

Communicating Effectively with Words, Numbers and Pictures:

Drawing on Experience

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ABSTRACT. A key requirement of all actuarial practice areas is the ability of the actuary to analyze and communicate complicated information effectively. Successful actuaries require not just excellent technical skills, but also highly-developed communication skills. Actuaries work at the interface of a broad cross-section of disciplines. Effective communication between the actuary and other professionals can prove the difference between success and failure for users of the information actuaries provide. Clients expect actuaries to resolve difficult technical problems, but they also require answers that are easy to interpret and implement. We discuss techniques for developing such skills, focussing in particular on technical writing, presentation and the use of graphics as a tool for communicating ideas effectively. Learning the principles of effective communication should form a critical part of an actuarial education.

The key principles of effective communication are:

- Identify your audience, consider their needs and abilities;
- Focus on substantive content;
- Choose appropriate communication tools;
- Use “language” that is simple, concrete and familiar;
- Integrate text, numbers and graphics;

- Respond to information complexity creatively.

We focus in particular on the use of graphics as a communications tool. Graphics are very efficient and potentially highly effective tools for conveying information. Understanding the principles of good graphic construction is essential for conveying information in a way that is accurate and aesthetically appealing. We also describe several common errors in graphic construction – and how to correct them – using real graphics from the business world.

KEY WORDS: Communications skills, errors in graphic construction, presentation skills, statistical graphics, technical writing

1. Introduction

Strong technical skills are a hallmark of the actuarial profession. But at least as important as these skills is the ability of the actuary to communicate information accurately, unambiguously, and effectively. The type of information that actuaries routinely communicate is complex. Yet it must usually be made available to people from a wide variety of often non-technical backgrounds. As a result, there is an enormous burden on the actuarial profession to be able to communicate information at an appropriate technical level while maintaining enough detail to satisfy professional actuarial standards. This need is more critical now than ever before as the actuarial profession takes on more prominent roles in management where the effective flow of information between organisational tiers can mean the difference between success and failure.

The ability to communicate technical information well is a learned rather than an inborn skill. Peculiarly, most current approaches to actuarial education do not specifically try to teach good communications skills, relying instead on students' abilities to "pick up" the skills as they need them, usually in the post-study workplace environment. This "baptism of fire" can unfortunately result in the skills being acquired at considerable cost to employers. They cannot necessarily rely on students who arrive straight from their actuarial studies to be able to communicate as effectively as they would like.

At the root of the problem is the fact that traditional actuarial education is focussed largely on the development of excellent technical skills – that is, at getting the calculations right – and usually without too much regard to how the results are presented. To a certain extent this approach is reasonable in that many traditional classroom/study exercises are "canned" questions, presented without sufficient background or context to make the presentation of the answer a critical concern. In setting exercises, instructors rarely have the luxury of providing strong motivation or background details for the calculations. Hence students can struggle to grasp the importance (both practical and theoretical) of the results. Examinations are conducted under strict time limits, so "getting details down on the page" emerges victorious over learning the ability to explain ideas to others. Unfortunately, any separation of actuarial calculations from their context can be counterproductive for actuarial students.

Finally, and most importantly, one of the critical aspects of technical communication is the ability to judge the level of the intended audience. At university, students write solutions for lecturers, so the amount of technical detail presented in answers is appropriately high – this situation is likely to be very different to that encountered by a graduate posed with the problem of preparing a report for a client.

In this paper we attempt to increase awareness among actuaries of the importance of communication skills to the professional development of actuaries. In so doing we develop a set of principles that can be used to promote these skills among actuarial students. Learning good technical communication skills is not as simple as picking up a writing manual from the reference section of the book store. While the skills that make for good technical writing overlap with good general writing skills, they need to be developed with special care. Moreover, technical communication can take multiple forms, including written, oral, graphic construction, and presentation skills. Graphic construction skills are particularly useful, as graphics are an

extremely efficient way to present, summarize and describe large sets of numbers. Fortunately, the same set of key principles governs all these disparate forms of communication.

Three major elements distinguish technical communications by actuaries from more general forms of communications:

- the need to describe complicated mathematical ideas and financial concepts;
- the heavy reliance on graphical tools to convey quantitative information; and
- the need to report on complex numerical data analyses in order to describe stochastic (random) behaviour.

Each of these elements places a different burden on the communicator, and each can be a significant barrier for non-technical audiences. So learning principles that specifically target these three areas is essential for actuarial students. Along with these particular skills, actuaries must also develop good general communications skills, and we will also discuss those here.

The position of actuaries at the intersection of so many disciplines, including banking, finance, economics, mathematics and statistics, places a considerable burden on their communications skills. They must speak the “languages” of multiple disciplines. As both information-consumers and information-providers, actuaries need to be flexible communicators, able to interpret and analyse intricate and complicated numerical information, yet also able to communicate the results of their labours in a way that is both comprehensive and that their clients can understand. The actuary is in this respect an “information intermediary”, a vital link between raw, unprocessed data and effective decision-making in the presence of risk.

2. Broad Principles for Writing, Talking, Drawing, Presenting

Several key principles apply to all forms of technical communication. The principles are intrinsically linked. Briefly, they are:

- **Know your audience.** Communications must be framed with a specific audience in mind. The likely ability and background of the audience is an important factor in deciding the level and type of detail communicated. Speaking to a conference of qualified actuaries about a stochastic model fit for calculating insurance premiums is a very different task to that of justifying use of the same calculation to a group of shareholders. The chosen content and style of communication should reflect that difference. The group of actuaries may be interested in learning about the actuarial assumptions underlying the modelling, as well as in obtaining some detail about the process of fitting and assessing the model against historical data. The language chosen to describe these features could be appropriately technical. The shareholder group, on the other hand, might want an overview of how the new technique may affect customer premiums, the language chosen in this case reflecting the broader, non-technical nature of the audience. The cost of misjudging the audience is high: the group of actuaries presented with a broad overview might react with distrust (“What are they hiding? Is this even correct?”) or even boredom (“Surely there is more to this than what we’re being told! Yawn!”); the shareholders confronted with the more technical discussion may react with confusion (“Huh? Why are they telling us this?”) or even anger (“What a waste of time!”).

- Content is supreme. The most polished presentation, whether it be written, oral or graphical, cannot make up for lack of substantive content. Florid prose in a report, ornate decorations in a graphic, or garish colours on a PowerPoint slide may well attract an observer's eye to what you have to say, but if there is no substance to it, they will just as readily look away. The old adage that one should open one's mouth only when one has something worthwhile to say is an extremely valuable lesson in effective communication. This principle holds equally well for all forms of communication, and despite its importance it is the principle most often violated. Of course, what constitutes "substantive content" will vary from one audience to the next, so understanding the audience for the content is an important part of organising information for presentation.
- Context is vital. It is critical that information is presented in an appropriate context so that it may be interpreted properly and unambiguously. This goal can be difficult to achieve as a number of factors affect the context in which information should be presented. In particular, both the intended audience and the nature of the content to be presented affect decisions about the context in which information should be presented. Every element of technical communication needs to be carefully considered as to how it might be integrated into an effective, efficient presentation. Technical or mathematical arguments, graphics and data analyses should be used to complement the main message to be presented – not to overpower it, nor as a substitute for it. Complex technical arguments should be motivated carefully in the context of the information to be presented, and should be explained intuitively rather than purely formally unless the specific circumstance (e.g., a meeting of technical professionals) demands a more formal presentation.
- "Language" should be simple, concrete, familiar. The information you present needs to be understood easily, and the best way to ensure such an outcome is to use direct, precise language. Here, the word "language" is intended in a broad sense to include text, pictures, speech, and even gestures. For writing and speech, jargon, acronyms, and obscure technical references should be avoided. Sentences should be short without being terse or choppy. Information should be presented specifically for your target audience, using words and expressions that you know to be familiar to them. Simplicity is also an important quality for graphics, but it is an elusive goal as simplicity of construction and simplicity of interpretation can be conflicting aims. Nevertheless, graphics should be constructed to be as simple as possible, avoiding redundant or obstructive graphical elements ("chartjunk"). Oral presentations accompanied by PowerPoint slides should integrate text and graphical elements in a clean, seamless way. Garish colour schemes and flashy transitions should be avoided, as should distracting background patterns – lack of content cannot be adequately disguised by these devices, and substantive content is diminished by their use. Simplicity is again an important but elusive quality, as oversimplifying a presentation by reducing it to a set of bullet points can lead to a stilted, formulaic perception.
- Integration is important. Most technical information is multifaceted, so its communication should be likewise diverse. Different modes of communication are effective for different members of your audience, so incorporating information as text, graphics and numbers is not redundant. The use of numbers or data in communicating information should be embraced rather than avoided as numbers lie at the heart of the content of much technical information.

Creative graphical displays of numerical information are extraordinarily valuable. The primacy of text in technical communications is more a reflection of the history of human communications than an inherent strength of text as a means to communicate information. One of the strengths of modern computer systems is their ability to more thoroughly integrate each of the elements of text, images and numbers into a single document. Of course, integration needs to be implemented in a way that is both creative and stylish so that the outcome is a cogent, aesthetic whole rather than a piecemeal mess.

- Effective technical communication recognises the complexity of information and responds to that complexity in a creative manner. Size and dimension are two elements of data complexity that pose immediate problems for analysts and communicators. Nowadays, enormous, complex data sets are commonplace (e.g., minute-by-minute stock prices on a portfolio of stocks), so a key task of technical communicators is that of describing complex data patterns as simply as possible. This idea is akin to data compression – the idea that gross features of large data sets can be summarised by using relatively few measures; for instance, representing complex returns series in terms of mean and standard deviation measurements is commonplace. Good statistical practice is essential if this data “compression” is to be a successful strategy in understanding large data sets. In describing large data sets, it is inevitable that some information will be lost in the description. Good statistics is about discovering what is important (“signal”) at the expense of what is not (“noise”). Graphics are a particularly efficient means to represent large amounts of complex information into a compact, interpretable form. Technical communicators therefore need to develop excellent graphic construction skills.

Almost all interesting information involves relationships between many variables or factors, so techniques need to be developed that allow such high-dimensional information to be displayed on the low-resolution, low-dimensional display surfaces that are available today. Computer screens, though we see them as a modern advance on paper, allow for much lower-resolution images than are possible on paper. As a result, the answer to the question of how do we effectively reduce the dimension of our data so we can *see* what is going on is complicated by the low resolution of the device we use to look at the data. Reducing the dimension of multivariable data by forcing it to be displayed in only one- or two-dimensions involves inherent loss of information, and we need to understand the extent and consequences of this information loss – “What are we missing and is it important?”

Exploring high-dimensional data for relationships between variables also raises complex issues such as cause-and-effect, and as far as possible, graphics should help us to assess the question of whether variables are causally related. Unfortunately, this can be a very tricky question, which relies not only on good logic, statistics and experimental design (where that’s possible), but also to a certain degree on the luck of having asked the right question in the first place.

Comparison is a vital tool in understanding data and communicating what you see. Good communication invites the question “compared to what?” in response to the size and nature of revealed data structures. Such comparisons promote logical thinking about the nature of relationships within data, and assist us in deciding what features of a data set are important.

Effective communication is interactive in the sense that it engages the audience to understand and actively participate in the thought processes underlying what is being presented. Their response can “feed back” into the analysis to allow an even better understanding of the data. Good communication elicits the “right” questions from the audience. Good graphic construction facilitates useful comparisons through careful thinking about the locations of graphical elements within a single graph or on a single page, and through the use of techniques such as small multiples (many graphics located close to one another so that they may all be compared in a single sweep of the eye).

The sorts of information actuaries must deal with can be incredibly complex. Good communicators do not seek to deny the complexity of the information they describe. Rather, they try to exploit what simpler structures lurk within the complexity to better understand the mechanisms underlying the complex data structures.

- Good communication is hard work! Even the most brilliant technical work can be spoiled by sloppy presentation. Poor grammar, crowded or careless graphics, poor organization of presentation layout, and even poor choice of presentation font, are all inimical to good communication. To communicate effectively, you must win your audience’s attention – and fight to keep it having won it initially. If your report is riddled with typographic errors, readers may assume that your carelessness extends beyond your typing, and discount what you have written accordingly. If your graphics are misleading, even unintentionally so, your audience may distrust other things you say. If your PowerPoint presentation is full of flashy transitions of bullet points, your audience may overlook your substantial content and simply enjoy the sideshow. The solution is simple: practice, practice, practice. Read your own writing (and if you cannot be bothered, ask yourself why anyone else would!) and try to be objective in critiquing it. Try to think about the sorts of presentations or reports that have engaged you, and remember what about them made you pay attention. Then do the same things yourself.

All the modes of communication described – writing, speech, graphics, and presentations – benefit from the application of these broad principles, but the principles apply in different ways to each of them. In what follows, we explore the different modes of communication and offer particular advice on how to promote effective communication of ideas.

3. Writing Technical Documents

Beginning, Middle, End: the importance of structure

Storytellers have held a revered place in society since mankind first developed language, and ancient storytellers like Aesop remain famous today. One of the central tenets of good storytelling is the idea that a good story must have a well-defined beginning, middle, and ending. So it is with good technical writing, and without such basic structure even brilliantly conceived ideas cannot be conveyed effectively. In story-telling, the beginning is used to set the scene, giving readers the chance to understand the basic setting of the story; the important elements of the story unfold in the middle, hopefully engaging the reader’s full attention; and the ending is the climax of the tale, tying together loose story elements, and presenting the “moral” of the tale. Each of these basic elements is critical to the story as a whole: a tale that begins in the middle is

usually confusing; one without an ending is unsatisfying and frustrating; without a middle, there really is no story!

Humble beginnings – “What’s my motivation?”

The story-teller’s craft remains useful for technical writers today, and technical documents that are written ignoring this structure can fail utterly. “Cutting to the chase” – thereby failing to adequately introduce and motivate the work – is a particularly common sin. Yet the beginning, or introduction, is particularly important for technical writers, as in some cases it is all that will be read! As a result, it is essential that the introduction to a technical work motivate the work carefully, summarise the main results, and highlight the important conclusions. In documents typically produced by actuaries, the “executive summary” plays this role. It is also useful for the introduction to signpost briefly what is in the remainder of the document – some readers may only be interested in a particular section, and may ignore the document altogether if they cannot find it easily.

One of the worst sins of technical writing is that of failing to motivate the work adequately. We have personally seen countless published papers and student projects that waded right into intricate technical arguments before we could read past the first paragraph. Often, writers mistakenly believe that they are wasting the reader’s time by giving background to their work. Not at all! In fact, by making the purpose of the work apparent immediately, authors make it more likely that readers will read past the first few paragraphs. There is an old joke that the average research paper in mathematics has 0.8 readers, including the author and the referees! Sadly, there is some truth in the joke, the blame laying squarely with authors who, by failing to adequately motivate their work, fail to engage reader interest at all.

An obvious question is: how should technical work be motivated? The answer lies in looking to the key principles described earlier. First, the intended audience for the work needs to be carefully considered. Ask yourself what they can be expected to already know about the topic, and begin there in fashioning a motivation for the report. Anticipate the question “Why are you telling us this?” from the audience. It is very important for both written and oral presentations to very clearly state at the start what the main issue is, why it is important, and what your solution is – outline the content. For some of the audience, this may be all they want; for others, it will allow them to frame your work in a context that is familiar and important to them – in other words, it will engage their attention. As well as stating up front what solutions you are offering, also try to state what the work does not do – a single document cannot solve all problems, and the audience needs to know early within what boundaries the work resides.

