

## Owen Jorgensen on Temperament

### About the Temperament Used by J. S. Bach and Others

By Owen Jorgensen

It was a significant historical event when J. S. Bach (1685 –1750) titled his volume of the 24 preludes and fugues finished in 1722 as "Das wohltemperierte Clavier" (The Well-tempered Clavier). This was the first time a great composer had written serious and lengthy keyboard music equally extensive throughout all the possible major and minor tonalities. Also, this was the only time in history that a composer mentioned on the music score a required tuning or temperament for the music to be performed.

The necessary specification in Bach's title that the keyboard must be "wohltempirte" was used to inform musicians who knew the meaning of the words "well-tempered" that Bach's new set of preludes and fugues could not be performed in any form of the traditional meantone temperament. Meantone temperament had been the standard common practice on keyboards since the early Renaissance. In this, the philosophy was to tune the most commonly used intervals as in-tune or harmoniously as possible at the expense of the other intervals that were never used during the earlier centuries.

In any meantone temperament form, two-thirds of the chords are far more harmonious and intune sounding than the same chords played in the modern equal temperament that is universally practiced today. Unfortunately, the remaining one-third of the harmony in meantone temperament is completely ruined by all of the out-of-tune intervals called "wolf" intervals. These are pushed into the remote, lesser used keys or tonalities on standard keyboard instruments. Bach knew that his music could never be performed in meantone temperament because of the extreme out-of-tuness among the raised keys (black keys on modern pianos).

In equal temperament, one can perform in all the major and minor keys without encountering any "wolf" intervals. Close approximations of equal temperament were used on most fretted instruments such as lutes and viols since the early Renaissance. Listening to the fretted instruments, musicians in history have always been familiar with the qualities and sounds of the quasi-equal temperaments. Regardless of this, "no Renaissance keyboard musician is known to have advocated or adopted equal temperament".(1) Musicians continued to use meantone temperament on keyboards even into the Baroque period. The basic harmony among the natural keys (white keys on modern pianos) that they used did not require equal temperament, and the music sounded significantly more harmonious and intune when performed in meantone temperament.

During the seventeenth century, there were a few progressive keyboard musicians who were beginning to modulate into the previously unused remote tonalities using many flats and sharps. This action required that the meantone temperament had to be altered somewhat. The practice of these musicians eventually culminated in the work of J. S. Bach who modulated through all the tonalities on his well-tempered keyboard.

Bach's term "wohltempirte" was based on the writings of Andreas Werckmeister (1645-1706) who was a prominent organist, organ examiner, music theorist, author, and composer. In 1681, Werckmeister wrote about "ein Clavier wohl zu temperiren und zu stimmen sey"(2) (a keyboard well to temper and to tune). In his book of 1691, he described the "wol temperirt stimen" and "der temperaturen wohl".(3) This terminology is now translated simply as "well temperament" in contemporary writing. For an example, see Willard A. Palmer's edition of Bach's *Das wohltemperierte Clavier*.(4) In some books, it is defined as "irregular temperament."

Werckmeister's well temperament published in 1681 was a continuation of the earlier process of altering meantone temperament to be more practical. His temperament was the first to modify meantone temperament enough so that one could perform throughout all the keys without hearing any "wolf" intervals, the same as can be done in equal temperament. The purpose of this well temperament was to preserve as much of the meantone temperament harmoniousness in the commonly used natural keys as possible while at the same time providing for unlimited modulation. This gave the progressive musicians an opportunity to avoid using the various quasi-equal temperaments which had always been despised because they destroy the harmoniousness in the commonly used keys that keyboard musicians had been accustomed to hearing for centuries. A valuable by-product of Werckmeister's temperament philosophy was the establishment of a variety of effects throughout all the keys that always provided interesting and refreshing color changes during modulations. This along with the harmoniousness in the popular tonalities were the advantages that well temperament held over equal temperament.

