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# *PITCH STANDARDIZATION AND PERFECT PITCH*

This is really two studies in one. The first is a discussion of the social process of pitch standardization. Nature gives us a smooth continuum of audible sound frequencies on which there are an infinite number of points. But the frequencies of the pitches we actually hear every day cluster around just a few socially conventional points. The first part of this paper tries to explain how and why that happens. It differs from other accounts of pitch standardization (such as Lloyd 1954) in that it tries to show how pitch standardization is just one of many kinds of social coordination, and that all these sorts of coordination share abstract features in common.

The second part of this study is a report of six interviews with people who have perfect pitch (also called absolute pitch). Perfect pitch is, among other things, the ability to hear a musical note and then instantly give the name of its pitch. This part of the study is, on the one hand, simply an ethnographic report of the things I learned during six relatively open-ended short interviews with people who have perfect pitch. However, it is my conviction that one cannot come to a full understanding of perfect pitch without a full understanding of pitch standardization. In this sense the first part of the study is simply a preliminary to the second part.

Indeed, I propose the thesis that no one would be able to develop perfect pitch if the pitches they hear around them were not distributed categorically, in clusters around a few dozen socially conventional focal points. Since it is pitch standardization that creates this categorical distribution, perfect pitch depends on pitch standardization. To phrase it the other way around, pitch standardization is a prerequisite for the existence of perfect pitch.

We usually think of perfect pitch as a psychological ability, and of pitch standardization as a social fact. By discussing both phenomena in the same paper, I want to show how a mental ability, that seemingly takes place wholly inside our heads, is crucially dependent on a social fact.

## *PART I—PITCH STANDARDIZATION AS A SOCIAL FACT*

Music is composed of combinations of notes. Each note has a specific pitch, timbre, loudness, and duration. The only characteristic of musical notes we will be concerned with in this paper is their pitch, and to stress this fact, I will use the term "pitch" where I could use "note." By a "pitch," I mean a sound of a particular frequency: the frequency is the number of times per second at which the pitch causes the air to vibrate. Human ears—young ones, at least—can hear pitches with frequencies from about 20 to 20,000 vibrations per second, or hertz (Hz). We think of pitches with fewer vibrations per second as "lower" and those with more vibrations per second as "higher." The lowest, leftmost note on a piano usually sounds a pitch of 27.5 Hz; the highest, 4186 Hz.

When we play music, we usually play many pitches in succession, and often several pitches at a time. Music sounds good when the relationship between these pitches follows certain mathematical rules. What sounds good to us—or, to put it another way, what mathematical relationships between two pitches make those pitches sound good—is grossly dictated by unchangeable laws of nature, and then fine-tuned by the musical socialization that we go through as members of a cultural group. The natural constraint is that pitches sound best together when the ratio of their frequencies is the same as the ratio of two very small integers. Two pitches whose frequencies stand in a ratio of 2:1 combine better than any other pair. On the piano, we call pitches with this ratio by the same name (we call the distance between them an *octave*). Two other frequency ratios which sound especially good together are 3:2 and 4:3.

Within these natural boundary constraints, we restrict the set of pitches we actually use through two conventional processes of social coordination. These processes coordinate, respectively, tuning and temperament.

### *Tuning standardization*

The melody of a song is defined not by the *absolute* frequencies of its pitches, but by the ratios between them.[1] For example, there are plenty of melodies which we can begin to define by saying that the second note and the first note stand in a frequency ratio of 4:3—such as "Hark the Herald Angels Sing." If you are singing the first two notes of such a melody, it doesn't matter what pitch you start on. It only matters that you can follow that pitch with another pitch that has exactly four-thirds the frequency of the first. If you start at 300 Hz, you need to follow with 400 Hz. But you could just as easily start at 303 Hz and then follow with 404 Hz. Or, start at 360 Hz and follow with 480 Hz. And so

[1] For people with absolute pitch, who are aware of pitch identities as well as intervals, this is not strictly true (as we will see later). But this is a fair statement of most peoples' experience of music.

on. Now, a cello, or a human voice, can produce any of these starting pitches very easily. It can start at 300 Hz, 303 Hz, 360 Hz, or anything in between—321 Hz, or 345 Hz, or 333 Hz, or even 311.13 Hz or 323.23 Hz. And then it can follow that pitch with another that has exactly four-thirds the frequency. And then it can continue on with the rest of the melody.