The power of summary – drawing conclusions

While the introduction is probably the most critical part of any document, the conclusion is, to a certain extent, just as important. Remarkably, many technical documents have no formal conclusion! Whereas the introduction foreshadows the importance and relevance of the results, and sets the stage for their revelation, the conclusion must definitively bring together the main messages of the work. The conclusion of a document must draw together several elements: it must summarise the findings of the work, both technical and practical; it must, if possible, make a direct recommendation based on those findings; and it must be written in a way that makes it

accessible even to those who are interested only in the destination rather than in the journey. The conclusion must be written in a manner that is both concise and precise. It must also be written in an authoritative style, and must be as far as possible self-contained. Critically, the conclusion must be written with a specific audience in mind. There is little point in writing an extremely detailed conclusion highlighting the technical achievements of the work, when the primary reader will be, say, a senior manager who has no interest in the technical details.

Why is technical writing different from normal writing?

Technical writing, whether it be in business or science or engineering, differs from the writing of general prose through the introduction of three major elements: the use of mathematical or other specific technical detail; potentially heavy reliance on graphical tools; and the important role numerical work plays in the underlying content. Each element poses a different burden on the technical communicator, but the first element probably represents the most formidable challenge to the effective communication of ideas. Put rather crudely, mathematics and its associated disciplines are akin to foreign languages to many people. For such people, comprehending a technical document full of mathematical ideas is rather difficult. Yet actuaries are notoriously “numbers people”, and asking them to completely put aside their most natural talents in producing technical documents is a preposterous suggestion. Much of what actuaries do could not exist without mathematics and statistics, and so it is inevitable that the kinds of documents actuaries read and produce should involve mathematical arguments. But the nature of actuarial business requires that actuaries must frequently communicate with professionals less technically-inclined than themselves. For example, actuaries designing new life insurance products must coordinate their activities with legal professionals who establish the contracts under which the products will operate. How can such disparate groups communicate effectively? The answer lies in the principle that information must be presented in an appropriate context so that the audience can tackle the information in a language and manner that is reasonable given their backgrounds.

So, how are technical or mathematical arguments to be presented, if at all? Certainly, mathematics should never be presented merely for the sake of doing so. Here, the key principles of audience identification and appropriate context guide us as to how to proceed. For example, an actuarial consulting report should contain the minimum amount of mathematical detail necessary for addressing the key consulting questions. Numerical advice should be included only insofar as it is necessary to answer the questions at hand. The client does not wish to (and may not be able to) read detailed mathematical arguments; nor do they need to see every interim calculation on the way to the final result. They do wish to know, however, that the recommendations made by the consulting actuary are based on appropriate assumptions and correct, logical thinking. Answers to questions should be framed in the same language as the original question is framed, and abstractions should be avoided. A common problem experienced by novice technical writers is that they forget that the excitement or enjoyment they derived from developing the intricate mathematical arguments that supported their work is rarely shared by the readers of the report. In some cases you can almost hear the work proclaim “this is such a clever argument!” Clever though it may be, if its presence disrupts the main message of the paper then it does not belong there.

Many actuarial reports are dual-purpose in that they are intended for both actuaries and non-actuaries. One way in which writers can make technical arguments available to the part of the audience for whom it is intended without impacting other readers is by way of a “technical appendix”. This idea is well-known in academia. Many academic journals discourage authors from including too much mathematical detail within a paper itself, but offer them the opportunity to include, say, technical proofs in an Appendix. This approach keeps the author focussed on the main issues in the paper, but also allows them to express mathematical ideas freely. Of course, we must recognise the huge difference between a published academic paper and a consulting report or a technical report for a client. There remains room within certain types of reports for what is essentially tangential material. How else can an interested actuary recreate what the author has done, either for their own interest or to learn the technique and apply it to their own work? However, in other types of reports – for instance, client-only documents – there is often no room for such luxuries. It is true that sometimes an unusual amount of detail is necessary, either because the problem specifically demands a mathematical solution and nothing else will do, or because the solution is particularly unusual or novel and becomes, of itself, the subject of interest. Again, context drives the types of decisions to be made here: in the case where a specifically mathematical solution is needed, it is this context that drives the need for the mathematics in the first place.

When mathematical or technical ideas need to be presented in detail, the way in which the detail is presented makes an enormous difference to the way in which the material is perceived. Most importantly, readers are much more easily able to comprehend mathematical or technical arguments if they are able to grasp the main ideas intuitively, rather than purely formally. This point suggests that necessary mathematical complexities should at the very least be prefaced by remarks that attempt to explain the goals to be achieved and the means of achieving them in an intuitive way. For example, if a new pricing methodology is best explained by a mathematical statement, then a report introducing that idea should, rather than simply stating the idea mathematically, motivate the need for the new methodology. It should explain how the development avoids problems with the existing methodology. In cases where there is no existing methodology, the writer should explain how the new technical developments facilitate a solution where none was previously possible. At the very least, such an approach disrupts what would otherwise be a continuous stream of mathematics into a more fleshed-out argument based on logical principles that most people can understand even if they fail to grasp the mathematical detail itself.

There is a broad literature dedicated to mathematical writing. Its focus is probably more appropriate to mathematicians or engineers rather than to actuaries, and little has been written for mathematical professionals in the context of writing for business professionals. Nevertheless, if your requirements include writing that is heavy in mathematical notation, it is worth reading the style guides produced for the Mathematical Association of America by Gillman [14] and Knuth [17], as well as those produced for the American Mathematical Society by Krantz [18] and Steenrod, Halmos, Schiffer and Diederichs [21]. Other notable works in this area include the books by Alley [1], Barras [3], and Higham [15], and the article by Ehrenberg [11]. Along with these references, there are countless corporate style guides and manuals for writers in business and finance, though these tend to focus on more routine business correspondence and reporting than actuaries usually have to produce.

Writing ≠ Problem Solving

One of the difficulties facing novice technical writers is the fact that writing is a task for which they seldom have any training or experience. While studying, most people write *solutions* rather than reports, and the main drive is to write enough detail in obtaining the correct answer so that a high grade will be awarded. Of course, such a strategy can be disastrous when the same person must write a consultancy report, since the parameters governing good solution-writing are very different from those governing good technical writing. No longer is it necessary to recreate the sequence of steps that lead to “the answer” – the reader probably does not care about those details. Rather, the reader is more likely to care about the interpretation and consequences of “the answer”. Writers must not make the reports they write be simply scripts for how the problem was solved, as this approach almost never produces the desired result for the reader (unless, of course, the reader asked the question “How did you solve this problem?”)

A useful way of discovering whether your own technical writing style is cumbersome is to read it aloud, as if you were trying to verbally explain it to someone. If, on carrying out this experiment, the writer finds that he/she has to stop repeatedly and explain one thing or another, then they have not written the document well in the first place. Technical writing places the writer as a filter between raw inputs (usually extremely technical) and comprehensible outputs.

Heuristics – when they are good, they are very, very good, but when they are bad, they are horrid

One resort to which technical writers can turn when the detail underlying their work is simply too overwhelmingly technical is to supply heuristic arguments that back up the claims made in the report. A heuristic argument is one that provides aid in the direction of the solution to a problem but is otherwise unjustified – a close analogy is that of trying to solve a complex problem through a series of educated guesses. The “correct”, justifiable solution will often be much more detailed than an heuristic argument, but is usually much harder to convey to a non-technical audience. Of course, when put to close scrutiny, most heuristic arguments turn out to be simply incorrect. It is easy to see why this must be so: if the heuristic argument were, indeed, completely mathematically correct, why then could it not be used in a formal sense as a proof? Nevertheless, heuristic arguments are usually seductive to readers, and as long as the writer makes clear that the arguments being offered are informal “educated guesses”, most readers will appreciate them for what they offer. Writers need to be careful, however, not to put forward heuristic arguments as if they were formally correct, as this stance will only annoy or confuse the reader who is able to follow the arguments closely. In any event, if heuristic arguments are offered as if they were formal mathematical arguments, the less technical readers will have stopped reading, so there is little point in pursuing the charade.

A similar comment applies to the use of analogies. Most analogies are imperfect, and the writer needs to be aware of the limitations of any analogy they plan to use before it is committed to paper. They must also be prepared to acknowledge where the analogy fails. Otherwise, readers unaware of where the analogy fails may unwittingly extend it to an area where it does not apply, thereby drawing incorrect conclusions.

The role of jargon

Like many technical fields, actuarial science and its associated disciplines of finance and statistics are awash with jargon. Accrual rates, annuities due, net present values, discounted cash flows, preserved benefits, life tables, mortality, exposure, loss adjustment expenses, loss reserving, rating factors, reinsurance, written premiums versus earned premiums: the list goes on and on. What is worse, each of the main actuarial practice areas (such as life insurance, general insurance, pensions or superannuation) has its own jargon, distinct from that used by the other practice areas! Fortunately, actuarial training is broad, and qualified actuaries must be familiar with all of the major fields. Nevertheless, it is plausible given the increasing complexity of the profession that an actuary in one practice area may find it difficult to converse with an actuary in another practice area. For clients and other business professionals, the situation can be even more frustrating. Further (admittedly anecdotal) evidence that jargon is now a serious impediment to sound actuarial practice is that a quick search of actuarial consultancy web pages reveals that many consultancies now explicitly promise explanations “in simple English, free from actuarial jargon” as part of their terms of business.

Yet, it is easy to see how beginning actuaries fall into the trap of routinely using jargon, since almost all actuarial education ingrains the jargon indelibly into the lexicon of the training actuary. A report on examination performance for examinations of the Institute of Actuaries in 1997 reads as follows¹ (our emphasis indicated in italics):

“Candidates were asked to prepare a letter explaining different interest rates quoted for the same loan. This report summarises the main points which the examiners were looking for in the solution.

Scripts were expected to read like letters to friends, without jargon and with any technical terms clearly explained. *Many candidates did not achieve this.*”

It is easy to spot jargon in a technical report you have written: “spell-check” it in your word processor (without using any custom dictionaries you have created). Assuming your usual spelling skills are fairly good, what you will find is that most of the words highlighted as incorrectly spelled fall under the rubric of jargon. The best advice is to avoid jargon wherever possible. Of course, the difficulty that arises is in the interpretation of “wherever possible”, since most jargon is usually shorthand that connotes some very complicated idea.

The general principle of “know your audience” is critical to how one makes the judgement of whether the use of a certain piece of jargon is appropriate. If the paper or report is to be read by a group of one’s peers, each of whom has had training in actuarial science, then it is usually acceptable to use jargon to some degree. On the other hand, if the report is to be read by a client (who, presumably, has non-existent or limited training in actuarial science or finance), then jargon should be kept to a minimum. Writers who follow this advice will often have to create lengthier documents than if jargon is not used, but the increase in length is worth the effort if it means that their reports can be read by the intended audience.

¹ <http://www.actuaries.org.uk/pastpapers/1997apr/q2a97rep.pdf>

A writer should particularly avoid creating his/her own jargon. Unless an idea is truly novel and earth-shattering (most are not), the temptation to coin a new phrase to describe it should be avoided. Of course, we can all think of obvious exceptions, but a key facility all writers should develop early on is the humility to accept that most ideas, even some very good ones, do not warrant the introduction of a new word into the already-crowded actuarial lexicon.

TMA (Too Many Acronyms)

Along with the excessive use (and creation) of jargon, perhaps the most annoying tendency displayed by technical writers is that of creating acronyms to label new techniques or ideas. Some use of acronyms is acceptable, provided it is absolutely clear to the writer that all members of the audience are familiar with the acronyms used. For example, in a report to Government minister, it is almost certainly acceptable to refer to the government departments using well-known acronyms, such as IRS or FBI. Nevertheless, acronyms can quickly get out of hand – some discussions we have had with members of the Australian Public Service have been an education in alphabet soup, to say the least! In terms of acronyms applied to actuarial methodology, while it may be perfectly clear to the writer that MoS stands for “margin on services”, it may be far from clear to the audience, particularly a non-actuarial audience. Oh, and only a frustrated mathematics graduate would ever consider ending a technical argument with QED, an acronym so old that the language from which it was drawn is now dead!

4. The role of graphics – modern cave painting?

Graphics are an exceptionally powerful way to communicate technical information because they can summarize and describe vast amounts of information in a compact, efficient and eye-catching way. Well-constructed graphics can transcend the barriers of language and numeracy because they rely on the almost automatic response of the human brain in interpreting shapes and patterns. This observation comes as no surprise, as early-childhood development invariably involves shapes and colors long before language or numeracy skills are learned. In fact, “visual” information is processed in a different part of the brain to “language information” or “number information” – in much the same way as a modern computer hands off complex video or audio processing to dedicated hardware away from the main processor. As a result, even people without specialized training in pattern recognition or statistics are able to interpret graphs reasonably well. The strengths of graphics rest with their familiarity, their almost universal interpretability, and their ability to transmit significant amounts of information quickly. Unfortunately, the reliance of graphics on human visual perception also leads to their greatest weaknesses – the human eye is easily tricked and, as a result, graphics must be constructed with great care lest they lead to misinterpretations and confusion.

Graphics are, by their nature, demonstrative, and the purpose for which they are constructed needs to be clear and unambiguous. Like effective writing techniques, effective graphic construction is a skill that needs to be learned. Howard Wainer, who has published several highly-readable papers on statistical graphics, is quoted as saying that “like motor car driving and making love, drawing graphs is an activity that most statisticians feel they can do well without instruction. The results, of course, are usually disastrous.” While humorous, this sentiment is, regrettably, all too true. Moreover, with the ready availability of computer packages

like Microsoft Excel, truly abominable yet visually attractive graphics are at the fingertips of anyone who can switch on a computer. Recently, while gazing in wonder at the array of graphics that Excel could produce, we could count only a handful for which we could conceive a sensible use. It is in this rather perilous environment that technical writers must struggle to maintain their integrity and credibility!

The first piece of advice we would give to an actuary interested in learning more about graphics and information visualization is that they go – no, run – out and obtain copies of Edward Tufte’s beautifully-crafted and insightful books on visual displays of information ([23], [24] and [25]). Tufte stands alone among workers in this area for the breadth and depth of his work, and his books are worthy of the library of anyone working with data. Tufte’s works examine the rationale behind graphics as a tool for communicating information, and they set out definitively and elegantly the key principles of information design and display. Other notable work includes the books by William Cleveland of Bell Laboratories ([9] and [10]), who has been at the forefront of developments in statistical graphics, the book and articles by Howard Wainer from the Educational Testing Service ([29], [27] and [28]) whose discussions of the good and bad of statistical graphics is both insightful and entertaining, and articles by Anscombe [2] and Tukey [26].

The role of graphics in business and financial communications has attracted some attention in the actuarial, accounting and finance literature. Beattie and Jones ([5] and [6]) explored the extent to which US and UK companies used – and abused – graphics in their corporate annual reports. Frees and Miller’s article [13] is a very interesting discussion paper on the topic of effective graphic design.

The first, and most important, rule of graphic construction is to identify the likely audience for the graphic. It is no coincidence that this is the same “golden rule” as for writing and presenting! Tailoring information for the specific audience is critical for all forms of technical communication. For example, while a survival curve is immediately meaningful to a life actuary, it is unlikely to be an effective graphical tool for a more general, non-statistical audience. Similarly, standard statistical tools like quantile-quantile plots, while they are models of graphic construction and invaluable statistical analysis tools, are of limited to no use in presentation to general audiences.

Two types of graphics

We will distinguish here between two types of graphics: presentation graphics, which are explicitly designed for use in a published report for the consumption of others; and analysis graphics, which are routinely produced as part of a larger analysis and would generally not be part of the ultimate report. Examples of presentation graphics include bar charts, histograms, time series plots, and pie charts. Graphics such as survival curves, quantile-quantile plots, residual plots, and so on are more often classed as analysis graphics. In our present context, most of our comments are applied to presentation graphics, but many also hold true for analysis graphics.