As a consequence of the more intune harmony in the natural keys of well temperament, it was necessary to allow the triads among the lesser used chromatic keys with many sharps or flats to become a little more dissonant than the same triads in equal temperament. Nevertheless, these rarely used triads were never considered to be intolerable. (With the great acoustical changes in the development of the modern piano, it has been found that these previously harsh harmonies add a significant resonance and beauty to the tone of modern pianos. This may be one reason why Chopin preferred the black keys.(5) Conversely, Haydn and Mozart composed mostly among the white keys because they began their training on harpsichords that did not have this acoustical advantage. However, they often modulated into the most remote keys in order to feature contrasting effects.)

Major thirds determine the color qualities or effects of triads or chords more than any other interval. Second in importance in this way are the major sixths and minor thirds. As the philosophy of well temperament developed, it eventually became apparent that the tonic major third C-E in the key of C must be tempered the least of any because there are no flats or sharps in the key signature for C major. In the keys of F and G which contain one flat and one sharp, respectively, the major thirds F-A and G-B were tempered alike and also a shade more than C-E. Continuing, B flat-D and D-F sharp were tempered more again because of the two flats and two sharps in the respective key signatures. E flat-G and A-C sharp were tempered still more and also very similar to equal temperament major thirds. This process continued around the circle of fifths until the ultimate was reached in the Pythagorean major third G flat-B flat which was the largest or most tempered major third allowed. This Pythagorean third (ditone) along with the four just intonation fifths involved was a final last remnant of the Greek thought from ancient times.

From the above, it is apparent that well temperament was not a haphazardly constructed temperament. Instead, it was governed by major thirds that gradually and evenly changed in their color effects around the circle. In this way, the major thirds supported the rules of tonality as it developed. Also, musicians could be secure in knowing what to expect as they proceeded to perform throughout all the tonalities.

According to theory, there can be only one equal temperament on the standard keyboard. In contrast to this, well temperament is an unequal temperament; therefore, an unlimited number of varieties of it are possible. When the major third rules are followed, the countless varieties of well temperament can be compared by measuring the amounts of tempering degrees done between C-E and G flat-B flat. The changing effects in various well temperaments can be either highly contrasting or very mildly contrasting, depending on the tastes of the tuners.

The tuning of equal temperament is a science based on following precise mathematical rules. In contrast to this, the tuning of well temperament can be a highly developed art depending on musical instinct,

experience, and aesthetic taste.

The slightly unequal tones of well temperament were the physical reason why the so-called "characters of the keys" existed on keyboards in the past. Most eighteenth-century musicians were aware of this fact. By the "characters of the keys", it was understood that each key such as C major, D major, etc., had its own unique distinctive qualities, personality, or key-color effects. Composers of the past chose the key for a piece that would enhance the spirit of their composition the most.

The "characters of the keys" cannot exist on keyboards when they are tuned in equal temperament. The reason for this is that intervals of a kind in equal temperament are identical in their sizes; therefore, there can be no varieties in this. Anyone of today who professes to hear any "characters of the keys" on an equal-tempered piano are psychologically deceived. It is psychological in equal temperament when one imagines that when one reads music written in sharps it sounds quite different from when it is written in flats. It is also psychological when playing music among the white keys it sounds different than when it is transposed into the black keys. Some musicians have acquired a second-hand appreciation of the "characters of the keys" through the spirits of the pieces in certain keys that they learned in childhood.

Werckmeister included the descriptions of several temperaments in his books, but he is famous only for his temperament known as the "Werckmeister III" published in 1681 and 1691. This is called "Werckmeister's Correct Temperament No. 1" in some books. His book of 1691, *Musicalische Temperature*, was highly successful and was distributed throughout Germany. It became a standard text book on tuning in Germany throughout the eighteenth century.

Werckmeister near the end of his life changed his mind about the unacceptability of equal temperament on keyboards. His new books published between 1702 and 1707 caused Werckmeister to be acknowledged as the prophet who made the practice of equal temperament on keyboards possible in Germany. To Germans, he is the father of equal temperament. Nevertheless, Werckmeister himself still preferred well temperament at the end of his life. He wrote that he was still willing "to have the diatonic thirds left somewhat purer, than the other, less often used ones". (6)

Bach had an indirect connection to Werckmeister through his very close friend and cousin Johann Gottfried Walther who was a disciple of Werckmeister. Walther visited or studied under Werckmeister in 1704. Werckmeister and Walther continued to correspond with each other. Walther's greatest contribution in music history was the completion of his monumental *Musicalisches Lexicon* published in 1732.

