

Zwicker E, Flottorp G & Stevens S S. Critical band width in loudness summation. *J. Acoust. Soc. Amer.* 29:548-57, 1957. [Psycho-Acoustic Lab., Harvard Univ., Cambridge, MA]

The effectiveness of critical band width (*Frequenzgruppe*) is demonstrated in loudness summation using 4-tone complexes and band-pass noises. The concept of critical bands as determined previously by methods involving thresholds, masking, phase, and loudness is discussed and related to Fletcher's critical masking ratio. [The *SCI*[®] indicates that this paper has been cited over 160 times since 1961.]

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"In October 1956 I came as a research fellow to Harvard's psycho-acoustics laboratory, Cambridge, Massachusetts. Perception of loudness had just started to be of interest for psycho-acousticians. To hire me with my background as an electrical engineer, for Smitty S. Stevens—the 'Boss'—was a kind of risk and neither he nor I was really enthusiastic; I, because I had not expected to work without daylight in the basement below Memorial Hall where the laboratory was located. How much Smitty changed his mind about me, I do not know; for my part, I was soon fire and flame and overcome by the fever that everybody felt working there close to Békésy, E.G. Boring, E.B. Newman, as well as Stevens himself. It was the special atmosphere, the conscientious, modest, but powerful spirit, and the personal, very distinct character that appeared in everything, even the beautiful red laboratory cat which usually sat in front of the main door in the sunshine.

"Of course, the equipment available was not overwhelming but with good ideas, hard work, and mutual understanding I knew outstanding results could be achieved soon. I started to measure the loudness of band-pass noise as a function of bandwidth. Looking in the electronic shop junkyard I luckily found some high-Q coils with obscure values which I used to build the narrow band filters needed, but, as a consequence,

ended up with center frequencies, obscure as well; the mystery why 440 Hz, 1420 Hz, and 5200 Hz became popular! Smitty—blowing up dozens of his famous smoke rings—and I soon started to discuss the *Frequenzgruppen* concept, that had been introduced in the Institute of Telecommunications, Technical University of Stuttgart, Germany, under the leadership of R. Feldtkeller. The limit dividing two ranges of bandwidth correlated with different behaviour which we called *Frequenzgruppe* was derived from observations at threshold (by Gassier), masking and phase (by myself), loudness of band-pass noise (by Feldtkeller and myself), and loudness of three-tone complexes (by Bauch).

"Some days later, Smitty showed me data from loudness comparisons with 4-tone complexes carried out by Flottorp during the summer before I came. The plots looked very scattered. Using the *Frequenzgruppen* concept, however, the data became meaningful and thus confirmed this concept. Meanwhile, I continued the loudness comparisons on noise bands. A discussion on how to publish the data ended up with the proposal to put Flottorp's tone and my noise data as well as the *Frequenzgruppen*-concept together and also to discuss the relation between Fletcher's critical ratio and the *Frequenzgruppe*. My English was still not nearly good enough to do that, so Smitty started to write while I finished the noise measurements and prepared the final figures. The most curious thing, however, was the fact that I did not know my coauthor personally. It was 20 years before I met Flottorp one day in Oslo where he works as professor of audiology at the Rikshospitalet.

"Since Fletcher's measure was not based on measurements as a function of the bandwidth, we decided to call it the critical masking ratio. The *Frequenzgruppe*, however, was translated into critical band. The critical band concept has been used very often since as a first approximation of the ear's frequency selectivity. This may be one of the reasons for this paper being cited. Another reason may be that the contents of several papers dealing with the critical band concept published by the Stuttgart-group in German were incorporated and thereby made available to readers without knowledge of the German language. I recently published a summary of the field in *The Handbook of Sensory Physiology*."¹

1. Zwicker E. Scaling. (Keidel W D & Neff W D, eds.) *Handbook of sensory physiology. Part 2. Auditory system. Physiology (CNS): behavioral studies in psychoacoustics*. New York: Springer-Verlag, 1975. Vol. 5. p. 401-48.