Bar charts and time series plots can be very useful graphical tools, but careful attention should be paid to the principles of good graphic construction even when constructing such simple graphics. Pie charts should probably be avoided altogether, as they suffer from several deficiencies that limit their effectiveness. For example, pie charts rely on a reader being able to spot slight differences between areas of sectors of a circle, a feat many people find difficult and unnatural. Moreover, pie charts usually encode only a handful of numbers, and a table is usually a much more efficient way to present such information. Edward Tufte goes so far as to opine that “given their low data-density and failure to order numbers along a visual dimension, pie charts should never be used.” [23] While we agree with Tufte’s sentiment, we concede one point in favor of pie charts: they are very familiar to audiences in business and finance, and this familiarity can make them easier to interpret. Nevertheless, variants of pie charts such as three-dimensional or exploded pie charts and the aptly-named doughnut chart, are anathema to effective communication.

Rules for Effective Graphic Construction

1. Substantive content should drive the need for graphics

A graphic should represent a significant piece of information. In simple terms, graphics are designed to attract readers’ attention. A simple analogue for a document containing a graphic whose content is uninteresting or trivial would be for you to be stopped in the street by a stranger only to be told “I have nothing to say to you”. This circumstance might leave you feeling bewildered, or even annoyed. So it is with meaningless graphics! It makes no sense to encode only a few numbers into an overblown graphic – in these cases, a small table makes much more sense, and gives readers direct access to the numbers involved – see Figure 1. Tufte is more eloquent in stating, unequivocally, that “visually attractive graphics also gather their power from content and interpretations beyond the immediate display of some numbers. The best graphics are about the useful and important, about life and death, about the universe. Beautiful graphics do not traffic with the trivial” [23]. Of course, decisions as to what is important are highly subjective!

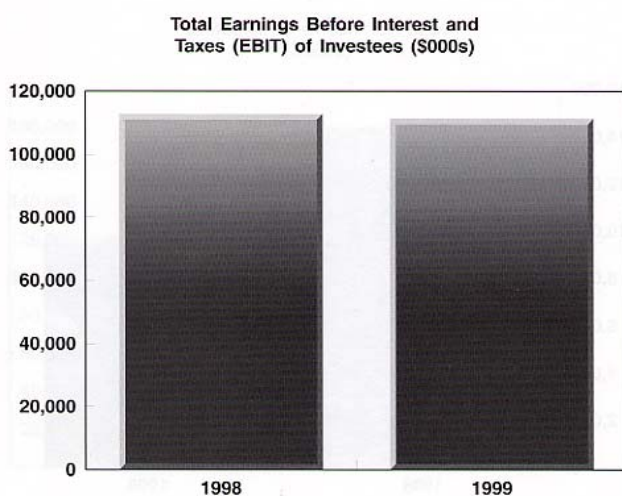


Figure 1²: This bar chart encodes only 2 numbers – about 112,000,000 for 1998 and about 110,000,000 for 1999. The bevelling and greyscale gradient on the bars reduces their perceived height, while the small amount of data encoded makes it a shame to waste an entire page in a report. A small, two-number table, or even a short sentence, would suffice.

² Source: © Australian Venture Capital Association Limited – Year 2000 Yearbook.

Lack of purpose in graphic construction is betrayed by several tell-tale signs. The first is low data density, a measure of how much data is represented in the space allotted to the graphic. We have seen numerous annual reports which force the reader through a forest of bar charts or pie charts, each of which represent only a handful of numbers. A better option would be the production of a single, moderate-sized table. Figure 1 shows how a whole page of a report can be taken up describing just two numbers! The report from which it was drawn contained eight similar graphics, each describing just two numbers.

Graphics adorned with excessive decoration can also conceal a lack of content. Figure 2 depicts such a case, where “chartjunk”, extraneous decoration carrying no information content, dominates the graphic to a ridiculous extent.

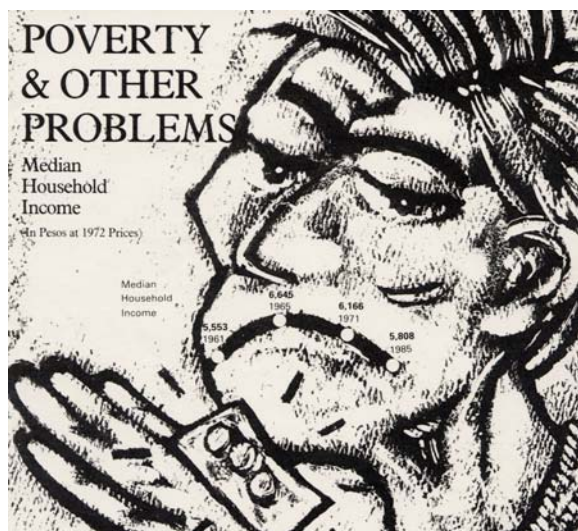
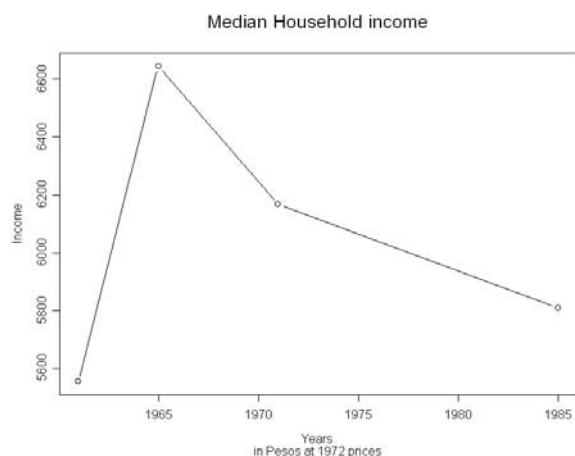


Figure 2³: This graphic encodes just four numbers. The decoration dominates the graphic to such an extent that it misrepresents the data hideously. Note that the horizontal distance which represents the 14 years between 1971 and 1985 is shorter than the preceding intervals of four years, presumably so the “mouth” – a decoration – remains in proportion with the face. Also, the final amount (5808) appears smaller (positioned lower than) than the initial amount (5553). Curiously, the authors have applied some good statistical practices – the amounts reported are medians rather than means, and the currency is adjusted to 1972 levels.



A re-working of the graphic shows a shape that is not mouth-like at all! In fact, it appears as if the rate of decline is slowing. Unfortunately, the long time period between measurements makes it difficult to sustain this argument.

Good graphics answer the question “Why?” as well as the questions “What?” and “How?” about a set of data. Where possible, graphics should reveal cause-and-effect relationships, although this

³ Source: ©MBC (Makati Business Club) Economic Papers, September 1988.

task can be a formidable one. Two excellent examples of how graphics might achieve this goal are given in Chapter 2 of Tufte's book *Visual Explanations*. There he shows how graphics were instrumental in the discovery of the means of cholera transmission, and how graphics, had they been more thoughtfully constructed, may have prevented the launch of the ill-fated 1986 space shuttle Challenger.

Despite the best intentions, the achievement of purpose in a graphic can be difficult to judge, as graphics can show both what is present in the data and what is not. As a result, graphics can surprise and delight us by making apparent features of the data that were not originally anticipated. Detailed data analyses involving graphs are best thought of as iterative processes. Preliminary, mainly graphical exploration of the data is followed by a deeper exploration based on model formulation, fitting and assessment. Graphics are an integral part of each stage of the analysis. Individual graphics also benefit from an iterative approach to their design, whereby each graphical element is carefully considered in the context of its interaction with other graphical elements.

2. Good graphics promote comparisons

Good graphics must be based on sound logical principles and good statistical practice. Graphics must not lie! Almost all interesting and important arguments involving numbers are relative – how big is one number *compared with another number*, and what does the difference in their size mean in the context of the problem at hand. Difference and change are the drivers of almost all decision-making, and so comparison is the most important tool of scientific inquiry that we have. This fact has long been recognised in formal statistical analysis: the idea of a controlled experiment dates to the earliest days of statistics. Good graphics reflect the same principles as good, logical reasoning. Good graphics invoke wise comparisons, and do so in a way that is both natural and aesthetic. There are several ways in which graphics can be constructed to facilitate meaningful comparisons:

- If two curves are to be compared, consider plotting their difference or their ratio rather than simply putting both curves onto a single axis. This technique forces comparison along a horizontal baseline, and so takes advantage of the fact that humans can perceive even slight deviations from straight lines, especially horizontal and vertical lines;
- Plots should be augmented by the addition of visual elements such as fitted lines wherever possible so that patterns in the data are easily recognised;
- Graphical elements that are close to one another are more easily compared than those that are far apart. As a result, placing multiple lines on the same set of axes, or multiple graphs on a single sheet of paper is an effective way to promote comparison. The latter idea, referred to as the use of small multiples, is a particularly effective way to describe large amounts of multivariate data efficiently. The concept behind small multiples is that a large number of similar graphics can be explored within a single eye span, and so even small differences between them become readily apparent. The worst case is where several graphics to be compared are spread over several pages, forcing the dreaded “paging forward, paging back, paging forward again” method of comparing graphs.

Mere proximity of graphical elements does not guarantee wise comparisons, as the optical illusions in Figures 3, 4 and 5 show.

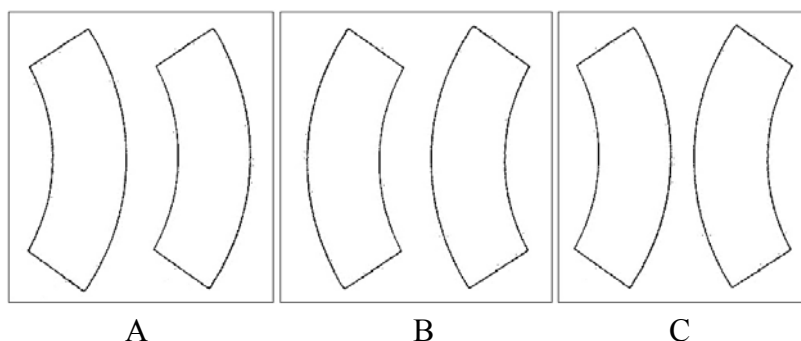


Figure 3: Which shape is larger, left or right, in each of boxes A, B, or C above? Most people would say that the left shape is large in box A, the right is larger in box B and the shapes are the same size in box C. Yet all the shapes are identical in size. The reason for the apparent differences in size is that the eye compares nearest-neighbor lines, so in box A, the right side of the leftmost figure is compared with the left side of the rightmost figure, resulting in the perception that the left figure is larger overall. Box B is perceived in an analogous way. In box C, the nearest-neighbor comparison compares lines of equal length, resulting in the correct perception.

Figure 4: Which of the two “middle circles” is larger? Most people answer that the one on the right is larger, when in fact they are the same size. Size is judged in relation to the outer array of circles in each case. The leftmost middle circle is small compared to the circles surrounding it, while the rightmost middle circle is larger than its surrounding circles. The result is an incorrect perception in comparing the two middle circles.

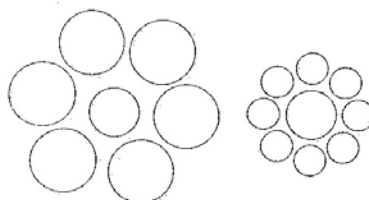


Figure 5: Which line segment is longer, i or ii? Most people answer that ii is longer, but the lines are the same length. The reason for this perception is that, rather than recognizing the segments as only the lines, the entire “arrow assembly” is visualized. In the case of segment i, the arrow assembly is “closed in” while the arrow assembly surrounding ii extends in each direction away from the ends of the segments. Proximity of the arrow assemblies to the segments makes it difficult for humans’ visual centers to dissociate the arrows from their internal segments in perceiving the correct lengths.



Figure 6 shows an example of the use of small multiples to compare the marketing budgets of several different kinds of firms.



Figure 6⁴: An imperfect use of small multiples. Here, 16 small graphical elements are placed close to one another to facilitate comparison between them. Unfortunately, the graphical elements themselves could hardly be worse: nested cylinders whose size bears scant relation to the numbers they represent. Overall, a good idea (small multiples) ruined by extraordinarily poor choice of symbols (nested cylinders). Note also the heavy use of jargon (“midicorps”, “microcorps”) and the poor choice of colors (two very similar shades of blue, yellow). A caption describes in three lines what the graphic was unable to impart...

An excellent graphic design which uses small multiples is the scatterplot matrix, which depicts all two-dimensional relationships among pairs of variables in a multivariate data set. This graphic manages to render high-dimensional information into two-dimensions, and does so in a way that allows the reader to quickly explore each two-dimensional plot in the array for evidence of correlation between the relevant variables – see Figure 7 for an example. This graphic design is good because it allows the viewer to examine many two-dimensional slices of the high-dimensional data space very quickly. Care must be taken, though, in interpreting the graph, as interesting directions in the data may not include those involving only two variables at a time. Such directions are simply not visible in a scatterplot matrix. Moreover, while the graphic is capable of showing association between variables, it cannot address the question about whether such relationships are causal. The establishment of causality must be more than a visual process – it also requires careful logic and, typically, good experimental design.

⁴ Source: © *Business Today* magazine, Feb 22 – Mar 6, 1998, page 67.

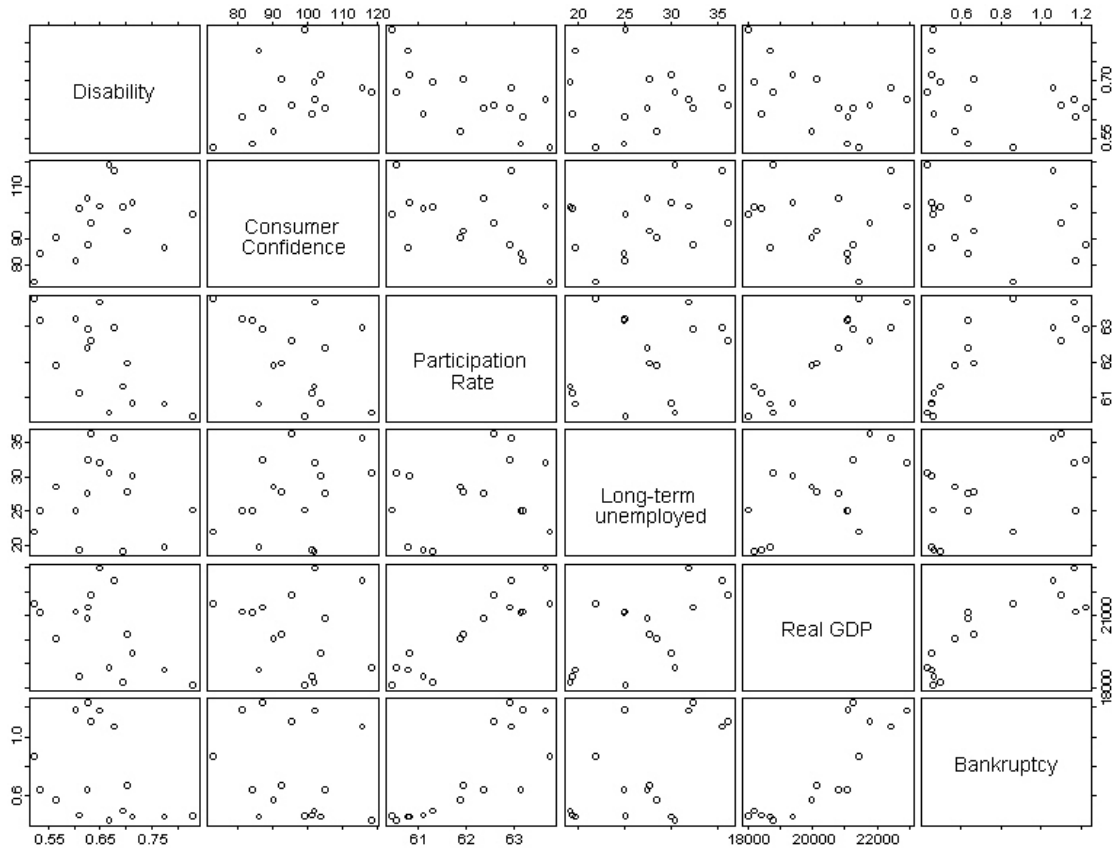


Figure 7: A scatterplot matrix exploring the relationships between various economic indicators and a disability index (number of disability insurance claims scaled by a measure of exposure). Covariates included were a measure of consumer confidence, employment participation rate, long-term unemployment, real GDP per capita and a total bankruptcy rate. The data was reported by Service and Ferris [20]. There appears to be an association between the disability index and each of the other variables – see the top row of the array. There also appears to be several relationships among the covariates (e.g., Bankruptcy and GDP, Participation Rate and GDP, Participation Rate and Bankruptcy) which make separating out the individual effects of each variable difficult.