The most commonly used term for equal temperament in Germany in 1722 was "die gleichschwebende Temperatur". The fact that Bach did not use the title *Das gleichschwebende Clavier* for his preludes and fugues is a strong indication that he did not accept equal temperament as the best solution for his new music in 1722.

All the musicians of the past who were against the adoption of equal temperament on keyboard instruments referred to the loss of distinctive key-characteristics in equal temperament as the greatest tragedy in music. In 1722, each tonality had a special quality, and this provided a reason for Bach to compose in all the keys,

It is unlikely that Bach would have considered equal temperament for his project. For example, what purpose would there have been for Bach to compose in keys like C sharp major if he was using equal temperament? In equal temperament, the Prelude and Fugue in C sharp major sounds identical to its transpositions into C and D major. In C sharp major, music is significantly more difficult to read and play, and there is nothing to be gained by using C sharp major in equal temperament.

Bach's intellectual feat of writing music in the difficult keys like C sharp major and F sharp major is by itself not impressive. Any amateur eighteenth-century composer could have written a piece in C major and then proceeded afterwards to add seven sharps or seven flats to the key signatures. Obviously, there were other reasons like the "characters of the keys" to compose in the difficult lesser known remote tonalities. At this time in history, both Mattheson and Bach obviously were exploring for new effects in the previously untapped remote-key resources of well temperament. The current popular notion that Bach composed in order to demonstrate equal temperament is ridiculous. Lute musicians already did this centuries before Bach's time.

The knowledge of how to tune equal temperament by ear according to today's standards did not begin to exist until 1887 and was not fully developed until 1917. (7) All equal temperament by ear attempts done before 1887 were only rough versions of quasi-equal temperaments. During the eighteenth century, it was believed that a monochord was necessary for tuning equal temperament. In contrast to this, no monochords were required for tuning many of the well temperaments. These were easily done by ear because they were unequal temperaments that did not require the exact mathematical alterations such as those needed for equal temperament.

There is no known evidence that Bach needed a monochord while tuning. Also, it is obvious that none of the listening techniques discovered between 1887 and 1917 were known to Bach. If they were, this valuable information would have been passed along to his students and relatives. Instead, Bach's son, C. P. E. Bach in 1753, described in very faulty and deficient terms how equal temperament was tuned by ear. (8) The results of this could only have been a rough quasi-equal temperament.

Johann Mattheson (1681-1764) was a German composer, theorist, and the most important writer concerning music and musicians from the Baroque period. His education was exceptionally broad, and his musical abilities evidently were unlimited. As an avant-garde composer, Mattheson was writing in all twenty-four major and minor keys by 1719, predating Bach's effort by three years. As a spokesman of the times in 1719, Mattheson wrote, "It is not the purpose of music that all the twelve semitones be of equal size; rather they should all sound pure and lovely.... But when they are tuned equally they all sound false. So, why make this effort" (9) to tune in equal temperament? This attitude remained strong among musicians through the end of the century. Mattheson's Forty-Eight Thorough-Bass Test-Pieces in all the keys was finished in the same year as the above statement. This is an indication that in Bach's time musicians did not find it desirable to apply equal temperament even though the music was written in all the keys.

In 2002, Mark Lindley wrote, "None of the masterworks of late Baroque and Classical German keyboard music was, in fact, created in a pervading ambience of equal-tempered intonational sameness among the various triads and keys, although some forward-looking composers did tend, like C. P. E. Bach, to think in such terms". (10) In consideration of all the above, equal temperament is not used by Frank French in his new CD recording of J. S. Bach's The Well-tempered Clavier.

