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Let's crack that joint: Psychoacoustics of the noise that gets under your skin

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Abstract

Despite common misconceptions linking joint cracking to arthritis, the behavior remains widespread, with many individuals finding it pleasant or stress-relieving. This study investigates the psychoacoustic properties of joint cracking to understand which joints produce pleasant sounds and sensations, and what specific acoustic features drive these subjective perceptions. We recorded and analyzed the self-elicited cracking sounds of 40 participants, covering over 590 joints (including fingers, cervical vertebrae, and others), and extracted over 150 audio features. Participants subjectively rated their auditory and sensory impressions using adjective scales, alongside personality trait assessments. Results indicate that cracking sounds from different joints occupy distinct acoustic spaces based on brightness, attack time, and acoustic annoyance. Specifically, finger cracking sounds are brighter, have shorter attack times, and are less annoying than neck or back cracking. Furthermore, the perception of pain and physical relief closely correlates with specific timbral characteristics, such as acoustic roughness and energy in the 500 Hz and 1000 Hz frequency bands. Finally, the study reveals that personality traits significantly influence how these sounds are perceived, demonstrating that the subjective enjoyment of joint cracking is deeply intertwined with objective acoustic properties.

Keywords: *psychoacoustics, audio signal analysis, joint cracking, personality traits, pleasantness*

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1. Background

The connection between cracking (finger) joints and the development of arthritis has long been suspected. However, studies examining joint-cracking behavior in children and older adults were unable to confirm this [1]. Despite the debunked claim that joint cracking is linked to arthritis, approximately 75% of the population still believes that joint cracking leads to joint disease later in life. About 18% are afraid of the cracking sound itself [2]. In alternative medicine, joint cracking is viewed as a sign of successful joint manipulation [3].

According to current research, small gas bubbles are formed over time in the joints at the edge between the joint bones and the synovial fluid. When the joint cracks, tension is applied at this edge, causing the gas dissolved in the synovial fluid to accumulate. This process is called tribonucleation [4]. The pressure required to produce a cracking sound is approximately 13 newtons. At a certain point, the bubbles implode, causing a "pop" or crack. This process has also been confirmed by mathematical models, and the calculated frequency spectra match the measured ones [5]. 75% of the energy applied is released abruptly as a cracking sound, noticeable as a rapid expansion of the synovial fluid. Finger cracking can reach a sound pressure level of 83 dB_{SPL} at a distance of 1 cm from the tibonucleation vesicles [5]. In joints that have been cracked shortly before, the joint space expands linearly and returns to the "pre-cracking curve" over the course of 20-30 minutes. Only after this the can joint be cracked again [4]. About 18% are afraid of the cracking sound itself [2]. At the same time, however, more than 75% of the study participants reported that they find the sound associated with joint cracking to be at least "pleasant"; nearly 50% associate the sound with stress relief [2].

2. Research Question

To better understand the perceptions of people who crack their joints, this study focuses on two questions:

- Which joints produce a cracking sensation that is particularly pleasant to hear and feel?
- Which acoustic properties are responsible for this impression?

3. Methods

For this study, the joint cracking sounds of 40 participants (20 ♀, 18 ♂, 2 ⚥, ages 18–45, average 23.2 years) were recorded on-site at the University of Vienna and Graz University of Technology and evaluated by the participant themselves. In total, the cracking sounds of 224 finger joints, 54 cervical vertebrae, and 316 other joints were recorded using a low-noise large-diaphragm microphone (Austrian Audio OC818, at a distance of 10 cm) under comparable room acoustic conditions (recording studio with RT60 ≈ 200 ms). The joint-cracking sounds were then analyzed for over 150 audio features. The participants rated the auditory and emotional impressions of their joint cracking using adjective scales (see Table 1). In addition, personal reasons for joint cracking, individual cracking habits, and personality traits were assessed using the Short Eysenck Personality Profiler (SEPPO) [6].

Table 1: Adjective scales (1–7) used to rate one's own perception of the cracking sensation and to rate the sound of each crack.

About the sound impression:	
dull	sharp
loud	quiet
low	high
full	hollow
familiar	irritating
unpleasant	pleasant
About the cracking sensation:	
heavy	light
relaxed	tense
releasing	non-releasing
unpleasant	pleasant
painful	not painful

Finally, correlation analyses and t-tests were used to examine the relationships between the crack classifications, the audio characteristics, and the personality traits.

4. Results

Regardless of age, gender, and personality traits, people liked cracking their finger joints and cervical spine the most. 95% of those surveyed said they like the sound of their own cracking.

For the following analysis results, p-values less than 0.05 are marked with an *, those less than 0.01 with **, and those less than 0.001 with ***.