This conveys an image of total freedom in terms of what pitch you start a song at. But there are in fact a number of factors which constrain this freedom, and in this section I will explain them one by one. Each factor provides some sort of motivation for musicians to get together to coordinate and restrict the set of pitches that it is OK to play. And with all these restrictions in place, it turns out to matter a lot what pitch you choose to start a melody on. As we'll see, of the pitches mentioned above, the only one that musicians are "allowed" to start a melody on is 311.13 Hz.

*Constraint #1: Ensembles must be in tune.* Each instrument must coordinate its starting pitch with the others. When several instruments play together—for example, the four singers in a barbershop quartet—it is important that they all keep a single reference pitch in mind—their "tuning" pitch. They then calculate the frequencies of the first note they sing, and ultimately of the rest of the pitches in the piece, as ratios based on this original pitch. Hence the tuning rituals that ensembles go through at the beginning of a performance. In some cases, one instrument sounds a note and the others match it, before the "performance" even starts; in others, the first note of the performance (sounded by a single instrument) becomes practically speaking a tuning pitch for the others. Such coordination between all the people who are playing at one particular moment is essential to a piece sounding good.

That makes it sound like it's OK for an ensemble to tune to any reference pitch they want—99, 500, 500.2, 666, 1492, whatever—as long as they tune to *some* pitch. But this is not true either, and it leads us to *constraint #2: Music must be within the range of the instruments*. Instruments have limited ranges. Each human voice can comfortably sing only so high and so low. The lowest pitch a cello can sound depends on the length of its strings. Now, all the pitches that an instrument plays in the course of a piece can be expressed as ratios of the tuning pitch or of the first pitch of the piece. So an ensemble has to use a tuning pitch that, for each instrument, generates a complete set of pitches *for the piece* all of which are within the range of the instrument. If a piece calls for an instrument to play pitches with frequencies up to twice the tuning pitch, and if the instrument has a maximum upper range of 1000 Hz, the tuning pitch must not be higher than 500 Hz or the instrument will not be able to play the piece. The coordination of pitch, thus, involves as well coordinating the limited ranges of all the instruments involved. Composers know this, and when they write music they keep the ranges of the instruments that will be performing it in mind.

What we've gone through so far makes it sound like for every piece there is a range of frequencies (say, from 300 to 500 Hz) to which an ensemble can tune, that this range depends on the ranges of the instruments being played, and that it doesn't matter which frequency within that range is selected as a tuning pitch as long as some frequency gets selected. But in fact, this is not true either. Well, it is true in ensembles which consist solely of instruments with a continuous pitch range, such as the human voice, the cello, and the trombone. But many instruments do not have continuous pitch ranges. A piano has eighty-eight keys, so it can produce just eighty-eight separate pitches, not an infinite range. The recorder and the xylophone are similarly limited, but it is first and foremost instruments with keys, such as the piano and the organ are built to be able to play only a very specific set of pitches. These instruments' pitch ranges can be termed discontinuous, discrete, categorical, or digital. This leads to *constraint #3: An ensemble which includes a discontinuous-pitch instrument must play the pitches that that instrument is set to.* Though a piano can be retuned so that it produces a different set of pitches, this is a time-consuming chore that takes special training and can't be done on the fly. Some other instruments, once made, cannot be changed to produce pitches other than their factory presets. So in order to perform a piece which includes an instrument with a discontinuous pitch range, an ensemble has to coordinate with the particular set of pitches that that instrument can produce. If, within a certain range, a piano is tuned to produce notes of, say, 500 Hz and 540 Hz (but not 518 Hz, 532 Hz, and so on), it is essential that a choir singing to the accompaniment of this piano tune itself so that it sings pitches whose frequencies form integral ratios with those of the piano. The choir will need to sing pitches with frequencies of (continuing the example) 250, 270, 500, and 540 Hz, and *not* 259, 266, 518, and 532 Hz.

