Why Experts Sometimes Do Not Perform Well in Unusual Situations

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Abstract

We expect that the quality of experts' decisions increases with their experience. This is indeed true for reasonably routine situations. However, surprisingly, empirical data shows that in unusual situations, novice experts make much better decisions than more experience ones. This phenomenon is especially unexpected for medical emergency situations: it turns out that the mortality rate of patients treated by novice doctors is a third lower than for patients treated by experience doctors. In this paper, we provide a possible explanation for this seemingly counterintuitive phenomenon.

1 Formulation of the Problem

At first glance, it would seem that the more experienced the experts, the better their solutions. This is indeed the case for reasonably routine situations. However, somewhat surprisingly, empirical data shows that in unusual situations, novice experts perform, on average, better than more experienced once. This is especially surprising in cases of medical emergency: in cases when high-risk patients were treated by relative novices, the mortality rate was a third lower than when patients were treated by experienced professional; see, e.g., [1, 2].

In this paper, we provide a possible explanation for this counterintuitive phenomenon.

2 Our Explanation

Formulation of the problem in precise terms. We have an observed value $\widetilde{x}$ of the desired quantity x. Based on this observation and on the expert's knowledge, we need to estimate the actual value x.

The observed value is imprecise, due to measurement and observation errors: the difference $\widetilde{x}-x$ is, in general, different from 0. Based on the prior experience, we can estimate the mean and the standard deviation of this difference. If the corresponding mean is different from 0, this simply means that our measuring instrument has a bias. In this case, we can re-calibrate this instrument, by subtracting this bias from all the measurement results. Thus, without losing generality, we can safely assume that the bias has been eliminated, so the mean is 0. Let us denote the corresponding standard deviation by σ.

The expert's experience-based knowledge consists of several cases for which this expert knows a reasonably accurate value of the corresponding quantity. For example, in the medical situation, an experienced expert is familiar with many cases in which, later on, the value of the corresponding quantity was measured more accurately. Let us denote the corresponding values by $\widetilde{x}_1, \ldots, \widetilde{x}_n$. These values are very accurate, in the sense that they are very close to the corresponding actual values x_i. However, all situations are different. As a result, the actual values x_i are, in general, different from x, and thus, the measurement results $\widetilde{x}_i$ provide only an approximate estimation for the desired quantity x. Again, from the previous experience, we can estimate the standard deviation σ_0 of the corresponding difference $x_i - x$.

Thus, we arrive at the following problem:

- we know the value $\widetilde{x}$ which is approximately equal to x with standard deviation σ:
$$\widetilde{x} \approx x \text{ (st.dev. } \sigma);$$
and
- we know n values $\widetilde{x}_1, \ldots, \widetilde{x}_n$ which are close to x with standard deviation σ_0:
$$\widetilde{x}_i \approx x \text{ (st.dev. } \sigma_0).$$

Based on these values, we must provide an estimate for the desired quantity x.

Let us solve this problem. A natural way to solve the above problem if to use the Least Squares technique (see, e.g., [3], i.e., to minimize the expression

$$\frac{(\widetilde{x}-x)^2}{\sigma^2} + \sum_{i=1}^{n} \frac{(\widetilde{x}_i - x)^2}{\sigma_0^2}.$$

Differentiating this expression by x and equating the derivative to 0, we conclude that for the resulting estimate $\widehat{x}$, we have

$$\frac{2 \cdot (\widehat{x}-\widetilde{x})^2}{\sigma^2} + \sum_{i=1}^{n} \frac{2 \cdot (\widehat{x} - \widetilde{x}_i)^2}{\sigma_0^2} = 0.$$

Multiplying both sides of this equation by $\sigma^2/2$ and moving all the terms not containing $\widehat{x}$ to the right-hand side, we conclude that

$$\widehat{x}\cdot(1+k\cdot n)=\widetilde{x}+k\cdot\sum_{i=1}^n \widetilde{x}_i,$$

where we denoted $k\stackrel{\text{def}}{=}\dfrac{\sigma_0^2}{\sigma^2}$. Thus,

$$\widehat{x}=\frac{\widetilde{x}+k\cdot\sum\limits_{i=1}^n \widetilde{x}_i}{1+k\cdot n}. \tag{1}$$

From the expression (1), we see that for this estimate, we do not need to know the individual values $\widetilde{x}_i$, it is sufficient to know their sum – i.e., equivalently, to know their arithmetic average

$$\overline{x}=\frac{1}{n}\cdot\sum_{i=1}^n \widetilde{x}_i.$$

In terms of this average, the sum $\sum\limits_{i=1}^n \widetilde{x}_i$ takes the form $n\cdot\overline{x}$ and thus, the formula (1) takes the form

$$\widehat{x}=\frac{\widetilde{x}+k\cdot n\cdot\overline{x}}{1+k\cdot n}. \tag{2}$$

How accurate is the resulting estimate? To analyze how accurate is this estimate, we need to consider the absolute value Δ of the difference between this estimate and the actual value x. Here,

$$\Delta=\left|\frac{\widetilde{x}+k\cdot n\cdot\overline{x}}{1+k\cdot n}-x\right|.$$

Explicitly subtracting the fractions in the right-hand side of this formula, we get the formula

$$\Delta=\left|\frac{\widetilde{x}+k\cdot n\cdot\overline{x}-x+k\cdot n\cdot x}{1+k\cdot n}\right|,$$

i.e., regrouping the terms in the numerator, the formula

$$\Delta=\left|\frac{\widetilde{x}-x}{1+k\cdot n}+\frac{k\cdot n\cdot(\overline{x}-x)}{1+k\cdot n}\right|. \tag{3}$$

Let us show that this formula enables us to explain the empirical phenomenon: namely, that while experienced experts make better decisions in routine situations, their decisions in unusual situations are worse than the decisions of novice experts.

What happens in reasonably routine situations. In reasonably routine situations, when x is close to the average $\overline{x}$ and thus, when the difference $\overline{x}-x$ is very small, the first term in the right-hand side of the formula (3) dominates, so we have

$$\Delta \approx \frac{|\widetilde{x}-x|}{1+k\cdot n}.$$

In this case, the more experienced the expert, i.e., the larger the corresponding value n, the smaller the value Δ and thus, the more accurate the expert's estimate. So, in such cases, indeed, the more experienced the expert, the more accurate his/her estimates.

What happens in unusual situations. Let us now consider unusual situations, when the difference $\overline{x}-x$ is large, so that the absolute value $|\overline{x}-x|$ of this difference is larger than the typical observation uncertainty $|\widetilde{x}-x|\approx\sigma$:

$$|\overline{x}-x| > |\widetilde{x}-x|. \tag{4}$$

In this case, for experienced experts, for which n is large, the second term in the formula (3) dominates, so we get

$$\Delta_{\rm exp} \approx |\overline{x}-x|. \tag{5}$$

In contrast, for novice experts, e.g., for experts with $n=0$ (e.g., medical doctors who have just received their degrees and do not have the experience of independently treating patients), we have

$$\Delta_{\rm nov} = |\widetilde{x}-x|. \tag{6}$$

Comparing the expressions (5) and (6) and taking into account the inequality (4), we conclude that here, indeed, $\Delta_{\rm nov} < \Delta_{\rm exp}$, i.e., that in such unusual situations, novice experts indeed make more accurate estimates (and thus, better decisions) that experienced ones.

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