4.1 Reasons for Joint Cracking

In addition to rating the sounds and sensations associated with joint cracking, participants were asked to explain why and in what situations they crack their joints. The responses were analyzed qualitatively. The activities during, before, or after which joints are cracked can be summarized into three factors:

- Lack of activity/boredom
- Stressful situations
- Physical or mental strain

It turns out that cracking one's joints is particularly common as a way to pass the time during periods of boredom (e.g., while waiting or sitting). Participants also crack their joints in stressful situations or when feeling nervous as a way to achieve mental balance. On the other hand, there is physical (and mental) tension, with participants reporting that they crack their joints before or after exercising, attending a lecture, playing music, or studying.

The reasons cited for joint cracking relate almost exclusively to the sensation and less to the sound it produces. Although all 40 participants surveyed stated that they generally like the sound of their own cracking joints, just under a third (30%) added that they do not like the sound of other people's joints cracking. It becomes clear that the evaluation of the sound appears to be linked to the physical characteristics of the process. The following reasons for cracking one's own joints were cited most frequently:

- Relaxation, a sense of release, stress relief
- Keeping busy (e.g., with the fingers)
- Habit
- Enjoyment of the cracking sound

4.2 Audio features of the Cracking Joints

The t-tests for the individual joint types that were cracked revealed three acoustic features that can be used to distinguish the cracking sounds of finger joints, the cervical vertebrae, and the thoracic vertebrae: based on brightness [7](fingers vs. neck: t = 8.306***; fingers vs. back: t = 10.179***; neck vs. back: t = 4.629***), attack time [7] (fingers vs. neck: t = -4.036***; finger vs. back: t = -4.510***; neck vs. back: t = -1.727***), and acoustic annoyance (according to Zwicker & Fastl [8]), a three-dimensional timbre feature space can be defined in which the three joints under investigation occupy distinct areas (see Fig. 1).

It is noticeable that the cracking sound of the fingers sounds brighter, has a shorter attack time, and is less annoying to the ear than the cracking of the neck and the vertebrae in the upper back. The cracking of the thoracic vertebrae, in turn, is also

brighter, less annoying, and decays more quickly than the cracking of the lumbar region.

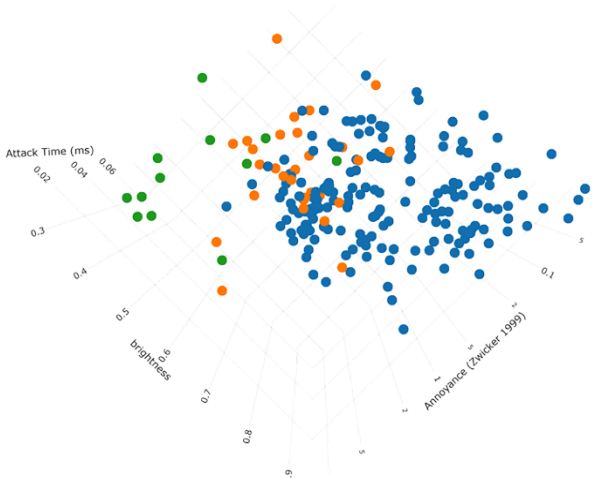

Figure 1. A comparison of the sounds produced by cracking one's fingers (blue), neck (orange), and back (green), based on the audio characteristics of attack time (in ms), brightness, and annoyance.

4.3 Correlations Between Cracking in Individual Finger Joints and their Audio Features

The obvious correlation that cracks perceived as sharper also have a higher value for acoustic sharpness (timbral sharpness [9]) was only partially evident in the correlation analysis across all cracking sounds (r = 0.359*) and was found to be significant only in the finger joints when the joints were analyzed individually (r = 0.356*), but not in the lumbar vertebrae or hemivertebral column cracking sounds.

Regarding the cracking of the fingertips, it is notable that as pain perception increases, so do the acoustic roughness (acc. to Vassilakis in [7]) of the cracking (r = 0.524***) and its energy content in the octave band around 500 Hz (r = 0.305*) (see Fig. 2).

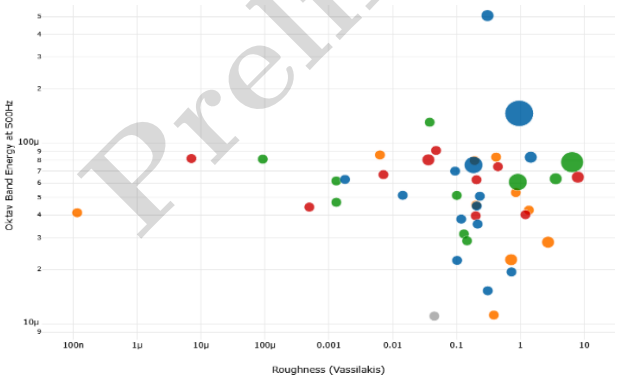

Figure 2. Perceived pain (represented by dot size) in the cracking distal finger joints of the thumb (gray), index finger (orange), middle finger (green), ring finger (red), and little finger (blue), as a function of timbral roughness and energy content in the octave band around 500 Hz.