Johann Philipp Kirnberger (1721-1783) was a very important German music theorist who had studied composition and performance under J. S. Bach for two years beginning in 1739. In 1771, he wrote that equal temperament was still "impossible to tune without using a monochord.... Equal temperament abolishes the variety between the keys and leaves us with only two characters since all the major keys on the one hand and all the minor keys on the other are completely alike. Therefore, we have not only gained nothing by (expanding to) twenty-four keys, but have instead lost a great deal. For the simple diatonic scales as the ancients used them ... produced different keys with distinct characters, from which that key was best suited in expression could always be chosen. Equal temperament abolishes this and leaves the

composer only with the choice between major and minor." (11)

The above thoughts by Kirnberger reflected those of late eighteenth-century musicians. He also wrote, "Each key has its own special degrees (Sayten) and intervals through which it receives its own character, its own impression, both in the harmony and melody, and through which it is distinguished from all the others". (12)

Kirnberger revered J. S. Bach as being the supreme composer of all time. He dedicated his life to transmitting the theoretical principles of J. S. Bach. He also struggled very hard to get some of Bach's music published. In 1779, Kirnberger created a temperament known as Kirnberger III. In some books this is called Prinz or Aron-Neidhardt temperament. This is a wonderful temperament, and it is simply the Werckmeister III altered and improved. In the original Werckmeister, the major third C-E was tempered a small amount wide. In the Kirnberger, C-E was made completely pure in just intonation. This had the effect of increasing the amount of contrast between the least tempered and most tempered thirds. Thus, the contrasts were more striking, and the "characters of the keys" were supported to a stronger degree.

Since J. S. Bach trained Kirnberger in harpsichord tuning, it would be very easy to assume that the Kirnberger III temperament was Bach's tuning. Kirnberger's writings are a very strong indication that J. S. Bach preferred well temperament over equal temperament, and this also explains why Bach did not use the term *Das gleichwebende Clavier* for his music.

Friedrich Wilhelm Marpurg (1718-1795) was a German music theorist who began to promote the idea of equal temperament on keyboards in 1756. Evidently it was still not very commonly practiced even though it was acknowledged and approved of in Werckmeister's latest books. As an avant-garde equal temperament enthusiast, Marpurg became an archenemy of Kirnberger. In 1776, Marpurg reported that he learned from Kirnberger himself that J. S. Bach's temperament contained no just intonation thirds. Therefore, Kirnberger's temperament is also not used in the new recording of *The Well-tempered Clavier* by Frank French.

The Werckmeister III temperament of 1681 was the first primitive attempt at creating a good well temperament, and it contained a few crudities. Because of the minor flaws and the following considerations, the Werckmeister III temperament also is not used in the present recording by Frank French.

Forty-one years elapsed between 1681 and Bach's great composition of 1722. During this time, refinements were done. Bach tuned by ear. By applying his experienced musical instincts and great aesthetic taste judgements he could have very easily tuned according to Werckmeister's philosophy while at the same time instinctively eliminating all the flaws and crudities. Bach's tuning was certainly more refined than Werckmeister's published mathematical specifications which were no more than a theory on paper. Bach in applying his talent would not have been concerned about any mathematics or specific numbers of beats. These are needed only for theoretically precise methods like the modern equal temperament.

Since the Werckmeister III temperament roughly followed the key-signature rules of tonality that had been developing, the temperament can be classed as a musical temperament more than as a scientific temperament such as equal temperament. As an artful temperament it was better to tune it through music testing rather than by the monochord directions provided by Werckmeister.

Concerning the theory on paper, corrections and refinements continued to be done. Francesco Antonio Vallotti (1697-1780) was an Italian composer and theorist. He corrected F-A and G-B to become the same size because of the one flat and one sharp, respectively. In the same way, he also corrected the pairs E-G sharp and A flat-C as well as B-D sharp and D flat-F. In addition, he reduced the beatings of the tempered fifths significantly so they would become much more pleasant to listen to; otherwise, this was still the Werckmeister III temperament.

Thomas Young (1773-1829) was a natural philosopher, physician, writer, administrator of science, musician, and master of many languages including ancient Egyptian. He is famous in history for his undulatory theory of light. He had a thorough knowledge of acoustics and temperament history including that of equal temperament. His Temperament No. 1, written down in 1799, was the Werckmeister III corrected to the ultimate degree. As such, it was almost identical to the Vallotti correction except that the major third C-E was made slightly smaller than the paired thirds F-A and G-B. Also, the paired major thirds B-D sharp and D flat-F were made slightly smaller than F sharp-A sharp or G flat-B flat. The major third C-E was tempered only an extremely small amount wider than in the original Werckmeister III. Young's theoretical temperament was the first in history to follow the rules of tonality completely. More clearly, in progressing through the circle of fifths, each tonic major third changed in its size or tempering according to its key signature in an extremely even and dependable manner. Young's temperament is the most musically perfect temperament that has ever been published.

