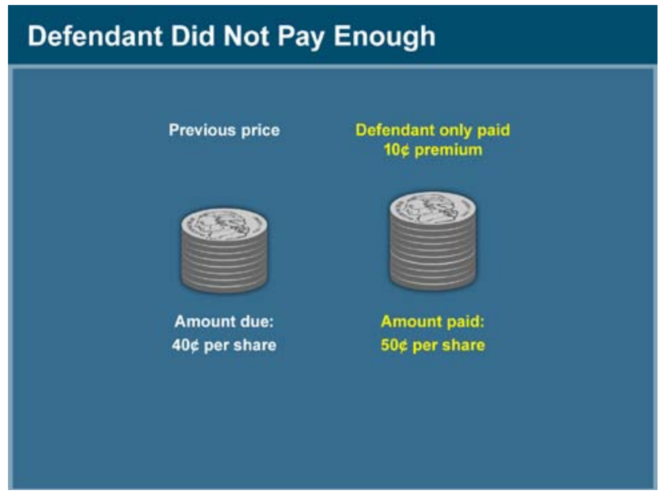
Despite these limitations, it seems plausible that framing effects might still contribute to the way a juror evaluates the totality of the evidence in a case. As Dr. Pandelaere points out, many people hold "the belief that numerical information is more objective, reliable and precise" than non-numerical information. Given that perception, presenting numerical information in a way most favorable to your client should be the goal of any trial presentation of this sort. Whether the evaluation of a single value exhibits a bias is not as important as ensuring that your data is framed in the most persuasive fashion possible for your case.

While Dr. Pandelaere's article explores ways to enhance your presentation by manipulating scale, it is also possible to emphasize and de-emphasize comparisons by manipulating visual perception. The following are some examples of graphics designed to illustrate the possibilities of visual framing effects similar to those that Dr. Pandelaere covers. How these visual unit effects would change the numerical ones that Dr. Pandelaere discusses would be an interesting course for future study, specifically because so much quantitative information is now presented visually to jurors at trial.

I would hypothesize that reinforcing scale manipulations with visual manipulations of this sort would likely hinder opposing counsel's ability to reverse the unit effect by merely raising awareness of the units. Furthermore, because visual manipulations are often subtle, they would likely not be pointed out to jurors at trial, making them less susceptible to reactance effects. This would lead to a premise that many trial graphics consultants likely have observed experientially: It is possible that the gestalt of a visual presentation can have a strong, yet subconscious influence on a juror's perception of a case.

These two examples demonstrate a visual example of the unit effect. Even though both graphics express the amount in the same monetary units (cents), the one on the left does so in a smaller visual unit (pennies) to emphasize the difference in amounts. The example on the right uses fewer, larger visual units (nickels) to minimize that same difference.




In addition to using different visual units, the layout invites the viewer to read each group of coins as single stacks and compare their heights. By altering the visual units, these graphics achieve a similar effect as when one changes the vertical scale of a bar graph to distort the differences in heights of the graphed data.

The following examples show three versions of a simple timeline illustrating the duration of two specific periods of time. The first two versions demonstrate the types of framing effect described in the article (merely changing the units). The third version explores the possibility of further emphasizing the difference in the two time periods by adding a visual element (a calendar icon) that corresponds to the change in units.