3. Graphics should be designed to be aesthetically pleasing

Proportion, perspective and scale are extremely important elements of graphic construction. Graphics need to be eye-catching without being garish. Every design element of a graphic should be carefully considered in terms of how it may affect the viewers' ability to perceive the content of the graphic. The aspect ratio of a plot, the ratio of the height of a graphic to its width, can dramatically affect how the content of a plot is perceived – Figure 8 shows such a case.

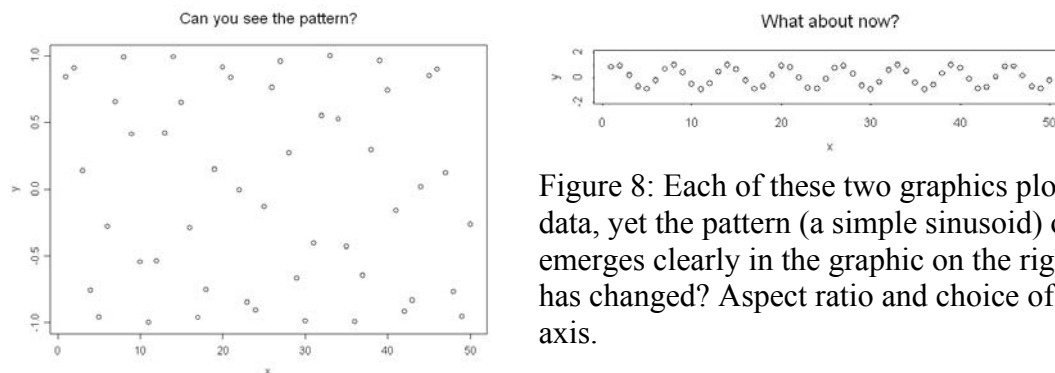


Figure 8: Each of these two graphics plot the same data, yet the pattern (a simple sinusoid) only emerges clearly in the graphic on the right. What has changed? Aspect ratio and choice of vertical axis.

Also, careful attention needs to be paid to the layout of graphics within a page. For example, two histograms sharing the same set of horizontal axes and bin-widths should be aligned vertically rather than side-by-side to facilitate easier comparison of their shapes.

Seemingly benign design aspects, such as choice of axes, are critical to drawing graphs that are easy to interpret. For example, the practice of including the zero point on all axes reflects a poor design choice, as zero may be nowhere near the bulk of the data. Unfortunately, such choices are often not left to users, as popular computer packages such as Microsoft Excel offer the “feature” of axes including zero as a default for some choices of line graph (and, strangely, not for others). While the default can, of course, be changed, many users will never exercise this choice. Figure 9 shows two versions of a graphic depicting household income data from Figure 2. Which is the more truthful?

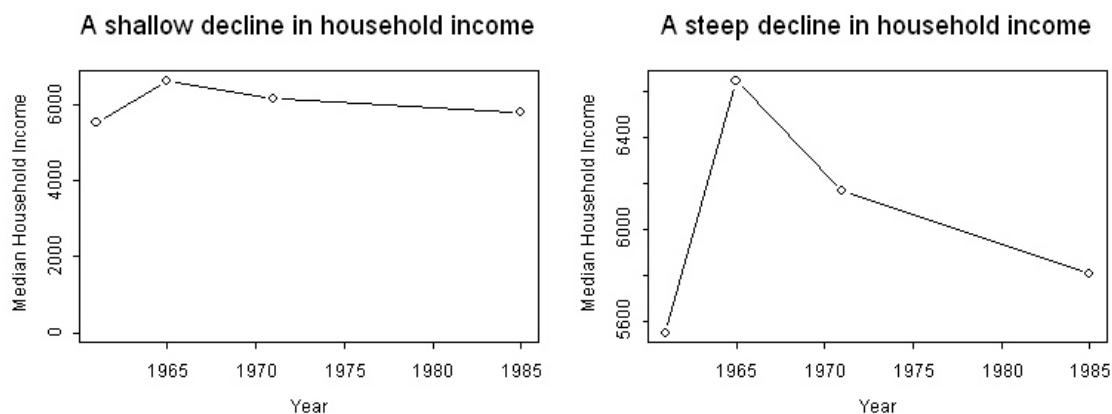


Figure 9: Median Household Income revisited. The forced inclusion of 0 on the vertical axis of the left plot de-emphasizes the extent of the change in income over time.

Other design factors that affect graphical perception include choice of plotting symbol, and the use of colors or shadings. A good general principle is that when a graphical element is used to encode a number or a set of numbers, that element should be of the same physical dimensions as the dimension of the information it is encoding. For example, bar charts violate this principle because they encode single numbers as two-dimensional objects (bars), rather than as one-dimensional objects (lines). Three-dimensional bar charts, available all too readily to users of packages like Excel, are even worse, as they encode a single number using a three-dimensional

object. The introduction of redundant dimensions promotes ambiguity in how one interprets the graphic (does the depth of the 3-D bar have any meaning?), and ambiguity is the enemy of effective graphic construction. Three-dimensional elements also risk introducing unusual perspective effects into graphics, the overall impact of which can be unexpected – see, for example, Figure 10.

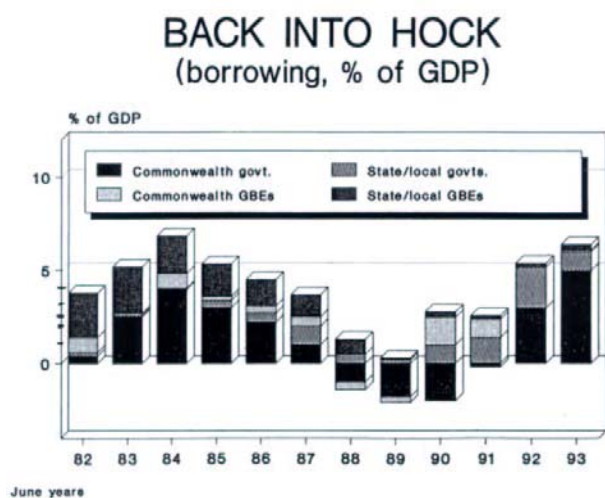


Figure 10⁵: An unusual perspective on public sector borrowing in Australia. Unfortunately, the introduction of a spurious third dimension into the plot causes bars that have “negative borrowing” components to appear as if they are in front of the other bars – they have leapt into the third dimension!

Color is a potentially effective tool in graphic construction, though its use has been historically low because the wide availability of computational and printing support for color is a relatively recent development. Nevertheless, color needs to be used carefully, as colors are not strongly visually ordered, whereas grey scales are. As a result, grey scales are preferable in many instances. Moreover, up to 5% of the male population suffers some form of color-blindness⁶, so designs should, as far as possible, not rely exclusively on color. Shading patterns such as cross-hatching can also lead to unusual and distracting optical effects such as moiré vibration.

Standardization of graphical forms within a report is another element of aesthetic practice that improves the impact and comprehension of graphical forms. We have seen annual reports in which several flavors of bar charts (stacked, three-dimensional, bevelled) have appeared on consecutive pages of the report. This practice causes readers to constantly switch frames of reference, and is an impediment to them grasping the graphical information quickly and accurately. It also makes comparison across graphics very difficult.

4. Graphics should be simple, both in interpretation and perception

Of the four principles discussed, this one is the most elusive, mainly because it is not always possible to attain graphics that are both simple to visually perceive and simple to interpret. A case in point is the use of transformations – data is often transformed so that when it is summarised by a graphic, the main features of the data are readily apparent. Yet, when a viewer comes to interpret the graphic, they must do so keeping in mind that the data has been

⁵ Source: Report on Public Sector Borrowing, Australian Public Service, 1994.

⁶ About nine million men in the United States suffer color-blindness, the condition only very rarely affecting women.

transformed, and that a back-transformation is necessary before any firm conclusions can be drawn. In order to obtain simplicity of perception, one must keep in mind the way human visual perception works. For example, people can see very easily when a pattern of data points deviates from a straight line, but may be unable to perceive similar scale deviations from a curved line. Equally, it is perceptually easier to observe deviations from horizontal or vertical lines than it is from lines at arbitrary angles – this is the principle that makes residual plots such an effective tool for assessing the quality of a statistical model fit.

Quantile-quantile plots, designed to assist in detecting when data does not plausibly arise from a bell-shaped distribution, are an example of excellent graphical construction. They achieve simplicity in perception, but they are not simple to interpret without training. The graphical premise underlying quantile-quantile plots is that data is transformed onto a particular scale where departures from normality are associated with non-linear patterns in the plot. Discovering such patterns is much easier, perceptually, than the process of deciding whether a histogram of the data looks bell-shaped. Most viewers cannot adequately envisage what “bell-shaped” means, whereas deciding whether a pattern is linear or not is easy. The difficulty arises once the visual pattern has to be interpreted in the original context. Inexperienced viewers make the mistake of interpreting the pattern as meaning that the original data itself has a linear relationship with some other variable – that is, they attempt a literal interpretation of the shape of the plot. Only when the link between distribution shape and the associated Q-Q plot is made do viewers realize the correct interpretation, but this layer of abstraction poses a formidable burden to most viewers.

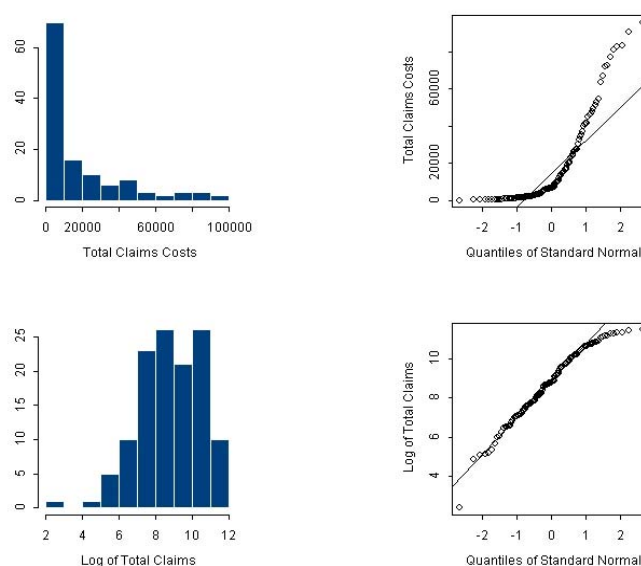


Figure 11: Are motor insurance claims normal? Baxter, Coutts and Ross [4] reported data on total cost of claims for 128 combinations of claimant age, vehicle age and vehicle type categories. Histograms of total claims for the 128 categories and the log of total claims are shown at the right, with associated Normal Q-Q plots on the left. The distribution of total claims is highly skewed to the right (indicated in the Q-Q plot by a non-linear, concave-up curve), while the distribution of log total claims is closer to bell-shaped, but slightly skewed to the left (notice the slight concave-down curvature in the Q-Q plot).

Other design elements also impact the simplicity of graphics. Impediments to simplicity include the abundant use of abbreviations on a plot, overuse of legends and different line types (e.g., dotted, dashed, dot-dash lines), and excessive decoration.

Major Errors in Graphic Construction

1. Misrepresentation of data

The most common error in graphic construction is the use of graphical elements that either deliberately or accidentally fail to accurately represent the data they encode. The simple paradigm to which all graphics should adhere is that graphical elements that represent numbers should be drawn in proportion with those numbers. While this seems like a very straightforward rule, it is breached surprisingly often, usually sacrificed to satisfy “aesthetics” and to preserve column space in newspapers. Two simple examples are cases where bars are not started at zero but at some other, arbitrary value, or where long bars are broken; see Figure 12 for two examples. In each instance, the relative heights of the bars are not in the correct proportion – the relevant visual metaphor is broken. This case can be contrasted with that discussed in Figure 9 for line plots, where the most relevant visual element was the *slope* of the line rather than its *height* above the baseline. Hence, the lack of a zero baseline is not as critical a problem for line plots as it is for bar charts which use relative heights of the bars to visually encode the numerical information to be transmitted.



Figure 12: Broken bars. Bar lengths should be proportional to the numbers they represent! In the left graph⁷, the largest bar should be only 1.005 times as large as the smallest bar, but visually the ratio of their sizes is about 5. In the right graph⁸, the larger bar should be about 1.6 times the length of the smaller bar, but visually the ratio of their sizes is about 6. In each case, the error favors the company producing the graphic. Amusingly, the fine print on the left graphic admits that the graphic is not drawn to scale – why bother to print it then?

⁷ © Vodafone, Source: Australian Communications Authority, March 2000.

⁸ Source: Wesfamers Retail Pty Ltd share offer for Howard Smith, June 2001.

Figure 13 shows another obvious misrepresentation where the time scale is seriously distorted. Ironically, the headline for this graph, when translated, reads “A picture is worth a thousand words” – unfortunately, almost all of the words we can use to describe the graphic are critical.

Eine Grafik sagt mehr als tausend Worte.

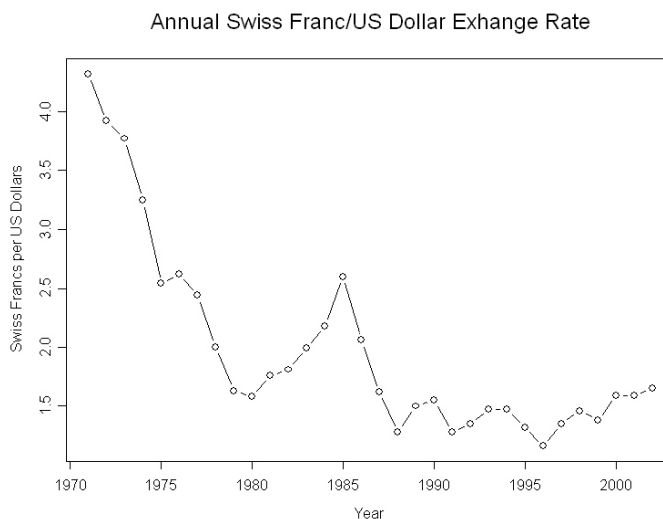
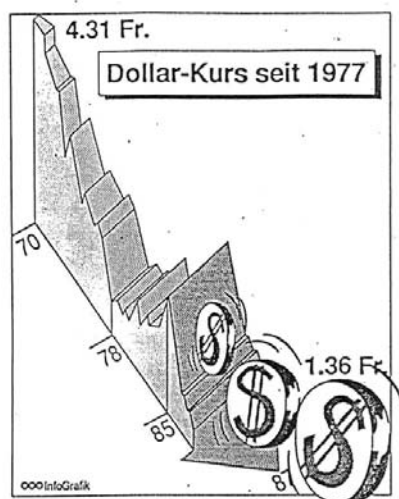


Figure 13⁹: In this graphic, the time scale is so distorted (the two years from 1985 to 1987 are represented on the time scale using the same distance as for the seven years from 1978 to 1985), and the viewing angle and perspective so distracting that the graphic is almost useless as a visual tool for understanding the US dollar/Swiss Franc exchange rate. It is extremely difficult to judge the extent to which the Swiss Franc had recovered its value in 1985 after the initial drop in the late seventies. Also, the width of the exchange rate curve increases as the curve moves down the page. The strong visual impression is that the relative size of the dollar to the franc is growing over time (see the increasing width of the curve, and the decoration of growing dollars rolling off the end of the curve). Of course, during the period under study, the currencies generally moved in the opposite direction. A simple time chart would communicate the correct information much more efficiently and unambiguously – see the plot on the right, which clearly shows the 1985 recovery of the franc to over half its 1970 value.