Young wrote that this temperament represented "the actual practice of the best instrument makers". (13) Thomas Young was certainly accomplished enough as a qualified acoustic scientist to make this judgement honestly. Young also wrote, "Indeed, in practice, this method, under different modifications, has been almost universal". (14) This temperament represented the common eighteenth-century practice more than any other; thus, it is often referred to as The Thomas Young Representative Eighteenth-Century Well Temperament of 1799. This is the tuning used in the new recording of The Well-tempered Clavier by Frank French.

Admittedly, this is still only another mathematical theory on paper; however, Bach and others who tuned from a musical standpoint rather than using monochords no doubt instinctively and empirically arrived at results very similar to the above. The process was simple. By ear they tuned the natural keys somewhat like in the old one-fifth comma meantone temperament, they let the fifths in the chromatic keys become pure, and they averaged everything in between so that triads when played in the order of modulation would change their color effects gradually and evenly. In any case, by using the theoretically correct Young temperament, authenticity is approached very closely according to present day knowledge. Bach's tuning certainly was more like the Young temperament than the Werckmeister III or any of the other known theoretical historical temperaments.

### The Effects on the Music

The Prelude No. 1 in C major from Book One of The Well-Tempered Clavier is an introduction to the whole set of preludes and fugues. It is written in a style that is quite different from the others. C major is the most harmonious key in all the well temperaments, and Bach's arpeggiated writing in such a high register reveals this clearly.

The major third between middle C and a higher E in the lowest parts is the only major third featured in this piece through measure ten. In measure eleven there is a lower G-B and in measure thirteen a lower F-A. These rather high major thirds are in a very exposed position, and they are ruined when played in equal temperament. Middle C-E in equal temperament has a beating frequency rate of 10.4 per second. This is entirely too fast to be pleasurable, and it gives C-E a very harsh quality. The lower G-B beats 7.8 per second, and F-A beats 6.9 per second which is still not good. As has been written previously, major thirds determine the effects or coloration in triads more than any other interval. Anyone who has become accustomed to hearing Prelude No. 1 in well temperament will realize how harsh this piece sounds in equal temperament and how unlikely it was that Bach used equal temperament.

If Bach had used equal temperament, he would have written this prelude in a much lower position in order to reduce the objectionable beating. In the high register that Bach chose for this piece, the arpeggiated harmonies sound like harps in heaven when played in well temperament.

In the Thomas Young Representative Well Temperament, the above major thirds C-E, G-B, and F-A beat 4.1, 4.3, and 3.8 per second respectively. In the original Werckmeister III, C-E beats 3.0 per second. In the Vallotti temperament C-E beats 4.4 per second. Any of these are a reduction by more than half from the objectionable beating of C-E in equal temperament. The fact that C-E, G-B, and F-A beat virtually at the same rate in the Young temperament facilitates the tuning process. Even though G-B and F-A beat roughly the same as C-E and therefore in vertical harmony they sound just like C-E, they nevertheless are tempered to be larger than C-E. Temperament scholars understand this truth.

In well temperament when Prelude No. 1 is transposed either a semitone higher or a semitone lower, it sounds unusually bad. This explains why there was much writing during the eighteenth century against the practice of transposition. Conversely, when transposition is done in equal temperament, nothing happens.

any sets of pieces through all the keys are arranged through the circle of fourths or fifths in the natural order of modulation. Bach's unusual and unique manner of arranging each prelude and fugue pair in a major key tied to a pair in the parallel minor key in chromatic step-wise motion may have been done for the following reason: In well temperament, when one plays a series of chords through a circle of fourths or fifths in the natural order of modulation, the changes in key-color effects are only mildly noticeable because they are so gradual. Conversely, when one plays the chords in chromatic succession up or down the scale, fantastic differences in qualities and effects are heard. To place a prelude and fugue in C major that has no sharps in the key signature nearby a pair in C sharp major containing seven sharps brings out the extreme differences in key-characters. The placing of the C minor prelude and fugue pair in between C major and C sharp major moderates the contrasting effects to be more tasteful. When listening to Bach's music arranged in chromatic order, the changing "characters of the keys" are always noticeable, and this adds interest to the music.