Keeping these three constraints in mind, then, makes it sound like there is a range of frequencies (again, say, from 300 to 500 Hz) to which the continuous-frequency instruments in an ensemble can be tuned, and that the actual frequency within that range which will be used depends on the frequencies which the discontinuous-frequency instruments accompanying the ensemble have been set to produce. But if there is more than one discontinuous-frequency instrument in the ensemble, this is only a fair statement if you assume that their pitch sets match—which is not something that can be taken for granted. This leads us to *constraint #4: In ensembles with multiple discontinuous-frequency instruments, the sets of pitches that they produce must match.* And, as I mentioned, resetting the set of pitches which a discontinuous-pitch instrument can produce is always difficult, and sometimes impossible. So it is essential that those instruments *come to the ensemble ground* in a state in which their pitch sets are already coordinated. It won't do to have a piano set at 500 and 540 Hz and a xylophone or an oboe at 510 and 550 Hz. That means that the piano tuner who worked on the piano several days before, and the factory workers who manufactured the oboe or the xylophone some years before, need to have set both to produce the exact same set of pitches. That is a type of social coordination which goes well beyond the simple ritual of tuning at the beginning of a performance. It requires a coordinated agreement about a socially standardized set of pitches that extends both over time—from the manufacture of the instrument through the time of the performance—and over space—from the place where the instruments were built to the hall where the music is made.

These four requirements—that ensembles be in tune, that music stay within instruments' ranges, that continuous-pitch instruments tune to discontinuous-pitch instruments and that all discontinuous-pitch instruments have matching tuning—are essential to good music making and they require and result in a tremendous degree of coordination of pitch. Though the number of points on the continous line of frequency values is infinite, the set of pitches that one will hear in any particular performance is extremely limited.

### *Temperament standardization*

The other way in which we restrict the set of pitches that we play is through our choice of a set of pitch *relations* that we consider well-formed and proper. As I explained above, music consists of more than single pitches; we usually play many pitches in succession, or several pitches at the same time. A piece of music can be defined (partly, at least) by the ratios between these pitches. There is, in theory, an infinite number of pitch-pairs (defined, again, by the ratio between their frequencies) that we could play in a piece. As I explained above, the ones we actually use are partly constrained both by natural factors: pitches with integral frequency ratios sound good together. However, there is a conventional, cultural aspect too. *Which* integral frequency ratios you choose to use is a matter of convention. And, in fact, modern Western music has chosen to thumb its nose at natural constraints by using a conventional temperament system which deliberately, though slightly, skews those "perfect" integral ratios.

In Western music, we typically use a set of pitch ratios which can be reduced to twelve basic ratios, the smallest of which (1:05946:1) we call a half-step and the largest of which (2:1) we call an octave. These twelve ratios correspond to the seven white and five black keys in each octave of a piano.[2] Other cultures and even certain Western composers have chosen to work with sets of pitch ratios larger or smaller in number than twelve.

[2] Ratios above the distance of an octave are derivable from this basic set of twelve. In fact, all twelve ratios are actually derivable from just one—namely, the ratio of a half-step, which is the twelfth root of two, or 1.05946:1. The frequency of each note on the piano stands in this ratio to the frequency of the note to its left.

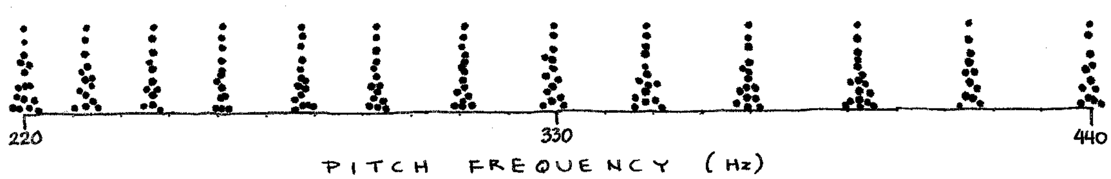
For reasons I won't go into fully—but which basically have to do with giving more flexibility to instruments which have a restricted set of discontinuous fixed pitches, such as the piano and organ—the pitch ratios that we currently use are very slightly different from the integral ratios that sound best to our ears. This perturbation, known as equal temperament, is a relatively recent innovation in the history of musical temperament. It means that instead of using 3:2 for the ratio known as a fifth, we use 2.996:2. Though this doesn't sound quite as good as a ratio of 3:2, it is not very far off, and over time we adjust our ears and get used to it.