A key misrepresentation common with financial data is the failure of the person constructing the graph to adjust monetary amounts for factors such as inflation. Invariably, if inflation is not accounted for, strong positive trends in variables such as spending are generally overstated – see Figure 14 which includes an admission that inflation had not been accounted for.

⁹ Source: Computerworld Schweiz, 1989, © *Cash* magazine.

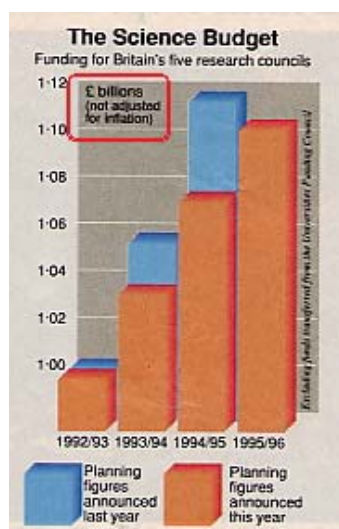


Figure 14¹⁰: Failure to account for inflation means that rates of change in budgets over time are difficult to interpret in real terms. Of course, the goal of the graphic may be to make it appear as if funding is growing at a rapid rate, but that may not be the case in real terms. Also, the alignment of the blue bars behind the orange bars makes it impossible to make a clear visual comparison of their heights – the blue bars appear smaller than they actually are since they are partially obscured by the orange bars.

Another, more subtle form of misrepresentation that is common when describing financial data is data aggregation prior to graphing the data. Aggregation is a form of data smoothing that allows for long-range trends to be observed in volatile data, but if data is over-smoothed by too broad an aggregation, important short-run information can be lost. For example, reducing quarterly or monthly data to annual data by aggregating quarters/months into years can cause significant seasonal variations to be obscured. In extreme cases, this approach can lose the most important or interesting information. As a simple illustration, in some classes of general insurance claims are likely to rise in certain seasons (e.g., storm and fire insurance claims will tend to rise in summer and decline in winter), and these critical trends will be missed if data on such claims are annualized. Of course, the amount of aggregation appropriate for a particular set of data depends critically on the question being asked. In the preceding example, annualized data would be appropriate if the goal of the graphic were to display the overall growth in claims over the last ten years. If, on the other hand, finer detail were required, the amount of aggregation would need to be reduced. Smoothing and aggregation inherently involve loss of information. The key to a satisfactory graphical outcome is to identify what extent of information loss can be tolerated for the question at hand to be reasonably answered. A straightforward way to avoid misrepresentation through aggregation is to experiment with differing amounts of smoothing before deciding on which graphic gives the most useful and truthful account of the data. Remember that good graphic construction is a process of iterative refinement – the search for truth in graphics is neither short nor easy.

¹⁰ Source: © *New Scientist*, 21 November, 1992.

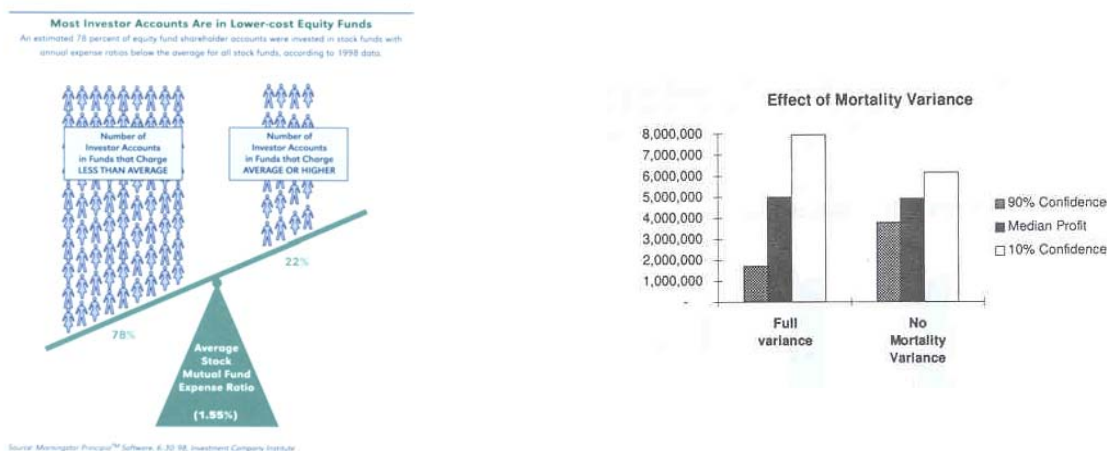


Figure 15: Other subtle misrepresentations in bar charts include failure to begin bars on a common baseline (making it harder to judge their relative sizes) and varying the width of bars (the perceived size of a bar is related both to its height and its width, so equal width bars should always be used). The graphic on the left¹¹ includes bars with oblique baselines and varying widths, making the judgement that the bar on the left is about 4 times the size of the bar on the right difficult. The graphic on the right¹² includes bars of varying width and color, complicating an accurate visual assessment of their sizes.

Perhaps the most common form of data misrepresentation occurs when bar charts are constructed using decorative elements other than fixed-width bars to represent data. One only has to pick up a copy of *USA Today* or browse their website¹³ to find a vast array of exotic shapes (e.g., hot dogs, bears, arms, legs, hats) presented as bars in a bar chart. The problem with these decorative elements posing as bars is that in order to make them look “real” their widths must remain in proportion to their height, so that as their heights grow so do their widths. As a result, although the relative heights of these “bars” are correct, their relative perceived sizes – usually their areas – are not. This design variation distorts viewers’ perception of variations in the data, and hence misrepresents the true situation.

2. Redundant dimension

Graphical elements should have the same dimension as the information they encode. So, a single number A is better represented by a line segment with length proportional to A than by a square whose side-length is proportional to A . This preference is based on what we know about human visual perception – when people are presented with a two-dimensional figure like a square, they usually perceive its size as its area (A^2) rather than its side-length or diagonal length.

¹¹ Source: © Investment Company Institute, Morningstar Principia™ Software, 6/30/98.

¹² Source: Lang [19], *Australian Actuarial Journal*.

¹³ See, for example, <http://www.usatoday.com/snapshot/news/snapndex.htm>

The introduction of spurious dimensions into a graphic also causes ambiguity for viewers. Some viewers will interpret characteristics in that extra dimension as carrying meaningful information, while others will not. The use of three-dimensional bars in bar charts can also create unusual depth and perspective effects to emerge. Simply, if the useful information in a bar chart is only represented by the height of the bars, then the bars should be rendered as lines, not bars, and certainly not as three-dimensional blocks, or, worse, cylinders or cones. In the case of three-dimensional bars, the perceived size of objects is their volumes (proportional to A^3), rather than their heights (A). The use of fixed-width, two-dimensional bars is acceptable only because their areas are in the same proportion as their heights, and because such bars are aesthetically nicer than simple lines. Nevertheless, varying the widths of two-dimensional bars introduces spurious information into the redundant second dimension, and hence changes the perceptual properties of the graphical element.

Some examples of problems arising from redundant dimensions are shown in the following figures.

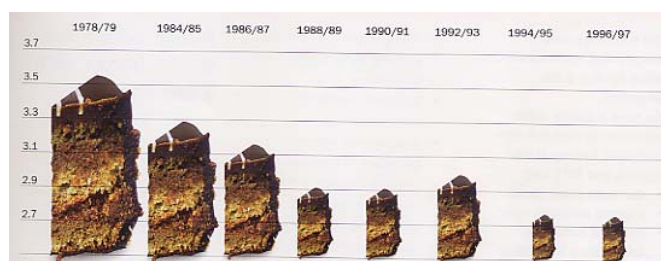


Figure 16¹⁴: Expenditure on Australian schools as percentage of GDP 1978-1997. In this graphic, bars are presented as pieces of a cake (a three-dimensional object). To maintain the proportions of a piece of cake, bars are of varying width. Other notable errors in this graphic include a non-zero

baseline for bars and a distorted time scale at the left of the graph. As a result of these errors, the ratio of perceived size for the largest to the smallest piece of cake is about 50 (using volumes) and about 15-20 (using areas), while the actual ratio of their sizes should be $3.5/2.75=1.27$.

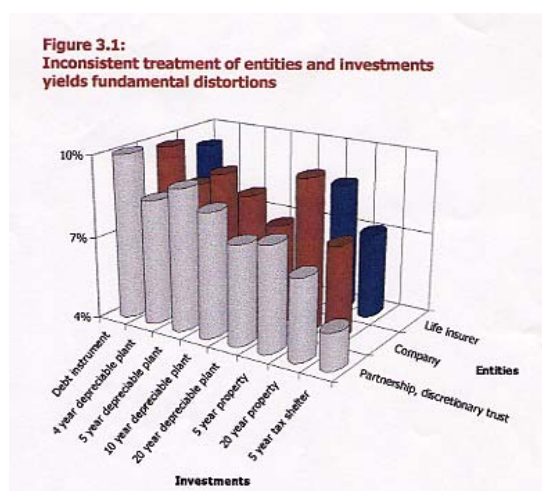


Figure 17¹⁵: Some fundamental problems arising from redundant dimensions include hidden bars and oblique baselines. Unfortunately, many of the measurements for life insurers cannot be recovered at all from this graphic, as they are completely obscured. The third dimension on this graph could be collapsed so that grouped side-by-side bars for each Entity could be presented on a two-dimensional bar chart with Investments on the horizontal axis and percentage on the vertical axis.

¹⁴ Source: Australian Education Union

¹⁵ Source: ©Australian Taxation Office (1999), *Tax Reform: not a new tax, a new tax system*.

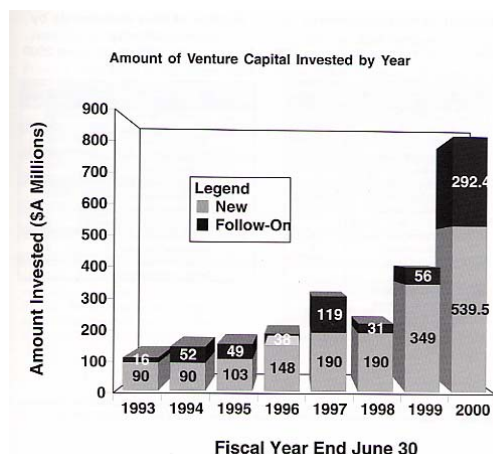


Figure 18¹⁶: Three-dimensional bars with perspective effects cause visual anomalies. In this case, the perspective induced has not only confused the artist (see the bar for 1996 where hidden lines and shading have been mistakenly drawn), but also means that the tops of some bars are visible (increasing their perceived height) while others are not. The effect is subtle but apparent.

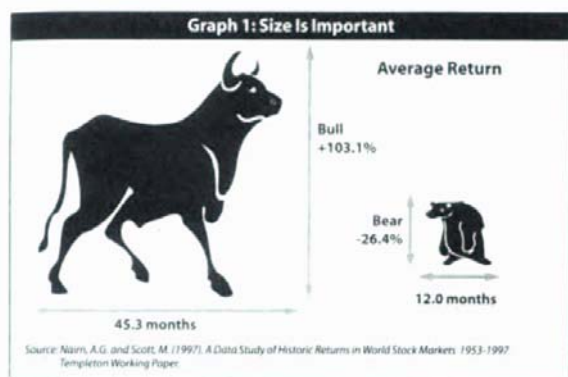


Figure 19¹⁷: Of bulls and bears. The graph encodes four numbers in almost the worst way possible. The decoration *is* the graphic! The information to be conveyed is that the average bull market lasts about four years and has a real return of about 100%, while the average bear market lasts about a year and has a real return of -25% . It is not clear how this comparison is served by depicting a bull that is, perceptually, about 10-15 times the size of a bear. This two-dimensional rendering of the data is largely

meaningless. The title of the graphic is richly ironic.

Not only does the problem of redundant dimension create distortion of information for viewers of a graphic, but it also slows their comprehension of the information in the graphic. A very interesting article by Fischer [12] explored the issue of whether redundant dimension in bar charts materially affected the speed of comprehension among viewers. He found that there was, indeed, a significant slowing of cognition for graphs containing such irrelevant depth cues. The last chapter of Cleveland [9] describes a number of other visual perception experiments with analogous results.

¹⁶ Source: Australian Venture Capital Association Limited – Year 2000 Yearbook. © Australian Venture Capital Association Limited

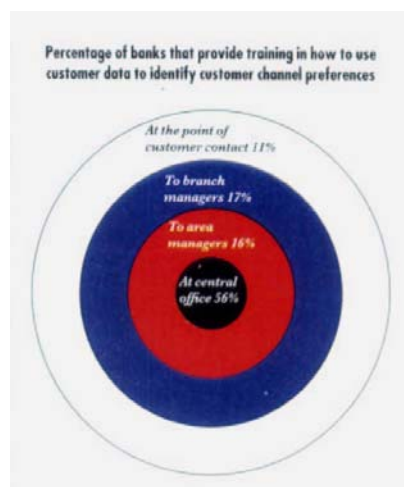
¹⁷ Source: © *Professional Investor* magazine, October 1997.

3. Excessive decoration

Graphics should be eye-catching, but not to the extent that the real information they should be communicating is drowned out by the extraneous decoration. Tufte refers to such elements as “chartjunk”. Decorations cannot rescue a graphic based on low or no substantive content. When decorations dominate a graphic, the graphic becomes itself a decoration, and it ceases to be a useful tool for communicating information. Worse still is when substantive content is hidden or distorted by decoration, because viewers may misinterpret or even distrust the information they receive. Put simply, if the information you wish to communicate is important, you do not need to highlight it with ornate decorations – the substantive content you provide will hold the viewers’ interest.

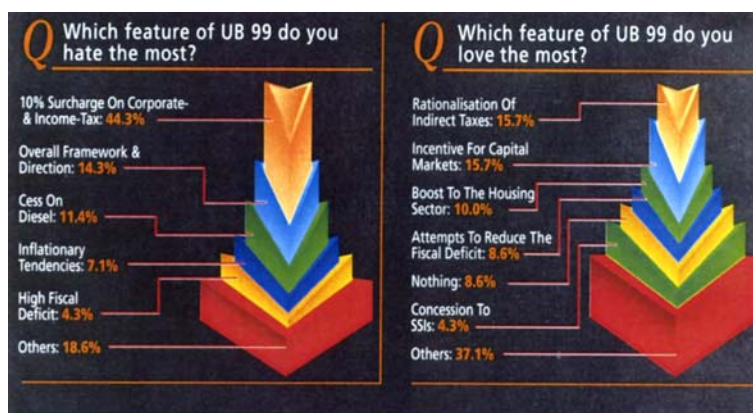
Figure 20: The excessive decoration Hall of Shame.

