The Perfect Slap

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1 The Slap

1.1 Introduction

Has someone very annoyed you so much, that you want to cause agony inside of them, and not have to face the aftermath of physical injury. Fear not, for I have the perfect solution for you, one that has been developed and refined over thousands of years - *The Perfect Slap*. Not only with this powerful technique will you be able to confound your foe, and cause them a lot of pain, you will not have to face the consequences. This slap will allow you to damage the victim psychologically, whilst not leaving long lasting physical damage. By reading the following passage you will learn how to unleash a five-finger salute to your opposers face. If you are in a hurry, you can skip to the conclusion to get a nice science free summary.

1.2 Pain prevention

There are three main categories of skin in a human body, the uppermost layer is called the epidermis (literally meaning upon the dermis) and is approximately $60\mu m$ thick on your lower cheek. This is mostly made up of dead skin cells, usually around 25 layers. The epidermis contains very few nerve endings and is considerably thicker ($150\mu m$ thick) on the palm of a hand than anywhere else on your body, meaning this is the layer that will translate the least amount of pain to you. This implies that when you slap someone, you essentially have biological armour on your hand. I would not recommend using a backhand as the epidermis on the back of your hand is not as thick. Although a backhanded slap could be seen as more insulting, but it would make you go through some pain too - something we want to avoid.

1.3 Pain stimulation

From vigorous testing, I have discovered that the second layer of the skin is in fact the part that gives you the glorious feeling after slapping someone. It is the layer of skin in which the mechanoreceptors (the receptors that provide the sense of touch) are most densely packed. This layer of skin is hidden underneath the epidermis and is thicker in your lower cheek than anywhere else on a human cheek, so if you want to inflict the least physical damage this is where you should strike. The sensation of pain is associated with activation of afferent C-fibres (basically nerve endings) found mostly in the dermis. These fibres are stimulated by both mechanical and heat stimulation. A study done by B.Olausson in 1998 (Institute of Clinical Neuroscience, Sahlgrenska University, Sweden), showed that the level of activation of the C fibres was highly correlated with the reported subjective level of pain - to summarise, they used powerful lasers to see if people hurt. The experiment showed that when the site of pain was less than 1mm, very little or no pain was reported, but when the diameter of the pain site was larger, 3mm in this case, more pain was reported. This finding suggests the importance of the special summation of activity across multiple afferent C fibres in the perception of pain. Basically the larger the surface area of the slap, the more pain the victim will feel, whilst the same amount of physical damage will be done. Thus the objective of your slap will have to be to activate as many of the c fibres as possible in one hit, giving the victim a perception of extreme pain. However, I do not recommend slapping people multiple times to activate the fibres, this could result in a slapping overdose an incurable state, as of today.

1.4 Pain reception

Before going into the actual physics of the slap one must understand the different kinds of pain pathways that cause you to feel the slap. Whether there will be an acute or dull pain, whether pain reception will be fast or slow. Usually when you get hit, you instantly feel a sharp pain, much like the pain your groin feels after falling into the river in F rowing. This is caused by A-delta fibres which send signals to your brain at speeds up to $40ms^{-}1$ (around $90mph$). The more diffuse and dull pain that you later feel is caused by C fibres. These are relatively slower, travelling at $0.5ms^{-}1$ (around $1mph$). On top of this, A-delta fibres require less activation energy compared to C fibres, meaning that less energy is required to achieve a quick, sharp pain feeling. A research done by the Canadian Institutes of Health Research showed that when an A-delta fibre is blocked, the feeling of the C fibres intensify, this suggests that if the strike is quick it will cause more acute pain, which can also dull the sensation the victim might feel later on. There is also a state that enhances the fibres abilities to send signals to the brain, this is

called hyperplasia making you have godlike reflexes. It occurs when tissue damage induces pain, causing nociceptors to become even more sensitive to it after the initial onset. So essentially it is important to strike the victim quickly to inflict the most acute pain, whilst making sure that the victim is not already hurt or tired, because if the victim is hurt or tired he/she will most likely have longer lasting pains from the slap.

1.5 Physics of the slap

Since your hand stops when you slap someone, your hand ends up with zero kinetic energy. So the kinetic energy that was in your hand must get converted into other types of energies, such as heat and sound (and pure pain obviously) but in this case it would be better to minimise sound energy given off so that most of the energy goes into the cheek. Therefore I will work out the energy going into a human cheek based on how much heat is transferred into the cheek. Due to the laws of energy conservation, you can assume that around half of the energy in the slap will go into the victims cheek. So you can come up with an equation showing the kinetic energy that will go into the cheek:

$$K.E. = (\frac{1}{2}mv^2) * \frac{1}{2} \tag{1}$$

In this equation the second $\frac{1}{2}$ shows that only half the K.E. will go into the cheek. The mass of a human hand is aroundd $500g$ so $m = 0.5$. The heat capacity of human tissue is around $3.75kJ \cdot kg^{-1} \cdot^{\circ} C^{-1}$. To inflict a decent amount of pain, and yet not hurt someone that badly, you should raise their skins temperature (which has a mass of around $40g$ or $0.04kg$) by around $0.5°C$. Therefore you get an equation for the energy needed:

$$\Delta E_{thermal} = m \cdot C \cdot \Delta T \tag{2}$$

With the ΔE signifying the difference in energy, the m standing for mass, C for heat capacity and ΔT for difference in Temperature. Subbing all the numbers in you get $\Delta E_{thermal} = 0.04 \cdot 3.75 \cdot 0.5 = 0.075kJ = 75J$. Then you can sub in the $\Delta E_{thermal}$ from (2) for $K.E.$ in equation (1) and get the speed of the hand. Therefore $75 = \frac{1}{2} \cdot 0.5 \cdot v^2$ which means $v = \sqrt{300} = 17.3ms^{-1}$. That is quite fast, equivalent to $62.2kph$ or $38.6mph$, almost as quick as an Etonian when getting a run. That is also around the speed of a professional spin bowlers ball, or the speed of go leisure go karts. But unless you can calculate the speed of your hand in your head whilst about to slap someone, you can call it quite fast.

1.6 Conclusion

Bringing everything together, you should start the duel with an insult, to get the victims attention, and for their humiliation. You could also pretend you are doing a magic trick with your hands, and then confound them whilst they are mesmerised by the movements of your hands this can only be done once per person. The perfect slap should have a hand speed of around $17ms^{-1}$, basically move your hand quickly, like you are about to do a tennis serve. The slap should also aim for the victims lower cheek, just above the jawline, but in front of the ear, this is the place with the highest density of pain fibres on the cheek, also it is known to be the best place to leave your glorious 5-star mark for everyone to see. If you hit the ear with that speed you could risk seriously damaging the victim, although it could be used for strategic self defence. The slap should also be done when the victim is least expecting it (for the shock factor), and also when the victim is at a resting heart rate (ie not doing any physical activity) to make sure there isnt longer lasting pain. Happy Slapping!