Though it is difficult to appreciate at first, temperament and tuning standardization are entirely separate problems of coordination. Temperament standardization is actually logically prior to tuning standardization. Temperament standardization involves choosing what intervals, ratios, or relationships we think create pitches which sound good together. Tuning coordination merely involves the choice of what frequency to use as a reference pitch, or starting point, when we play music which is in a certain temperament. The set of intervals chosen during the process of temperament coordination provides the input to our tuning coordination activities, because it gives us the formula for deriving from a given reference pitch all the other pitches we will play. Thus for a piano tuner, the decision of what temperament to tune a piano in needs to be made before the piano tuning starts.

***How tuning and temperament limit the set of pitches that we actually hear***

When we agree on a standard temperament and a standard tuning pitch, it severely restricts the set of pitches that we hear when instruments make music. If musicians agree on the equal temperament system, and on a base tuning frequency of, say, 500 Hz, people out there in the world will only ever hear those pitches whose frequencies are derivable from 500 Hz by applying the twelve basic ratios I mentioned above. In fact, since 1939 the international standard tuning pitch has been fixed at 440 Hz (see Lloyd 1954 for the story). In Western music tuned to our tuning standard of 440 Hz, we will hear pitches with (for example) frequencies of 349.23, 369.99, 392.00, 415.30, and 440.00 Hz. We will never hear pitches of, say, 355, 375, or 402 Hz. The privileging of pitches like 415.30 Hz over pitches like 402 Hz is entirely a matter of convention, not something dictated by nature.

To understand the effect that this has on our experience of sound, imagine that we took a sheet of graph paper, ruled a line on it, marked one end of the line as 220 Hz and the other as 440 Hz, listened to several CDs or went to a concert, and then proceeded to record the frequencies of all of the pitches we heard. We would get something like this:




It is not that it is physically impossible to produce pitches in between the clusters on this chart, but rather that it is not socially conventional for musicians to do so. In other words, it is not nature, but rather the social conventions of standard tuning and of equal temperament, which have produced clumps or aggregations at these points. Standard western tuning is a social fact.

Thee tends to be upward pressure on pitch standards, and orchestras sometimes tune a little high.[3] But even if they tune to 443 Hz rather than 440, this will not generate pitches that, for example, fill in the experiential gap between 415.30 Hz and 440 Hz. At most, bright tuning will simply extend the range of the 415.30 Hz cluster up to around 418 or 419 Hz. It still will not produce pitches of 425 or 430 Hz! And sure, musicians playing continuous-pitch instruments often hit wrong notes which fall in the gaps between the clusters. But this happens relatively infrequently, and doesn't mar the overall pattern of clumps.

This type of normative clumping is analogous to what we experience in cognitive domains such as letterform and color. Social convention restricts the number of meaningful alphanumeric symbols to those that we think of as proper letters of the alphabet and numerals. We don't normally see, or think about, graphic symbols that might be, say, halfway between an A and an H. Similarly, the focal points of color categories like red, blue, green, and yellow are more commonly used than transitional colors like reddish-orange or blue-green.

In all these cases—letterform, pitch, and color—a combination of natural and social forces restricts the set of focal points that we perceive within a cognitive domain. In

[3] It seems that music sounds better to our ears when it is a little higher than usual. I stress the *than usual.* If everyone tunes high all the time, the sense of contrast with everyday humdrum tuning is lost, since there is nothing to contrast it with—which means that if everyone tunes high, there is an incentive to tune even higher! This constitutes a standard prisoner's dilemma. There is an individual benefit to "defecting" and tuning high in any individual situation. There is a social benefit to maintaining a tuning standard because high tuning eventually makes performance difficult for instruments with a limited upper range (such as tenor and soprano voices). For more on this issue, see Lloyd (1954:789).

each case, it is natural constraints that set general boundary conditions on what is possible (the human pitch range, the prominence of red and green, the fact that we cannot practically read letters fifty feet tall) and then it is through social convention that the ultimate focal points are actually chosen.