A¹⁸. More a target than a pie chart, but visually all wrong. The black circle, marked 56% accounts for only about 4% of the area of the figure. The red annulus, marked 16%, accounts for about 17% of the total area. The blue annulus, marked 17% accounts for about 34% of the total area. The white annulus, marked 11%, accounts for the remaining 45%. The graphic encodes only four numbers. Amazingly, although this graphic appears to be pure decoration, the red section actually has about the right percentage of the area!

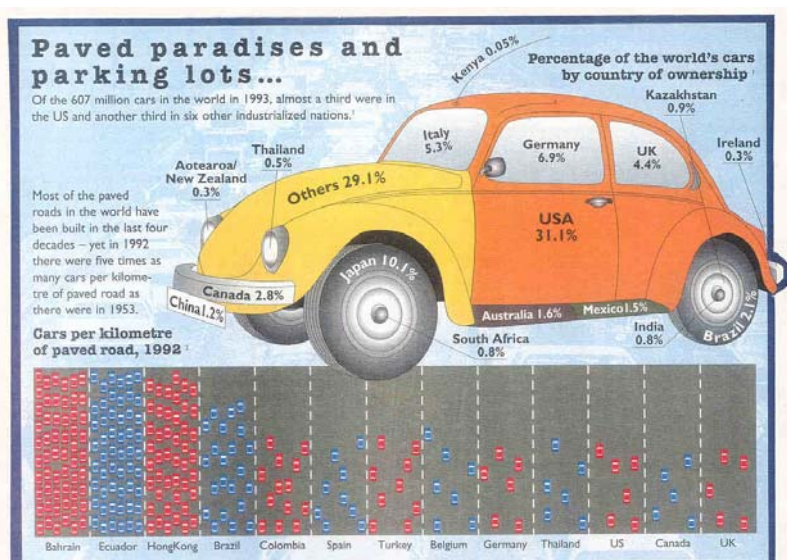


¹⁸ Source: ©BusinessWorld magazine, January, 1997.

B¹⁹. When is a pie not a pie? When it's a tower! Although the heights of the components of the tower appear to be in the right proportions, the perceived sizes (areas) of the pieces are definitely not. It certainly looks interesting, but it is not informative.



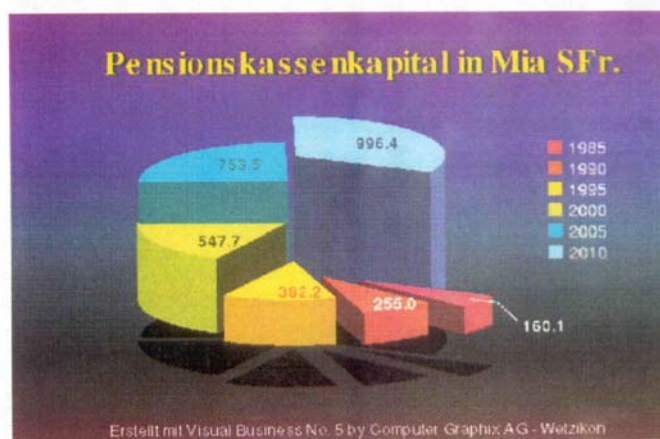
C²⁰. When is a pie not a pie, II? When it is a Volkswagen! The sizes of car parts represent the proportion of the world's cars in each of several nations. The sizes do not seem in the correct proportions (e.g. the proportion representing the US seems larger than 31.1% to the eye). We also question the value of any pie chart where the "Others" category takes about 30% of the chart. The bottom bar chart is unusual as well since it is not bar height that encodes information within the chart, but rather the density of cars within each bar.



¹⁹ Source: © *Business Today* magazine, March, 1999, reporting on the 1999 Union Budget of India (UB 99).

²⁰ Source: © *The New Internationalist*, May 1996.

D²¹: A pie spiral of pension fund capital. Each step of the spiral represents the amount of pension fund capital at five year intervals. The amount of capital is encoded as the heights of the sections, which appear to be in roughly the right proportions. Yet, the angle subtended by each section also systematically grows as the eye moves up the spiral, so the perceived size of segments – measured as volumes – grow much faster than they should. The amounts given are cumulative, though this is noted nowhere on the graphic. Conventionally, time is depicted as increasing from left to right. Here time grows in a spiral, purely as a decorative effect. The graphic encodes only six numbers.



4. Multiple vertical axes

Authors commonly construct graphics in which several data series are plotted on a single plot with vertical axes on each side of the plot corresponding to the different series. While this device saves some space, it almost always introduces visual effects that encourage inappropriate comparisons between the two series. If two series are thought to be related, scatterplots are a far better tool for assessing any relationship.

Intersections between lines on a plot with multiple vertical axes are particularly easy to misinterpret. Visually, intersections between the series suggest a sudden change in the ordering of the two series – one suddenly appears larger than the other. Of course, the effect is usually spurious, as the series are on entirely different scales, and the intersection is an artifact.

Similarly, varying slopes on a plot with multiple vertical axes lead to a misinterpretation as to the relative rate at which the two series are changing. The rate of change of each series is completely dependent on its vertical scale, so relative rates of change in a plot with two vertical scales are meaningless – indeed, by changing the scale on one of the axes, one can change the viewers' perception of the plot completely.

²¹ Source: © Computer Graphix AG, *Info*, January 1990.



Keeping in Step on the Exchange Markets

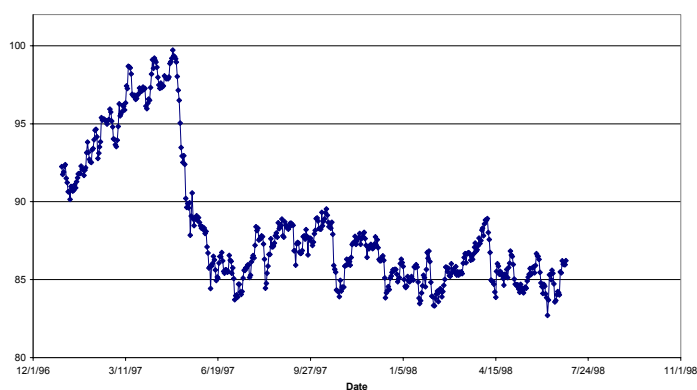


Figure 22²³: The graphic attempts to show the relationship between height and relative mortality risk by plotting two series, height and mortality, on the same graphic. Although the heights are presented in ascending order on the plot, they are shown as equidistant from one another when, in fact, they are not. Graphics must respect the fact that numbers have not only order but also magnitude, and failure to do so creates distortion. A much better graphic for examining the relationship between height and mortality is a simple scatterplot relating the two, depicted below the original graphic. A horizontal reference line was added to the new plot at height 1 to reflect a baseline mortality risk. Apart from the initial error of plotting multiple, different-scaled series on the same graphic, the graphic suffers a number of other weaknesses. These include the lack of explicit vertical axes, choice of stylized human figures as bars (redundant dimension), and ambiguity about where the “shadow” bars begin (do they begin at the feet of the human bars, or at the line separating red background from blue background). Somewhat serendipitously, the heights in the data are almost equidistant from one another, so the “shape” of the mortality curve depicted in the original graph is almost, but not quite, right.

Figure 21²²: The graphic shows the yen declining in value at about the same rate as the Australian dollar between January 1997 and June, 1998. Of course, the differing scales for the two exchange rates mean that the actual rates of change were very different. Note the right vertical axis is actually in *reverse* numerical order.

If, as the title of the graphic suggests, the goal is to show that the Australian and Japanese currencies were moving together, a simpler and more direct method would be to simply plot the Yen/\$A exchange rate against time. That plot, created using Excel, appears below and shows clearly that the two currencies effectively became linked (the level in the plot essentially stabilizes) after an apparently major event in May, 1997. The plot also gives an idea of how variable the “link” between the two currencies was, post-May 1997.

²² Source: © *Business Review Weekly*, June 1998.

²³ Source: © *TIME* magazine, November 11, 1996.



Grow Taller, Live Longer

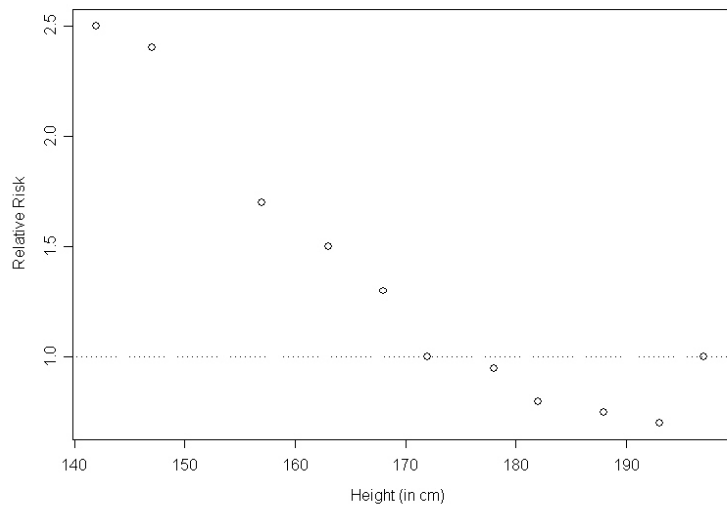


Figure 23, below, shows an example of where two series plotted on the same graphic interact particularly poorly, even though the series are just two ways of considering the same information.

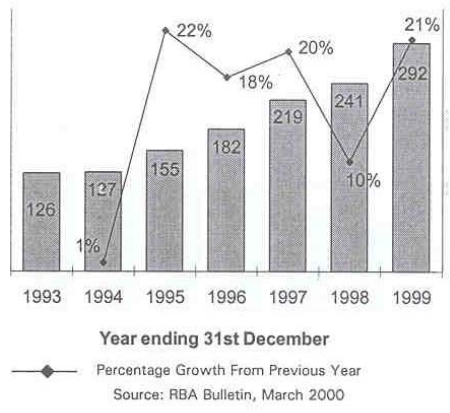


Figure 1.2: All Superannuation Unit Trust Funds Under Management

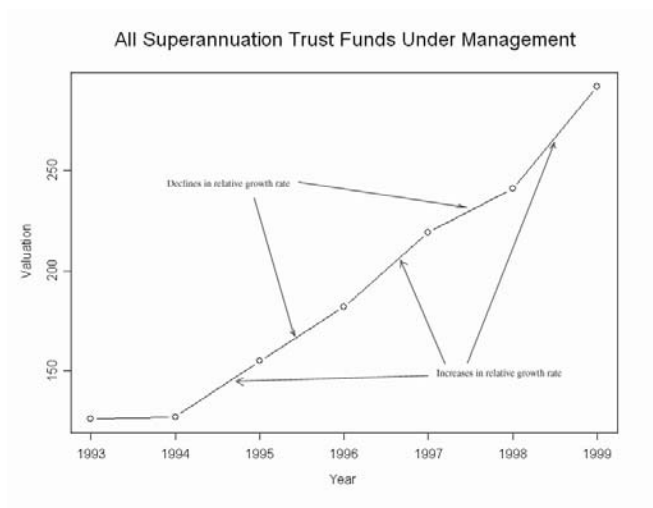


Figure 23²⁴: The graphic on the left represents the valuation of superannuation unit trust funds under management over several years in two ways: as raw amounts (bars) and via percentage growth from previous year (line). Both series are plotted on the same graphic, though no explicit vertical axes are provided (numbers are instead presented on the graphic itself). The plotted line is like a second derivative of the original series, a quantity that is not easily visualized. The two plotted series are visually at odds – although the original series always grows, the line plot suggests regular declines. In fact, the declines depicted are in the relative *rate* of growth. The graphic also suffers other construction errors. The mixing of graphical elements (bars and lines) is visually jarring. The lack of explicit vertical axes is also a problem as it forces the data to be presented directly on the graphic (which begs the question of why a graphic is needed at all). A more effective, and simpler, way to view the data would be to present a simple line chart of the original annual valuations – see the graphic on the right. Variations in growth rate are easily seen in such a graph as the line either levers up or down from its previous angle.

5. Breaking with established conventions

We all view graphics through a set of inherent filters that allow us to perceive information quickly and easily. Some of these rules are obvious, such as lines going upward on a page representing increase while downward sloping lines connote decrease; words should read left to right; when comparing graphical elements, larger objects represent larger numbers than smaller objects; and so on. Other rules are less obvious, but are nevertheless commonly encountered: time on a plot evolves from left to right on a horizontal axis and from bottom to top on a vertical axis; white represents absence while black represents presence; an object in the background of another, same-size object will look smaller. All of these rules reflect our real-life visual experience, and they assist our brains in coping with the incredible amount of visual information we must deal with daily by streamlining the process of understanding what we see. As a result, when these conventions are broken, either in the real world or in a graphic, we become confused, and information usually processed in the automatic, visual part of our brains must be passed to another part of our brains to be processed afresh. Conventions exert enormous impact on what we can understand easily, so we should not break them frivolously or carelessly. When you construct a graphic, think about what you *see* and relate it back to what you *mean others to understand* from the graphic. Linking the visual to the cognitive is an essential part of graphic construction. The following figures show how breaking conventions can radically alter viewers' perceptions of a graphic, to the point where they can perceive the complete opposite of what the information behind the graphic actually means.

²⁴ Source: Carrett and Stitt [7], *Australian Actuarial Journal*.

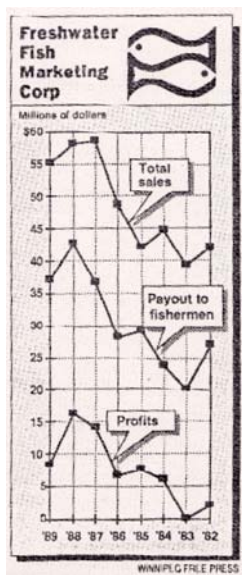
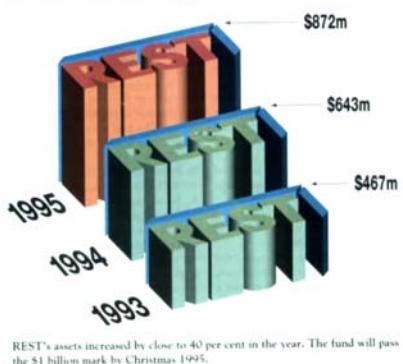


Figure 24²⁵: Fishing for profits. A quick look at this graphic suggests that sales and profits are falling for the Freshwater Fish Marketing Corporation. Time to get out of business? Hardly! A closer examination of the time axis at the bottom of the plot reveals that time is plotted in *reverse* from 1989 to 1982 – in fact, profits and sales have risen since 1982.

Assets continue to grow



REST's assets increased by close to 40 per cent in the year. The fund will pass the \$1 billion mark by Christmas 1995.

Figure 25²⁶: An initial viewing of this graphic suggests a three-year decline in assets until one looks to see the direction of the time axis – back and to the left. This graphic has numerous other weaknesses including redundant dimension (there is a real question as to which element, height or width, encodes the asset amount in this graphic), excessive decoration, and no explicit vertical axis. The graphic encodes only three numbers.

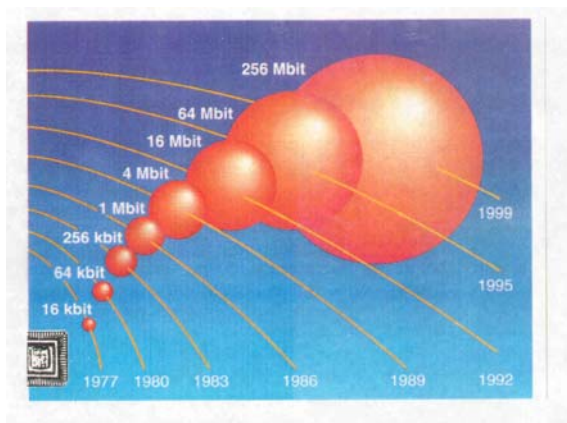


Figure 26²⁷: The speed of microchips has increased exponentially since 1977. But the curve traced out by the spheres in this graphic is turning in the opposite direction to that expected of an exponential increase. The *fact* of an increase is apparent, but the *nature* of the increase is not. Also, instead of increasing in equal-sized steps from left to right, the time axis in this graphic is traced out by a set of concentric curves. The spheres have volumes that are not in the same proportions as the numbers they represent. The graphic is far more decorative than it is informative.

