The complexity of timbre

Timbre is a complex matter. Sound quality, sound identity has many dimensions. Hermann von Helmholtz - founder of sound research - already noticed that. He had two different theories. One for the timbre of speech sounds, the vowels and consonants, and another theory for the timbre of musical instruments.

Helmholtz
According to him, the vocal perception was determined by formants: energy maxima at fixed frequencies. This was his so-called *Absoluuttheorie*. In his opinion, the timbre of musical instruments was only determined by the mutual strength ratio of the fundamental and overtones: the *Relativtheorie*. Later Stumpf doubted that and stated that there was more, for example the noise share in a sound. Khöler also showed that, depending on their frequency, also sine waves have a timbre similar to the vowels of speech. Khöler's thesis that simple harmonic sound vibrations already possess a vowel quality also indicates that timbre can not be seen separately from pitch. Just play a speech sample one octave higher or lower: as a real alchemist you have turned his identity into chipmunk or dinosaur.

Erich Schumann
In 1929 Karl Erich Schumann (Robert’s grandson) published *Die Physik der Klangfarben*. An important work in which he found a characteristic dimension of the sound identity of wind instruments and linked them to objectively measurable quantities such as frequency and amplitude. At first the 'spectral fingerprint' of sounds and secondly the variations in these 'fingerprints' related to different dynamic playing levels. He formulated his timbre laws (*Schumannschen Klangfarbengesetze)* by means of research on wind instruments such as oboe, English horn, bassoon, flute and clarinet.

His conclusion was that the timbre of these instruments can be explained accordingly as the timbres of the vowels. These instrument sounds also exhibit such a characteristic spectral envelope, a frequency characteristic with one energy maximum or several maxima at certain frequency(s). Formants, however less pronounced than with vowels.

Formantstreckengesetz
This is Schumann's first law. It states that the sound of for example an oboe is characterized by a characteristic spectral envelope: an energy maximum, a formant area around F6 (MIDI note number 89), regardless of the played pitch. Schumann discovered that as the basic pitch rises and gets higher and ends up in the characteristic formant area, the instrument loses its characteristic identity. If you play the entire scale of the instrument from high to low, it means that each pitch also shows a different mutual intensity ratio between the fundamental and the overtones.

Akustisches Verschiebungsgesetz
Another important discovery of Schumann can be found in his second law,

the *Akustisches Verschiebungsgesetz*. It involves shifting the energy in the spectral envelope from the lower to the higher harmonics depending on how loud you blow. The harder you blow, the more the energy shifts to the higher overtones. The spectrum envelope 'tilts' from its center point somewhat to the left. This second law is very fundamental for all acoustic sound generators. The greater the driving force, the more complex the vibration shape becomes. And, the more complex the waveform, the stronger the overtones.

Akustisches Sprunggesetz
Instrumental sounds, for example bassoon English horn and oboe clearly show two formants in their spectral envelope. In the case of forte playing on the instruments, the same phenomenon appears as with the *Akustisches Veschiebungsgesetz*. The maximum energy peak shifts from the first to the second formant area.

Formanten-Intervallgesetz
In this fourth law, Schumann states that the strongest overtone in the first formant area always forms a fixed frequency ratio with the strongest overtone in the second formant area: oboe 1: 2, English horn 2: 5, bassoon 3: 8.

Timbre: an American short-cut
In 1960 The American Standards Association (ASA) decided that a definition should be laid down. That it was difficult shows the definition: timbre is that which distinguishes two sounds of equal pitch and equal loudness.
Only a negative definition: anything that does not concern pitch and loudness. This ASA definition is therefore laid down no less than 31 years later than the publication of Schumann. And, there is no sign that indicates that Schumann has been read.

Prof. Dr. Dr. K. E. Schumann was in the wrong camp in World War II. Was that maybe the reason? Besides being a renowned sound researcher, he was also an authority in the field of explosives. And as such he was also head of the arms development agency of the German military.

It really could not have been this reason. At least, one of his pupils, Werner von Braun, made a great deal later with the Americans. He also was a leading figure in nazi Germany. Von Braun became head of the American missile program after the Second World War.

John Gray, 'Scaling The Musical Timbre'
And yes, if the Americans interfere, then Klangreich just becomes Soundistan. Because of that negative formulation of timbre, there is a lot of sound research that is based on isolated sounds that are all normalized to pitch and loudness. John Gray took it very thoroughly (1977). He made computer simulations of instrument sounds such as oboe, English horn, bassoon saxophones, flute, and string instruments all normalized by volume and one pitch, Eb4 (MIDI note number 63).

He then examined the differences and similarities with a computer analysis method that was very popular at the time: multidimensional scaling. The results looks impressive: One large sound cube containing all small cubes, the various instruments, all projected on their own place, determined precisely on the basis of the coordinates on the three dimensions of the large sound cube: left-right, front behind and low-high.

The left-right axis has to do with the degree of equality and inequality in the structure of the partials the sound. Front-back is related to noise components at the beginning of the sounds.

The vertical axis relates to the spectral energy distribution. This research found a lot of resonance in the Anglo-Saxon world and was often quoted positively.
I also was very impressed and used Gray's 'timbre cube' in my first FM publication. Shame on me...

Criticism came from the German professional press. In particular Christoph Reuter wonders how on the basis of isolated synthesized sounds, on just one pitch that often does not even reflect the instrument-specific character - Eb4 on the contrabass, for example - can draw conclusions about the real instruments, their entire range and dynamics...

WindInstrFrmnts
Load the `WindInstrFrmnts patch`. A simple synth patch in which different synthesis principles are united. Standard subtractive VCO> VCF> VCA, Formant synthesis with two band pass filters, and formant synthesis according to Fricke and Voigt, with a pulse wave signal with fixed duty time. Variations 1, 3, 5 and 8 show examples. It is actually an imitation of the Martinetta and the Variophon, one of the first wind synthesizers from the seventies from Germany. Go to www.variophon.de where you can find a very contemporary treatise - also in English - about this so-called Pulse Forming Synthesis. You will also find a very extensive bibliography on this topic

Schumann was still introduced to the Variophon. On 25 April 1985 he died, 87 years old. At his funeral the Heeresmusikkorps 2 from Kassel played "Ich hatt 'einen Kameraden". Schumann was also an excellent musician he composed marches and based his instrumentations on his own timbre laws.

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