### *Tuning rituals*

As with any other system of social coordination, an elaborate and diverse set of rituals and practices teaches us about pitch standardization, and then ensures that we follow through on it. Examples of these rituals and practices include:

(1) the manufacture of tuning forks and pitch pipes to prevailing standards
(2) the use of guaranteed tuning stamps by manufacturers of discontinuous-pitch instruments (see Lloyd 1954:799)
(3) the periodic pitch standardization ritual gatherings reported in the Solomon Islands and Brazil (see Lindley et al. 1980:781)
(4) the various international conferences that have worked to set standard pitches in the West
(5) the pitch with a frequency of 440 Hz sounded by the BBC at 6 p.m. each evening (see Lloyd 1954:802)
(6) the note played by the oboe before an orchestral concert for everyone to tune to

What varies between these different tuning rituals and ceremonies is the breadth of coordination that they engender. There may be more or less people involved, the coordination may take place for a varying amount of time and over a varying distance, but the goal is always the same: to ensure that all the participants in the ritual use the same set of pitches so that they stay in tune and sound good together—or, in the case of the guaranteed tuning stamps, to symbolize one participant's (the manufacturer's) fidelity to that coordinative agreement.

### *Pitch labels*

With a set of standard pitches established, one can come up with an absolute set of pitch labels which uniquely identifies each standard pitch. The most common type of label for pitches is a name, but as we will see, there are also other types of labeling. Note that a *relative* set of pitch labels would be one which identified the different *intervals* (i.e., the ratios or relationships) between the tuning pitch and the other pitches in a piece of music.[4] An *absolute* set of pitch labels identifies the actual *frequency* of each pitch played. The alphabet-based pitch names (A, B flat, C sharp and so on, plus the various competing octave indicator systems) are the type of pitch labeling that is most familiar to most of us. The table lists the alphabet-based pitch names for the standardized Western pitches between 220 and 440 Hz. Our conventional system of musical notation actually uses an alternative method of distinguishing pitches—namely, contrasting configurations of dots and bars. (It also uses conventional graphic symbols for loudness, duration, and other aspects of a musical note.)

**Standard pitches in equal temperament**

| ***Pitch name*** | ***Pitch frequency (Hz)*** |
|---|---|
| A below middle C | 220 |
| A#/Bb | 233.08 |
| B | 246.94 |
| C | 261.63 |
| C#/Db | 277.18 |
| D | 293.66 |
| D#/Eb | 311.13 |
| E | 329.63 |
| F | 349.23 |
| F#/Gb | 369.99 |
| G | 392.00 |
| G#/Ab | 415.30 |
| A above middle C | 440 |

Pitch labeling, and musical notation in general, greatly expands our ability to transmit the capacity to play a particular piece of music. Think about how useful sheet music is. By recording each musical note through a system of visible marks, we are able to commit a piece of music to paper and send it to people who will be able to reconstruct it

[4] The *do-re-mi* system is perhaps the most common relative pitch naming system. The name *do* is used to refer to the tuning pitch or tonic center.

and play it for themselves, though they may never have heard it and may be distant in time and space from the person who composed it.

Because we have standardized tuning and temperament, written musical communication needs to be able to transmit the idea of specific pitch frequencies. In order to do so, we have to have an effective labeling system for each of the experiential clusters of frequencies discussed above. This system may be graphical or lexical or something else—but *some* system is essential if we are to be able to communicate the idea of a specific frequency from one person to another, or even from one person to that same person an hour or a few days later.

My hypothesis is that the process of labeling these clusters in the domain of pitch is just the same as the process of conventionally labeling other kinds of experiential entities, whether they are letterforms, numerals, colors, or concepts.