²⁵ Source: © Winnipeg Free Press, obtained from <http://www.stat.sfu.ca/~cschwarz/Stat-301/Handouts/Descriptive/BadGraphs/seafood.gif>

²⁶ Source: Retail Employees Superannuation Pty Ltd (REST) *Super News*, October 1995.

²⁷ Source: © *Scientific European*, October, 1990.

6. A modern problem: too much power, too much choice

Ten years ago, producing graphics was the domain of the graphic artist. Unfortunately, graphics artists were more often trained in art than in statistics, and, as a result, many information graphics were beautiful to look at, but poor at conveying information accurately. Today, almost anyone with a standard PC running standard software can produce professional-looking graphics. Popular office software like Microsoft's Excel or Lotus' 1-2-3 spreadsheet programs can produce a dizzying array of graphics. Excel can produce 14 standard types of graphics – column, bar, line, pie, scatter, area, doughnut, radar, surface, bubble, stock, cylinder, cone and pyramid – each with multiple variants for a total of 73 basic designs plus numerous “custom” charts. Yet only three of these – the most basic bar/column chart, line chart, and scatterplot – are worthy of common use.

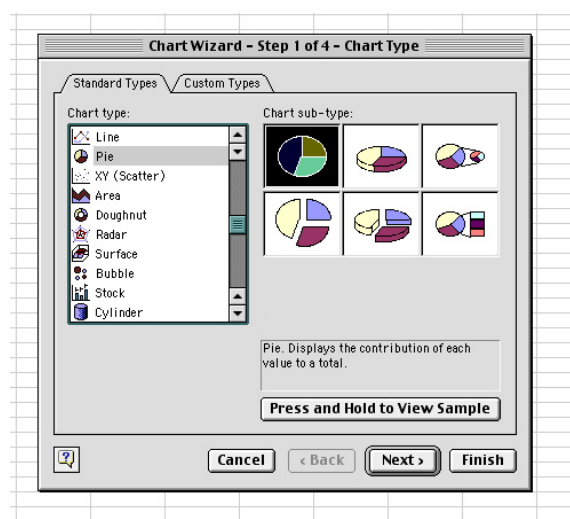


Figure 27: Choices, choices. Excel's Chart Wizard offers an astonishingly long list of graphical possibilities, almost all of them full of graphical pitfalls. Pictured are the six variants of pie charts: basic, 3-D, basic with sub-pie, exploded, 3-D exploded, and basic with sub-bar.

Bar and column charts differ only in whether the bars run horizontally or vertically. We prefer vertical bars, because “up” is a more natural direction to describe increase or accumulation than “left to right”. Three-dimensional variants of these charts always introduce redundant dimensions, and should therefore be avoided. Stacking of bars together makes comparisons of their components difficult since each component has a different baseline as we move from bar to bar. Variants which replace fixed-width bars by other geometric figures like cones or pyramids suffer redundant dimensions, but also fail because the shapes chosen are narrower at the top than the bottom, and so the bar's height is de-emphasized.

Line charts are particularly useful for representing data developing through time. Our strong preference is for line plots rather than bar charts to be used for time series data, since the joining of adjacent points in a line plot emphasizes the movement of the series through time, a visual element not replicated using bar charts. Three-dimensional variants of line charts are particularly hard to interpret. Area charts, created by filling the area under line charts, are generally ineffective as it is usually the height of the line above a baseline, not the area under the line, that encodes the appropriate information. Even if the area is used to encode information, ambiguity results as some viewers will interpret the height of the line as the relevant graphical element for perceiving the information in the chart.

Stock charts are a variant of bar or line charts that track high, low and closing stock prices for a particular stock over a number of days. These charts share the properties of bar or line charts, with the further advantage that professionals in finance are very familiar with their interpretation. Nevertheless, there is little to distinguish them from simple bar charts or line charts. We do, however, recommend line charts be used for stock prices rather than bar charts to emphasize the “flow” of stock prices over time.

Pie charts fail largely because although humans perceive straight lines very effectively, our ability to perceive subtle differences between sectors of a circle is unreliable and variable. Three-dimensional, exploded and doughnut varieties of pie charts only complicate our perceptual difficulties, and should never be used. Tables of numbers prove much more effective.

Scatterplots are very useful for exploring two-dimensional relationships, and higher-dimensional information can be encoded through the appropriate choice of plotting symbols. For instance, a relationship in four dimensions can be represented in two dimensions by plotting the first two variables as coordinates of a scatterplot, but instead of points, plotting rectangles whose height and width are proportional to the third and fourth variables, respectively. In a similar vein, Excel’s bubble charts use circles to encode a third variable. Bubble charts are not effective because the values of a third variable are encoded as the diameters of the circles, but the perceived size (area) of a circle is proportional to the *square* of its diameter.

Radar charts (also known as star charts) can be useful for visualizing continuous multivariate data, but the resultant shapes need to be interpreted carefully. They are best used in small multiples, where a large number of radar charts can be compared quickly to assess variability in multivariate data. Surface charts, including perspective plots, contour plots, and wireframe variants, are useful for visualizing three-dimensional data, but have limited use in other contexts.

Creators of graphics must not confuse artistic sophistication with graphical sophistication. In almost every case of graphic construction, simpler is better. Decorative or “realistic” effects like three-dimensional bars or complex shadings can dramatically affect viewers’ perceptions of a graphic, and should be shunned in favor of simple, unadorned elements. Remember, your content will drive interest in your graphic, and lack of content cannot be concealed by flashy visual effects. When constructing graphics using packages like Excel, and when faced with complex variants of simple graphical forms, ask yourself what the additional complexity might achieve. If the answer is only that it makes the graphic look nicer or more sophisticated, then opt for the simplest version in every case. Modern software gives us unprecedented choice when constructing graphics – exercise that choice wisely, always keeping in mind the needs of the viewers of your graphic.

5. Presenting numbers in technical communications

Communications by actuaries inevitably involve conveying complex numerical information to other actuaries, professionals from other disciplines and clients. From simple reporting of numbers to complex sensitivity analyses and financial simulations, the type and range of numerical information to be communicated are broad. These requirements impose a particular

burden on actuaries because many less-technical audiences regard numerical analyses and simulations as a kind of “black box” from which emerges the desired outcome – an answer or a decision. Yet, as all actuaries know, actuarial calculations and analyses are iceberg-like in that only a small fraction of the work carried out is ultimately displayed in detail. How the results of many hours of complex calculations can be pruned into a manageable, easily explained form is the major problem faced by actuaries seeking to communicate their work. Moreover, actuaries cannot assume that policy- and decision-makers are familiar with common actuarial terms, and so it is critical that all communications are cast in as simple and familiar a language as possible. Wise use of graphics is part of the answer to this problem, but non-graphical techniques are also important parts of the actuarial communicator’s craft.

The most important rule for communicating numerical work is that the communicator must always present the numerical results in a way that addresses the original question or issue in the same language as that in which the question was raised. The divide between formal, numerical answers and plain-language answers must *always* be crossed by the communicator, and the audience must *never* be forced to take this responsibility. Plain-language answers will be appreciated by the audience no matter what their technical level. Even for audiences at the highest technical levels, communications that summarize numerical results in a direct, easy to understand way will be regarded as insightful and useful.

The second rule for communicating numerical work is that, although a plain-language approach should always be used in summarizing the work, it is nonetheless important to recognize the power of numerical arguments and, therefore, not to avoid using numbers. Numbers carry meaning beyond what can be transmitted using only words and images, and their inclusion remains an important part of technical communications.

The key to following both these rules is, obviously, to strike a balance between detail and summary. Identifying the needs of the audience is critical to knowing what balance will work well, but some broad advice is possible that can assist communicators in finding the right mix.

- Regardless of what detail ultimately will be communicated, simulations and sensitivity analyses need to be broad enough to draw proper conclusions. Numerical results need to be backed up by appropriate rigor, and analyses that do not consider enough cases or which are based on inappropriate assumptions usually lead to incorrect conclusions and warped logic. Our experience, based on reading many reports and papers, is that too many authors promote “black box” thinking by testing their techniques on only a few “toy” cases before pronouncing the technique worthy. If a new methodology is to be recommended for use with real data, it should be tested out on real data. We have seen new techniques that were tested out on “data” drawn from just three theoretical distributions founder when they were first applied using real data. If real data cannot be obtained then simulation studies must be broadened to reflect real-world experience as much as possible. Similarly, sensitivity analyses must reflect the types of departures from set assumptions that are both credible and probable in the real world experience. Whenever new methodology is to be presented, the onus *always* rests with the presenter to demonstrate the merits of the new technique. If this demonstration is carried out in a half-hearted or unrealistic way, the methodology itself is discredited, and readers are likely to judge that the methodology does not work outside some simple examples.

- Actuary, heal thyself! Actuaries are well-trained in statistics, but all too often we see in papers and reports large tables of numbers presented, undigested, accompanied only by a dismissive statement that the author's conclusion is "clear from the information presented in the table". No matter how careful or correct the calculations underlying the creation of such tables of numbers, the content of the tables must be analysed with care, using proper, statistical techniques. Nothing should be declared as simply "clear from looking at the table" – this technique puts the burden of analysis on the reader, when it actually rests with the author. Further, greater care with such analyses of results often shows the stated conclusions to be far from clear given the information in the table!
- Actuarial modelling is an iterative process that generally cannot be faithfully described in a technical report or paper. More likely, the report will contain the final results of a modelling procedure, with little or no discussion of what other models were considered, what diagnostics were carried out on the way through the analysis, and so on. Usually, it is acceptable to merely state the results of the model-fitting exercise, but it is critical to at least mention what assumptions underlie the analysis, as well as a statement as to their tenability. Diagnostic procedures, though they form an important part of the modelling, would rarely be reported in the final document, and authors should resist the temptation to report their results as a step-by-step description of the analysis as it unfolded. Of course, any data uncovered as unusual should be noted, especially if they have been removed in the course of the analysis.

As an example of the application of these ideas, consider a general insurance setting in which the actuary is required to implement and describe a stochastic model for claims experience based on a number of rating factors. First, the actuary needs to consider carefully what assumptions will underlie the analysis. These assumptions would need to be clearly stated in describing the model, along with a reasoned discussion of choice of rating factors, availability and source of data, and so on. In this case, a generalized linear model for claims experience might be appropriate, and a formal statistical analysis of building a model would proceed. The actuary might then present the results of the model fitting, perhaps in a table, together with p -values for the various rating factors. While the formal modelling process is now complete, the actuary's task in communicating the information has only just begun. Readers cannot be required to draw their own conclusions from a set of p -values alone – many non-technical readers simply will be unable to make such judgements unassisted. The actuary must describe the final model in plain language, note what rating factors were found to be important in the analysis and which were not. Any anomalies that arise from the modelling process, such as factors that were considered *a priori* important but which were not included in the final model, need to be explained carefully, in as plain a language as possible. Finally, the actuary must draw a proper conclusion, which may include a formal recommendation that the new model be considered for evaluating future claims experience.

6. General issues in effective writing

Since technical writing is a subset of writing in general, the principles that govern good general writing undoubtedly apply to technical writing. Many of those principles are covered in abundance in many readily-available general style guides, the most authoritative of which are the University of Chicago's *The Chicago Manual of Style* [8] and Strunk and White's superbly-crafted, 85-page *The Elements of Style* [22]. It is nevertheless useful to cover the important issues here as well.

Grammar is important

Nothing annoys readers more than reports that are poorly written from a grammatical perspective. We don't wish to dwell here on the rules for good grammar – excellent grammar guides are available in the reference section in just about any bookstore. Nevertheless, certain issues do arise regularly that deserve special mention. First, if it is possible, writers should ask a colleague to read their work before they submit it to catch any glaring problems. At the very least, writers should use the automatic spell-checking and grammar-checking facilities built into modern word processors to catch the obvious spelling and typographical errors. All reports should be proof-read carefully, as spell-checkers will not find all mistakes. For example, we often see “form” instead of “from” used in reports. Astoundingly, despite the ready availability of good spelling and grammar-checking tools, we also regularly see submitted papers that would not pass a primary-school spelling and grammar test. These papers can usually be rejected quickly, as it is often the case that sloppy writing skills go hand-in-hand with sloppy technical skills.

We are reluctant in this forum to enter the ever-raging debate on the use of “I/We” in technical papers, and we feel that this is more a matter of style than of correctness. Masculine pronouns, and the ubiquitous “he/she”, should be avoided in favor of plural pronouns (they, their) to minimize the risk of alienating a large proportion of the audience. Other more formally grammatical issues, such as active versus passive voice and issues like maintaining the appropriate tense within a paragraph are also important, but are more than adequately covered in popular style guides.

Precise, Concise, Wise – Keep it Simple

As far as possible writers should adopt a precise, concise style that transmits information as efficiently as possible. Strategies that promote such a style are those that avoid complicated grammatical structures. While it is often tempting to do so, writers should avoid tangential comments or asides, particularly when the writing style required is formal. Writers need to think critically about what they are saying, even down to the level of small phrases. The adoption of a deliberately simple, concise writing style achieves this purpose admirably.

Of course, we must recognise that each writer has their own personal style, and that it is futile to try to produce automatons who each write in a uniform, simple manner. Nevertheless, it is possible to adopt a straightforward writing style without sacrificing your individuality. An easy step is to take the time to re-read each document you write and proof it, searching not only for

grammatical and technical errors, but also for stylistic gaffes that can be just as damaging to your report's ultimate fate as even the most grievous technical error.

Never say “die” – Words and phrases to avoid

Certain style guides essentially prohibit the use of long or difficult words, recommending instead that simple words be used whenever possible. We view this issue somewhat more liberally, arguing that these are matters more of style than substance. Nevertheless, it is true that simple, short sentences that use primarily simple, straightforward prose are unlikely to be ambiguous. Unfortunately, they also tend to be fairly dry and uninteresting to read. When writing, one should always have a dictionary and a thesaurus close by (we simply point our web browser to <http://www.dictionary.com>). Examples of words that can and should be avoided (with alternatives shown in brackets) include: utilise (use); facilitate (help); endeavour (try); terminate (stop); transmit (send); demonstrate (show); initiate (begin or start); necessitate (need); elucidate (explain); and so on.

Don't be a draft dodger!

These days the temptation to compose documents at the keyboard is almost too great to decline. This practice has become extremely widespread as so many of our communications become electronic, and the proliferation of e-mail as a way of doing business has only worsened this bad writing habit. We are aware of several very able professionals who type every document they create directly into the computer, even composing complex mathematics “on the fly” thanks to the power of the modern “word” processor. Of course, such innovations have done wonders for “productivity”, subjectively measured in terms of pages of output. But they have also been partly responsible for a sharp decline in the ability of people to carefully *craft* their documents.