The vertical harmony in Prelude No.1 in C major sounds abrasive and less harmonious when it is transposed into C-sharp major in well temperament. Bach no doubt knew this. In his Fugue No. 3 in C sharp major he wrote the music from a melodic standpoint rather than a vertical harmony standpoint. By doing this, the vertical harmony problems in C sharp major were eliminated. Among the black keys, all melodies are greatly enhanced by the sharper leading tones and wider major sixths and major thirds in these keys. This offsets the losses in harmoniousness. Just as Prelude No. 1 is ruined when it is transposed into C sharp major, the Fugue No. 3 is spoiled when it is transposed down into C major. In this latter transposition, Fugue No. 3 sounds very lifeless and dead because of the much flatter leading tones and narrower major sixths and major thirds among the natural or white keys in well temperament

In the original meantone temperament published by Pietro Aaron in 1523, the three augmented seconds F-G sharp, B flat-C sharp, and E flat-F sharp were not the minor thirds F-A flat, B flat-D flat, and E-flat-G flat that everyone is accustomed to hearing as an interval having a ratio of 5 to 6. The augmented seconds in this temperament were smaller intervals that had a ratio of 6 to 7. These smaller intervals are often called small minor thirds. As an interval, they do not exist in equal temperament. In the well temperaments, the three above named augmented seconds were preserved as being the smallest minor thirds available in the temperaments. A fourth narrow minor third G sharp-B was added to the group.

The extreme narrowness of these intervals caused them to sound extra minor or sad and depressed in the keys of E flat minor, F minor, G sharp minor, and B flat minor. As a result, many authors in the past described the "characters" or emotions from these tonalities as being fit for extreme sadness, depression, grief, death, funerals, etc. (15) When listening to Bach's music in these keys, notice how closely he adhered to this spirit, especially in Book 1.

## Foot Notes

1. Mark Lindley. "Temperaments" in *The New Grove Dictionary of Music and Musicians*, second edition (New York: Macmillan Publishers Limited, 2002), 25: 253.
2. Andreas Werckmeister. *Musicalische Temperature* (Quedlinburg: Theodori Philippi Calvisii, 1691; reprint with an added preface and commentary notes by Rudolf Rasch, Utrecht: The Diapason Press, 1983), Rasch, 14.
3. The above reprint, 1.
4. J. S. Bach. *The Well-Tempered Clavier* edited by Willard A. Palmer (Sherman Oaks: Alfred Publishing Co., Inc., 1981), 3.
5. Owen Jorgensen. "The Well-tempered Clavier, Part 4." *Piano Technicians Journal* (November 2003), 33. "Part 5." (December 2003), 32. "Part 6." (January 2004), 34.
6. Mark Lindley. "Temperaments." 25:254.
7. Owen Jorgensen. *Tuning* (East Lansing: Michigan State University Press, 1991), 568-711.
8. C. P. E. Bach. *Essay on the True Art of Playing Keyboard Instruments* (1753). Translated by William J. Mitchell. (New York: W. W. Norton, 1948), 37.
9. Rita Steblin. *A History of Key Characteristics in the Eighteenth and Early Nineteenth Centuries*, second edition (Rochester: The University of Rochester Press, 2002), 51.
10. Mark Lindley. "Temperaments." 25:257.
11. Rita Steblin. *A History of Key Characteristics*. 74.
12. *Ibid.*, 75.
13. Thomas Young. "Outlines of Experiments and Inquiries Respecting Sound and Light." *Philosophical Transactions* 90, Part 1 (January 1800), 144.
14. *Ibid.*
15. Rita Steblin. *A History of Key Characteristics*. 225-298.