In the second half of paper we will be able to explore a number of different pitch labeling systems, including not just pitch names and dot-and-bar configurations, but also systems based on metaphor, color tags, and repertoire associations. We will also see that, just as letters and concepts are not recognized in isolation but as part of larger gestalts like words and scenarios, it is possible to come up with labeling strategies for larger musical gestalts such as chords, keys, and sequences of pitches.

### *Side issues: precision and travel*

In the section on tuning standardization I tried to show how each new constraint requires a progressively greater degree of precision in the coordination of pitch. Now I want to briefly explore the limits of pitch precision. Virtually any listener will be able to tell the difference between a pitch of 100 Hz and one of 700 Hz. Similarly, if I sound a pitch of 440 Hz and then one of 420 Hz it is easy to tell that the second is not the same as the first. But let's say I play a pitch of 440 Hz, and then later in the same piece I intend to play 440 Hz but actually play 438 Hz instead. If the listener even notices the difference, they are likely to consider 438 Hz as within the range of things that can tolerably be thought of as "the same" as 440 Hz. But the difference between, say, 440 Hz and 439.95 Hz, is most likely going to be completely imperceptible. Clearly, we have a certain threshold of difference below which we are perfectly willing to accept two pitches as the same even if there is actually some small difference between them. Being aware of these standards of precision—of our degree of sensitivity when we make judgements of similarity—is important if we are going to think about the categorical nature of pitch.

The spatial extent of pitch coordination is an important and tricky issue. These days, musical recordings, the radio waves that carry broadcast music, and even musicians themselves—with their instruments—travel all over the world.[5] Pitch standardization is an international issue which requires global coordination. In the past, though, there was no radio, no musical recordings, and no pianos. Musicians traveled, but much less often and much less far, and the only way of communicating a piece of music impersonally was through sheet music. There were also fewer discontinuous-frequency instruments. Organ design formed an important constraint on tuning standardization, but the pitch of organ pipes (as with some other instruments) actually varies quite a bit depending on the temperature. While I have not made a close historical study of tuning standardization

[5] Recordings travel in time, too, which points up how there is also an important temporal dimension to pitch coordination.

(Lloyd 1954 and Lindley et al. 1980 are good starting points), it is fairly clear from Lloyd's historical table (1954:793) that, just as linguistic dialects varied more in the past, zones of pitch coordination once covered much smaller areas than they do now. Lloyd lists historical A values ranging from 370 to 567 Hz. The pitches used over a relatively large area (e.g., Europe) may thus have formed an unclustered, non-categorical cacophony in, say, 1600. However, at the level of a single town, pitches may have been calibrated to (say) a single church organ, and thus people who did not travel beyond that town probably experienced frequency clusters of the sort illustrated in my chart.

### *Pitch standardization and perfect pitch*

This extended introduction has been necessary because pitch standardization forms the input to the development of perfect pitch. People with perfect pitch have taken our standard pitch system and built it into their minds, where they have access to it without any help from pitch pipes, tuning forks, well-tuned pianos or any other sources of pitch calibration. In Part II of this paper we will learn more about perfect pitch from the people who have it, and come to understand more about the relationship between pitch standardization and perfect pitch.

## *PART II—INTERVIEWS WITH PERFECT PITCH POSSESSORS*

In order to learn more about the experience of having perfect pitch, I interviewed six people who have it. The interviews took place in the New York metropolitan area in February, March, and April, 2000. Each interview lasted between 35 minutes and an hour. From the second interview on, I came with a small list of general topics in mind, and tried to hit each of them at some point during the interview. Other than that, though, the interviews were fairly unstructured and I encouraged the interviewees to talk about whatever aspects of their experience they wanted.

I recruited my interviewees through personal contacts; five of the six through people I knew as a former choral singer and the sixth through a family member. Four of them were male and two female. One was an undergraduate music student, three were graduate students in music, and two were professional musicians. Two were African-American, two were Euro-American, and two were Asian-American.

