Quantum Interpretation of the Intelligence Quotient

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The interpretation of IQ scores has been notoriously contentious for 80 years. Moreover, explanations are entirely lacking for some striking observations, such as the recent discovery that listening to music by Mozart temporarily raises IQ significantly, by nearly 10 points. Here I outline a new interpretation derived from quantum physics, the "QI of IQ."

My basic hypothesis is that intelligence arises from the vibrating molecules within our brains. There are a great variety of molecules, so our brains certainly oscillate with a wide range of frequencies. However, for simplicity, I adopt the approximation employed by Einstein in his famous paper of 1907 treating the heat capacity of solids. This represents the net effect by a single harmonic oscillator. The vibrational frequency, F, is proportional to the square root of the ratio K/M, where the constant K denotes the stiffness of the vibrating tissue (varying from airy to rocky) and M the effective mass (ranging from light- to heavy-headed). For the present qualitative discussion, IQ is considered to be directly proportional to the vibrational amplitude, although the precise relationship will need to be determined experimentally.

Figure 1 shows the probability distributions of the amplitude for the lowest three allowed quantum states of an oscillator, labeled by quantum numbers n = 0, 1, 2. Both the positions and number of undulatory maxima differ markedly for these distributions. The relative populations of the various states depend on the ratio F/T, where T is an effective temperature governed by interactions with the environment.

If T is sufficiently low compared to F, most of the oscillating molecules reside in the lowest energy state, n = 0, termed the ground state. The probability distribution of its vibrational amplitude indeed has exactly the same bell-shaped form as the IQ-distribution curve. According to the conventional IQ scale, the peak corresponds to IQ = 100. Scores one standard deviation higher or lower, IQ = 115 or 85, respectively, correspond to the maximum and minimum vibrational amplitudes within the re-

Figure 1. Probability distributions for the lowest three quantum states of a harmonic oscillator (n = 0, 1, 2). Dashed parabola indicates region of motion allowed by classical mechanics; shaded regions show domains made accessible by quantum tunnel effect. Vertical scale indicates energy in multiples of hF, where h is Planck’s constant and F the oscillator frequency. Horizontal scale indicates vibrational amplitude. According to the QI of IQ, the midpoint of the horizontal scale (zero amplitude) corresponds to IQ = 100; positive and negative excursions (expansion or contraction of the oscillator) are indicated in multiples of the standard deviation, which is 15 IQ units.
region allowed by classical mechanics (within the dashed parabolic curve). Amplitudes beyond this region, although classically forbidden, are allowed by quantum mechanics, but with rapidly decreasing probability. This is a consequence of the celebrated "tunnel effect," which permits a quantum particle to sneak into places that it does not have enough energy to reach. In the ground state, the total probability of achieving an IQ above 115 is about 16%. For IQs above 150, usually considered the "genius" range, the total probability is only 0.04%; that corresponds to only 400 people per million.

Fortunately, such "tunneling enhancement" is not the only way to achieve high IQs. If the temperature is high compared to the characteristic frequency, the oscillating brain may visit excited states more often than it resides in the ground state. As seen in Figure 1, in an excited state, the maxima of the probability distributions shift to wider amplitudes. The classically allowed region also becomes much larger than in the ground state, by a factor of the square root of $2n + 1$. By virtue of this factor alone, a ground state IQ of 115 would be amplified to 150 in an excited state with $n = 5$. This indicates that "temperature enhancement" as well as tunneling must have a major role in human intelligence.

Despite the undulations in the excited states, the sum of the probability distributions, with each state weighted by its population, in fact again has the same bell-shaped form as for the ground state. The width of the net distribution, however, is wider, reflecting the temperature-dependent population of the excited states.

Implications and ramifications of this QI of IQ are readily apparent, even to anyone well below the mean. Here I note only a few consequences:

1. The importance of the ratio $F/T$ resolves the old controversy about heredity vs. environment. For somebody born with a rock-hard head (large $K$) or an intellectual lightweight (small $M$), the frequency $F$ will be large, hence the vibrational amplitude small. Yet a sufficiently large $T$, supplied by a "hot" intellectual environment, can still provide a favorable $F/T$ ratio.

2. While people subject to intellectual excitement clearly can experience a large enhancement of IQ, that can occur also in a relaxed mode. This is analogous to pushing a child on a swing; a large amplitude can be obtained either by a mighty shove or gentle nudges, properly timed. The hitherto mysterious effect of Mozart's music surely results from such gently resonant nudges.

3. Since any oscillator contracts as well as expands, both the tunneling and temperature effects operate just as strongly to depress IQ. This immediately explains a commonly observed phenomenon (shamefully ignored by psychologists ignorant of quantum dynamics), the fact that often smart people do dumb things.

References