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## Is a Picture Worth a Thousand Words… in Energy?


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**Abstract**

The old adage that a "picture is worth a thousand words" is quantitatively analysed. The average energy used by men and women of Britain for speaking while standing is calculated per minute and the energy consumed per word is estimated. Energy consumption per word is estimated to be 0.0283J and 0.0223J for men and women respectively. The mass-energy equivalence equation is used to convert a physical picture's mass to energy. This energy value is then converted to words to see if the adage is on the right scale of magnitude, particularly for a picture of size A4.


**Introduction**

A "picture is worth a thousand words" is an adage that refers to the power of an image to visually convey an idea relative to the lesser capacity of language to describe that same idea or emotion. The adage is not intended to be quantitatively correct but rather is meant to give an impression of the immense scale of information that can be captured in an image. In this paper, the quantitative aspect of the statement is questioned, particularly with regard to the energy expense of spoken words and the energy stored in a physical photograph.

**Speech Energy Consumption**

Engaging in speech itself requires the expense of energy by the human body. This energy consumption is dependent on several factors. These can be individual specific, such as metabolism, gender, height and weight or can be situation specific, such as whether the person is standing or sitting whilst talking. The assumption used for this paper is the standing whilst talking situation.

The average age, height and weight of the average male and female in Britain were sourced in order to find an average value for calories expended per hour during talking. According to the study, the average British male is 38 years old, weighing in at 83.6kg and 175.3cm tall. The average British female is 40 years old, at 70.2 kg and 161.6 cm [1]. These values were input into an online calculator to calculate hourly calories use for speaking [2]. Note that the method of the calculation is unknown but assumed to be reliable. The output results of the calculator were 61 and 48 calories per hour of speech for men and women respectively.

These values were then converted to find the calories used per minute by dividing the above values by 60 minutes. Then the average word count per minute (wpm) for conversation was sourced. According to the National Center for Voice and Speech in the United States, the average is 150wpm [3]. It is assumed here that this is similar to the average conversational wpm of individuals in Britain. Thus, the average calorie use per minute of speech was equated to 150 wpm. The next step of the calculation was converted from the calorie unit to Joules, which is the SI unit for energy. 1 calorie is equivalent to 4.184 Joules. The calculations are shown below.

**Men**

$$\left\{\left(\frac{61}{60}\right) \times 4.184\right\} \text{ Joules per 150 words} = 4.25 \text{ Joules/150 words}$$

Therefore:

0.0283 Joules/word or 35.3 words/Joule

For 1000 words:

28.3 Joules

**Women**

$$\left\{\left(\frac{48}{60}\right) \times 4.184\right\} \text{ Joules per 150 words}$$
$$= 3.35 \text{ Joules/150 words}$$

Therefore:

0.0223 Joules/word or 44.8 words/Joules

For 1000 words:

22.3 Joules

**Physical Photograph Energy**

A physical photograph consists of ink deposited onto paper. The ink and paper both have mass ($M_i$ and $M_p$ respectively) which can be converted to energy ($E$) according to Einstein's mass-energy equivalence equation [4], where $m$ is mass in kg and $c$ is the speed of light, ~$3\text{x}10^8$ $ms^{-1}$.

$$E = mc^2 \quad (1)$$

The mass of paper and ink deposited to create a picture is often quoted in grams per square meter (gsm). If approximate values of these quantities are known, along with the area of the picture ($A$), the mass ($m$) for the above equation can be obtained. The 1000 factor is present in order to convert the grams to kilograms

$$E = \left(\frac{M_i + M_p}{1000}\right) \times A \times c^2 \quad (2)$$

**Calculating Word-Energy Value of a Picture**

Once a value is obtained from equation 2, this can be multiplied by the words/Joule count estimated for either men or women. This will give the total words that must be spoken in order for energy consumption to be equivalent to the energy stored in the mass of the picture.

An example calculation is included here. The most common picture printing paper used is between 180-200gsm [5]. As an average, 190gsm is used for $M_p$. One source stated that four colour offset printing can add up to 5 grams of ink per square meter ($M_i$) [6]. The area $A$ is for a typical A4 size sheet, which is 0.06237 $m^2$ [7]. This assumes the picture covers the entire sheet.

$$E = \left(\frac{5 + 190}{1000}\right) \times 0.06237 \times (3 \times 10^8)^2$$
$$\approx 1 \times 10^{15}\ Joules$$

For Men, this is approximately $3.5\text{x}10^{16}$ words. For Women, this is approximately $4.9\text{x}10^{16}$ words. This is on the scale of ten quadrillion.

Speaking at 150wpm, the average UK male will take around 443 million years of talking constantly to consume the same amount of energy stored in the photograph. Similarly, the average UK woman will take around 622 million years of constant speech.

**Conclusion**

Based on the assumptions made, it can be concluded that the adage may need some modification to be quantitatively correct. The equation 2 introduced here is flexible to include different masses of paper and different amounts of ink deposition so it can be used for a wide range of picture types. It could instead read "an A4 picture is worth ten quadrillion words in equivalent energy value". That is definitely something to mention when at loss for conversation topics to make the situation less awkward.

**References**

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