Although I had originally hoped to have a group with very diverse musical specialities, it turned out that I wound up interviewing six people all of whom either had or were receiving formal training as pianists.[6] All six had sung in choirs; three belonged to a choir at the time of the interview, and one other was working as a choir director. All of my interviewees were people who had chosen music as their vocation. It would be interesting to interview people with perfect pitch who have not chosen musical careers.[7]

I found my informants basically eager to talk about their musical lives and their experience of perfect pitch. They were also generally eager to hear about the experiences of other people with perfect pitch and to know more about research on perfect pitch. Most had read or heard various stories and theories of perfect pitch, but none reported having made an in-depth study of it.

[6] One of my interviewees had actually begun his musical training on the accordion, a keyboard instrument for which having perfect pitch may be specially useful.

[7] For example, I know one such person, now a university professor, who had very early musical training but later abandoned the study of music. He considers his perfect pitch rusty and very "imperfect."

My research involved no particular ethical issues aside from a commitment to keep the identities of my informants private. I do not have perfect pitch and my relative pitch is not very well developed.

All my interviews were fully transcribed. Since there were only six interviews, I outlined this paper by simply filling out a thematically organized grid as I read through the six transcripts. For each theme I marked the relevant interview and page numbers.

Although it is politically incorrect to do so, I have chosen to use the term "perfect pitch" in this paper instead of "absolute pitch." Most scholarly writers and editors prefer to use "absolute pitch," and the word "absolute" is indeed a very appropriate term for describing the way that perfect pitch possessors link names to frequencies, not frequency ratios. But I find that most people in daily life actually call the ability "perfect pitch," that in doing so they mean exactly the same thing as "absolute pitch," and that the term "perfect pitch" is shorter and easier to say.

I have organized my summary of these interviews into six broad themes which I deal with in the six sections that follow. In the first two sections I discuss, first, the essential core meaning of the term and the experiences that all my informants shared, and second, the diversity and variability of my informants' experience of perfect pitch. In the four following sections I discuss the struggle to develop relative pitch; each possessor's discovery of perfect pitch; the social and educational consequences of perfect pitch; and the meaning strategies used to identify and label different pitches and keys.

### *The core features of perfect pitch*

The essential core of perfect pitch—constant for all six of my informants—consists of three abilities. First, the ability to give the conventional name of a pitch that they hear (pitch recognition). Second, the ability to sing a pitch correctly given its name (pitch production). Third, the ability to remember and reproduce a pitch that they have heard (pitch matching).

These three abilities are related. Pitch production is the reverse of pitch recognition. And pitch matching can be thought of as pitch recognition followed by pitch production. To be able to match pitch—for example, to reproduce a pitch heard the day before—one must store it somehow. Pitch recognition—knowing the name of the pitch—is simply a way of storing it in memory.

All of my informants were able to recognize pitches by giving the conventional name of the pitch—A, B flat, C sharp, and so on. There are certainly people (many people, perhaps) with the ability to match pitches, who do not however know the conventional names of the pitches, and therefore cannot communicate their identifications of pitches to anyone else. (See Levitin 1994 for more on this issue.)

Two of my informants mentioned this issue. One said that "If I'm at the bus stop or on the street, and I hear someone singing a piece from the radio that I might know, I see how close they are to the pitch that I remember from the radio . . . If I know something is in C, and someone else is singing it in C note for note, then my guess is that they're pretty close to having whatever perfect pitch is." The brother and father of the other informant are reportedly able to match pitch—"to sing perfectly in tune a song that had been played maybe a day or two before on the radio"—but they do not know the names of the notes they are singing. This informant mentioned having noticed that "among musical people like my colleagues . . . I find that a really, really high number of them are able to hum a song in exactly the key that it's played on the radio." Whether one calls this "perfect pitch" or not, the point is that pitch matching does not imply the ability to label a pitch using some socially conventional system. All my informants can communicate the identity of a pitch to others using pitch names or dot-and-bar notation on musical staff paper. Those people who can only match pitch must either be using a completely subjective (even subconscious) pitch labeling system, or some entirely different way of remembering pitches.