The benefits of on-line composition are obvious: changes to your document, even major ones, can be made simply and easily; whole sections can be added or deleted at a whim; built-in grammar and spell-checkers can eradicate typographical and other errors; and “intelligent agents” built into modern software can automatically structure documents into a variety of familiar and impressive formats. It is easier than ever for the written word to look professional. The same cannot always be said, however, for the quality of the content! No amount of “intelligent agent” software can alter the fact that writing, both technical and non-technical, is a *craft* that benefits from reflective thought and practice. In our experience, no matter how skilled the writer, the first draft of a piece of technical work is never acceptable as a piece of finished work. Indeed, the second, third and fourth drafts often need significant polishing before the final document is produced. Good writing requires not only skill, but also patience. A writer must be prepared to read and re-read their document several times and make changes as appropriate before the document can be considered for submission. Unfortunately, it is clear to us that many authors do not regard the process of refining a set of draft documents to a finished piece of work as either necessary or even desirable. Obviously, we strenuously contest this view.

Titles, Abstracts and References

Many reports are judged solely on the basis of their title, summary and reference list. Indeed, for many written works, these are the only parts of the document that are widely read.

The Title

Titles should be brief and descriptive. Obviously, these two goals are somewhat at odds, but we recommend that a brief title is usually more effective than a long one. In particular, the temptation to try to incorporate all the ideas from the report into the title should be avoided. The main question authors should ask themselves before selecting a title is “what would make *me* want to read this paper”. The answer to this question will invariably lead to a reasonable title. Fans of Dickens will be disappointed to learn of our disapproval of titles commencing with word like “on” or “wherein”.

The (Executive) Summary

In some ways, material for the summary needs to be chosen even more carefully than the title. It needs to adequately cover the main ideas from the report without overwhelming the reader with unnecessary detail. A good basic structure is to have a separate short sentence describing each of the main ideas in the report. Longer reports typically need longer summaries, but only in rare cases should the summary exceed a single page in length.

Mathematical or technical symbols are almost never useful in the summary, and effort should be made to convey necessary technical information in another manner.

References

Where a technical document is meant for wide distribution, the reference list is an important part of the work. Almost all technical work is derivative in some sense, and it is critical that the relevant research of others be cited fairly and appropriately. Only directly relevant items should be cited, unless the paper is clearly a review article in which case a more comprehensive set of references is appropriate. Writers should be careful not to unduly reference their own previous works. Of course, there is a natural tendency to cite one’s own work, especially if one views each article as part of a cogent line of thinking. Nevertheless, if a writer produces a reference list where their own citations significantly outnumber those of other authors, accusations of self-indulgence are probably warranted.

7. Effective presentation skills

Just as critical as the ability to write well is the ability to present technical information to a live audience. Although all of the principles of effective communication described earlier also apply to giving live presentations, a number of factors distinguish this form of communication from the others described in this article. We recognize that many of the guidelines presented in this section can be found in a variety of articles written specifically about presentation skills. Nevertheless, we feel strongly that good skills in this area are increasingly important as the actuarial profession evolves and actuaries take on more prominent management roles within companies.

Timing is a dominant issue in giving a presentation. Presentations usually have set time limits. Speakers should always adhere to these time limits as presentations that go over their allotted time can cause annoyance, even anger, in an audience. If you are speaking, you should assume that everyone in the audience has a plane to catch right after the talk, and time your talk

accordingly. Nobody will ever complain if you finish a few minutes early! Arrive early for your talk. Never rush in at the last minute and have to fight for oxygen as you begin to speak, as the audience will assume you are disorganized, and your entire presentation will be affected by that impression. Arriving early allows you to check that any equipment works, allows you to relax a little, and often gives you the opportunity to make yourself familiar with some of the audience.

The live component of your presentation is ephemeral – unlike in writing, there is usually no chance to edit out mistakes, or to totally recast a whole part of the presentation. On the plus side, there is a spontaneity associated with speaking to a live audience that cannot be captured in writing or other forms of communication.

Presentations afford the communicator a unique opportunity to directly interact with their audience, either explicitly through a genuine dialogue or implicitly by adjusting the presentation on the fly in response to audience reaction. A good communicator can sense the mood of the audience, and respond accordingly by varying the tempo of the talk – by focussing on particular issues that seem to pique the audience’s interest, or de-emphasizing topics that are clearly of less interest to the audience. The ability to skip ahead in a presentation or to slow down gives the communicator an enhanced opportunity to engage the audience’s attention – and to keep it throughout the presentation.

The forum of a live presentation often allows the speaker to use language less formally than is usually required in a written report. While speakers still need to structure what they say according to good grammatical rules, natural speech is considerably more free-form than writing. Other forms of non-verbal communication like eye-contact, gestures, and facial expressions evincing emotions (e.g., smiling!) are possible with live presentations, and if they are used wisely they can make the presentation come alive more than any written report could ever hope to achieve.

More than in any other form of communication, audiences for live presentations are precious. If you lose an audience during a talk, you may never get them back. Live audiences are notoriously variable, with factors like time of day potentially having a significant impact on audience behavior – a successful pre-lunch presentation could be a post-lunch bomb! As a result, audiences must be respected. Finding the right level for a presentation is a critical but tricky proposition. Never assume an audience knows nothing and speak down to them – this will *always* alienate a reasonable proportion of the audience whether they are knowledgeable or not. Use plain language as far as possible, avoiding jargon and colloquial expressions unless you are absolutely certain everyone in the audience will understand it. Regard the audience as intelligent but potentially uninformed, and fashion your presentation accordingly. Look at your audience’s faces and eyes, and learn from their reactions whether you are pitching your material at the right level – and adjust your presentation if necessary.

Try to learn beforehand the culture of the audience to whom you will be presenting. Will the audience expect to be able to interrupt to ask a question or will they wait until the end of the presentation? Will there be any particular people in the audience to watch out for – e.g., a senior manager who always asks a question out of left field – and think beforehand how you will handle that situation should it arise. Unlike writing, live communications can be fluid, and you will be

judged on both your presentation itself and on how you react to the moment within the live environment. The best approach to counter this uncertainty is to be enthusiastic and confident. If there is a lectern available, do not use it! Move freely on your “stage”, and directly engage the audience whenever possible. Speak at a comfortable volume, modulating your voice as you would when talking to a friend. Above all, be natural and as relaxed as possible.

Structure your presentation

Just because a presentation is live does not mean that it should not be carefully scripted, and, like all forms of communication, it should be structured in a way that is logical and clear. Begin by stating the overall goal of your presentation. Make it clear why what you are discussing is important, to whom it is important, and what your solution is. Audiences conditioned to sound-bites need to know the main message of your talk up front.

Whatever your preferred mode of presentation – overhead, PowerPoint slides, physical charts, or just plain speech – always prepare a handout for the audience to take away with them. A handout is a tangible reminder of your presentation, it gives your presentation a life beyond the hour in which you speak, and it also makes it possible for people who cannot attend the presentation itself to receive your message. A handout also signifies that you stand behind what you say – you are willing to commit it to paper, and hence to close scrutiny. Because the audience will be taking the handout away with them, it needs to be prepared carefully.

First, the handout must contain your name and contact details – if a question occurs to a person the day after your talk, they will want to contact you. The handout must also contain the date of the presentation as the date allows the audience to place what you say in some historical context. Preferably, the handout you create should be a document prepared specifically for that purpose, and not just a copy of your slides or a copy of the full, written report on which the presentation is based. Copies of slides tend to be too bare bones to serve as a reasonable handout. Yet you do not want your talk filled with people whose heads are all down annotating their copies of your slides while you speak. In a similar vein, a copy of the full, written report is likely to be too detailed to be a good handout – it will get filed and never looked at again as a reminder of your talk. People often go to talks so they can avoid reading the full report! The handout you prepare should be a summary of your talk, should cover each point you raise in plain language, and should include any key graphics or tables on which you want the audience to focus. The handout is also a safety valve in case you forget to mention an important point. It is a special-purpose document, and must not appear as simply an afterthought to the presentation itself. It will represent you far longer than the presentation itself will.

Although structure is important, live presentations are inevitably less-structured than written documents. This aspect of presentations is a double-edged sword. Some presenters fail to recognize that some structure is critical, and their presentations typically meander around and never make any real impacts. Good presenters impose structure on their presentations, but can take advantage of the freedom offered by the live environment to adjust their presentation in a variety of ways that promote audience engagement. For instance, judicious repetition of key ideas can be extremely effective in delivering the required message. Such repetition might

involve casting the same idea into a different setting, or, sometimes, simply repeating it verbatim for effect (an idea which almost never works in written communications).

The mechanics of presenting

Presentation has an element of presence and a physicality not found in written communications. It usually relies heavily on technology for delivery, and logistical preparation is an important component of giving an effective presentation. How material will be presented (overheads or PowerPoint?), how your output should look, what the room is like (lighting, layout), how large the audience is likely to be, even the time and day of the presentation, are all critical questions in the planning of your talk.

Most business presentations these days are delivered using Microsoft's PowerPoint presentation software, although some holdouts still use overhead projectors. If you are using PowerPoint, it is best to bring your own laptop computer (or, at least, one with which you are familiar) and your own data projector, to minimize the chance that you will be unable to operate the locally available facilities. This practice also avoids difficulties related to operating system differences (Windows/Macintosh/Linux), logins (you may not have an account on the system at the delivery site), and versions of available software. In cases where you are unsure of being able to access appropriate facilities, you should bring two copies of your presentation on separate disks (or preferably on CD – we have been in the audience when the sole copy of the presentation was on a defective floppy disk!) as well as a copy appropriate for use on an overhead projector. Be prepared for the worst!

Overhead slides

Overhead slides should be typed rather than handwritten, and should not be too crowded as people at the back of the room need to be able to read it. Dark ink should be used to promote visibility, and avoid at all costs what Tufte refers to as the “trapezoidal strip tease”, the practice of concealing the overhead and revealing the contents one line at a time. This technique can be annoying as it suggests that the presenter is hiding something from the audience. It also discourages the audience from engaging in the presentation as it forces them to follow the presentation at an artificially imposed pace and it encourages linear thinking.

PowerPoint slides

In many ways, presentations delivered in PowerPoint suffer most of the same problems as presentations delivered on overheads, plus some new problems related to the features of the software. As in the case of Excel, PowerPoint gives users an incredible number of choices for the display of information, but again our recommendation is for presenters to use many of the features conservatively. The interface for your presentation needs to be chosen carefully, paying particular attention to the following issues:

Colors: Color schemes need to be chosen very carefully to present the appropriate image. Dark writing on light backgrounds is recommended as it provides the best readability at a distance. Light writing on dark backgrounds is also a reasonable, high-contrast choice, but

is less legible at a distance, suffering particularly if the projection device is not focussed correctly. Other color choices are usually disastrous, particularly red writing on blue backgrounds which results in uncomfortable vibration effects. Also, combinations of red and green cause particular difficulties for members of the audience who are red-green colorblind.

Transitions, Advances and Fades: PowerPoint provides multiple sophisticated visual and sound effects that can be used in transition from one slide to the next, or even from one line within a slide to the next line. Without exception, these effects are flashy, distracting nuisances. The audience is not there to see a “movie”, complete with special effects. In fact, since almost everyone uses PowerPoint these days, it is hard to regard these effects as anything special any more. Transitions used to advance from one line to the next within a slide are the PowerPoint equivalent of the “trapezoidal strip tease”, a technique we refer to as “slideshow karaoke”, as the presenter inevitably reads each line as it zooms into view on the screen. Such techniques fail largely because they force the audience to read what is on the screen when what you really want them to be doing is listening to what you say. If reading the slides is all there is to your presentation, then you do not need to present it – just send the slides to be read when the audience finds time.

Fonts: As far as possible, use standard, sans serif fonts for your presentation. These fonts have maximum readability at a distance, and are guaranteed to be available on any standard computer on which you can run your presentation. Odd, or decorative fonts should be avoided at all costs – they play the same role in presentations as chartjunk plays in graphic construction – that is, they de-emphasize your content.

Backgrounds: Also avoid the use of distracting logos or backgrounds to your slides. Company logos should be discreet and tastefully placed. People only need to know where you are from once, so large distracting reminders on every slide are overkill. Similarly, PowerPoint’s default collection of clip-art is, by now, familiar to most people who have been to a presentation, and use of it, rather than making your presentation more interesting, may well remind members of the audience of talks they did not like. Why take that chance?

Layout: Slide layout is important, and PowerPoint’s default layouts are reasonable, though they favor the use of dot points more than we recommend. The use of dot points promotes simplistic, linear thinking, and we favor a more flexible approach that uses ideas like hyper-linking creatively to allow the presentation to respond to audience reactions. An approach that invites audiences to ask questions and make comparisons assists in turning the presentation from a monologue to a dialogue, and enlivens the presentation. Slides that mix text, graphics and numbers tend to be more interesting and promote such dialogues, but care must be taken not to clutter the slides too much.

Speaking strategies

Speaking before a live audience can be a traumatic experience, and some nervousness is common when confronted with this situation. Good speakers use this nervousness to their advantage by

channelling the resultant energy into an enthusiastic delivery style. Good communication is fostered if the audience feels comfortable with the speaker. Good eye contact, natural gestures, and a relaxed attitude will all help create such an atmosphere. If possible, have the lights on in the room when you are delivering your presentation. This choice will make it easier to establish and sustain eye contact with your audience, with the added benefit that it will be less likely that members of the audience will fall asleep. Unfortunately, the use of overhead projectors can require that the lights be turned off, but modern data projectors are powerful enough that they can be comfortably used with the lights on.

The best presentations are those delivered in a steady voice using a natural tone, much as if you were involved in a conversation with another person. Being natural will help you avoid nervous habits like uttering “umm’s and aah’s” or fidgeting. The best way to avoid these nervous habits is to realize the power of silence in a presentation. Never speak just to fill silence – the result is almost always less desirable than saying nothing! Speakers utter “umm” or “aah” as a filler for pauses while they summon the next word or phrase. But pauses between sentences or ideas can be extremely useful as they give the audience time to absorb what has just been said. Pauses can also be used deliberately to give more effect to the preceding statement. Silence can, indeed, be golden. Fidgeting can be controlled by holding a laser pointer or a pen, but such props should be used sparingly or their effect can be more distracting than a reasonable amount of hand movement.

Finally, always be ready for questions from the audience. Never react with surprise, dismay, or, worst, disdain towards the questioner. Your overall performance may be judged by how you handle direct interactions with the audience, perhaps even more so than by how you actually speak! Be aware that many questions are more directed at drawing attention to the questioner than towards embarrassing the speaker, so treat all questions with respect. Be prepared to take time answering questions, and to admit you do not know the answer if necessary. Questions can also be an excellent way to enliven your presentation, and encouraging questions sends the signal that you are confident and competent. One way to encourage questions is to “plant” a colleague in the audience who will ask a pre-arranged question. This approach can induce other questions from the audience, though it can backfire if your colleague deviates too far from the script.

8. Conclusion

While the content of most actuarial communication is obviously technical, the craft of communicating such technical information effectively is as much an art as it is a science. Just because the information to be conveyed is usually highly structured and detailed, this does not mean that you cannot exercise creativity and style in communicating it. Nevertheless, technical communications must conform to certain guidelines to be effective. Above all, understanding your audience’s abilities and needs is critical to the successful communication of your work. The rubric “say what you mean and mean what you say” captures the idea that good technical communications result from meaningful content described in a straightforward way. Further, the best technical communications recognize the power of combining text, images and numbers into a compelling presentation.

Finally, spend some time in the shoes of your audience. Learn from your own experience in listening to and reading the communications of others. Remember what attracted you to presentations you enjoyed, and what repelled you from presentations you disliked. Attempt to emulate the techniques used in the good presentations you have experienced, and take note of tactics that have failed to capture your attention in the others. Try to be as objective as possible in assessing how effective your communication style is. If you cannot be objective, ask a colleague to assist by critiquing your style.

Learning effective technical communication skills is a difficult and frustrating task, but the rewards of possessing such skills are well worth the price of obtaining them.

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