In general, however, the cracking of the distal finger joints was perceived as pleasant. The perceived loudness is correlated with a shorter attack time (r = -0.349***) [7] and a higher energy component at 1000 Hz (r = 0.45***) (see Fig. 3). For the other finger joints as well, a correlation was observed between the attack time and the perceived loudness (in each case, the shorter the attack time, the louder the sound was perceived; r = 0.395***). Cracks that felt more relieving were associated with lower acoustic annoyance [8] (r = 0.289**).

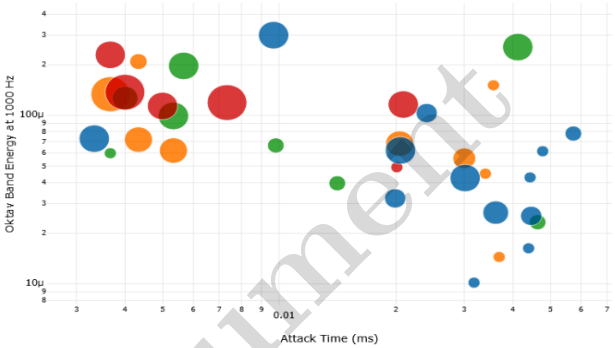

Figure 3. Perceived loudness (represented by dot size) of cracking finger joints of the thumb (gray), index finger (orange), middle finger (green), ring finger (red), and little finger (blue) as a function of attack time and energy content at around 1000 Hz.

For the vertebrae, cracking sounds with a longer attack time [7] (r = 0.729**) and a greater amount of energy between 2 and 4 kHz (r = 0.624*) were perceived as more tense, while those with increasing timbral hardness [9] (r = 0.600*) were perceived as less relieving. Paradoxically, the perceived volume decreases as the brightness [7] (r = -0.705*) or timbral sharpness [9] (r = -0.700*) increases.

Cracking sounds in the cervical spine were perceived as more pleasant when associated with a short attack time (r = -0.407*), high percussive loudness [10] (r = 0.429*), and a high energy amount in the mid-frequencies (1000 Hz: r = 0.458*). The perception of pain during neck cracking appears to be related to the timbral booming [9] (r = 0.411*) and its acoustic roughness (acc. to Vassilakis in [7])(r = -0.399*). In other words: the stronger the low-frequency components and the less rough the sound, the more painful is the crack impression.

4.4 Personality Traits and Perception of Cracking Sounds

The analysis of personality traits revealed that individuals with higher scores in extraversion were more likely to perceive their creaking sounds as satisfying compared to less extroverted individuals (t = -2.328*).

Individuals with higher neuroticism scores were more likely to perceive their creaking sounds as loud compared to less neurotic individuals (t = -2.657**).

For the psychoticism dimension, the t-test revealed several correlations: Individuals with higher scores on this dimension perceive their cracking sounds as lighter (t = 2.062*), find the sound more pleasant (t = 2.048*), quieter (t = 2.000*), more muffled (t = -2.644**), and richer (t = -2.955**).
With regard to the dimension of openness, no significant differences were found in the evaluation of sound and perception between people who were more vs. less open.

4.5 Interactive Display

Using the cracking recordings, and given the wide variety of different cracking sounds produced by the 40 participants, a 3D model of a skeleton and a hand was created, allowing users to interactively click on individual joints to make them crack. The scatter plots from Figures 1, 2, and 3 are also available as interactive versions with playable sounds at the same web address [11].

Figure 4. QR code for the study's website, including interactive scatter plots and clickable 3D joints: `https://muwiserver.univie.ac.at/body_crackles`.

5. Conclusion

It has been known for some time that the cracking sound produced when pressure or tension is applied to joints is caused by the implosion of small gas bubbles that accumulate between the bones and the synovial fluid during the stretching motion.
Based on the brightness of the sound, the attack time, and the degree of acoustic annoyance, cracking finger joints, the neck, and the vertebrae can be easily distinguished from one another by their different timbres. Cracking the distal finger joints becomes more painful as the sound becomes rougher and the energy components at around 500 Hz increase. As the acoustic annoyance decreases, finger cracking is perceived as more relieving. Pain associated with cracking the cervical vertebrae is accompanied by an increase in timbral warmth and — in contrast to the sensation of pain when cracking finger joints — by a decrease in roughness.
Overall, the cracking of fingers (especially in the distal joints) and the cervical spine have been rated as particularly positive.

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