All of my informants had been exposed to music very early on. Of the five informants who gave a clear account of their earliest musical experiences, their ages at first musical exposure were 2½, 3, 3, 3, and 4. In two cases this first exposure consisted of formal lessons, and in two it involved playing with toy instruments. The other informant's mother gave piano lessons out of the family home, and the informant was there during lessons. My interviews thus support what appears elsewhere in the literature on perfect pitch, namely that early musical exposure is the best known predictor of the development of perfect pitch. None of my informants had consciously trained themselves to have perfect pitch and indeed the conventional wisdom in the music world is that this is exceedingly difficult if not downright impossible:

> I have a friend who has been trying for three years to develop some sort of sense of absolute pitch. He's got great relative pitch. But he's just been struggling for three years, and it's still, it's like he hasn't done anything, and he gets so frustrated. So I think it's a difficult thing, something that would take an immense of time, and effort.

Most of my interviewees had at some point heard various folk theories of the genesis of perfect pitch, such as the following: "I was in high school biology, senior biology, and my teacher said that perfect pitch is a gene mutation." They did not generally go into detail on these theories, but none of my informants seemed to believe in an exclusively genetic or exclusively environmental theory of its origin. It is pretty clear that there is no genetic factor which can specifically predict perfect pitch in an absolutely determining way. And I am certain that since pitch recognition and production depends on the ability to label pitch categories, and since pitch categories are a product of standardized tuning and temperament, environmental exposure to standardized pitch is both a logical and an empirically demonstrable prerequisite for the development of pitch recognition and production abilities.

What is up for debate is the degree to which different people may or may not be endowed at birth with varying abilities to *match* pitch (regardless of whether it falls into experiential categories), to perceive pitch categories, and thus to develop full recognitive and productive abilities given the appropriate environmental exposure. As one informant said: "A lot of people would talk about people being born with it. But I think some people have an ability to *acquire* it rather easily as opposed to not very easily."

### *The variability of perfect pitch*

By variability I mean both variability between people, and within a single person across time. Not everyone has perfect pitch in exactly the same way. And a perfect pitch possessor's ability is not the same from day to day or year to year, nor is it "perfect," unlimited, or mechanistic and computer-like.

**Some people are better at some notes than others.** One informant said "Sometimes I'll get a little confused between F sharp and G" and "I found I have a problem with A flat. I sometimes confuse it with A." Indeed, this informant did confuse A flat with A at one point during our interview. There is a continuum of absolute pitch recognition ability all the way out to those people who develop an absolute sense of only a single pitch out of the twelve in the Western equal-tempered scale. (Such people can then, rather laboriously, use their relative pitch capabilities to figure out the other eleven notes of the scale.) None of my informants were like this; with the exception of the one informant quoted above, they were equally good at all notes. Another informant said that having an absolute sense of one note was not something that people thought of as perfect pitch:

> Perfect pitch for me, it's just the ability to pick out a note [any note]. . . I really don't have to think about it or relate it back to the instrument I play. For example, some people who . . . play trumpet . . . they have B flat [but no other notes] in their head if they play long enough, so they relate everything back to that B flat.

**Different tuning standards produce differently set perfect pitch abilities.** Two informants who know each other well, and who both belong to a musical group that has gone on tour in Europe, independently brought up how their pitch is calibrated slightly differently. One of them said:

> I think my pitch is A=440, because if I sing a C, and if I go to a piano that's just been tuned, it will be the same pitch—in America. But when I went to Europe, I'd sing a C, and I know the piano is just tuned, and their C sounded sharp, I sounded flat, because they tune to A=443 over there . . . X [the other informant] says [X's] pitch is higher than mine, and it's true. [X] says that having an Asian background, [X] is used to hearing music performed in the Far East, where their A is tuned to 443 for greater brightness in the orchestra. And [X's] growing up with that has given X a pitch base at 443, so [X] can recognize all the pitches under the umbrella of 443. Whereas I, being raised with Western orchestras and Western music, 440 is what we still use in America. So my pitch is naturally lower than X's . . . I think it's basically relative to what the standard is in the area where you live.

The other informant said:

> Y is always dead on 440. When I went on tour [with Y, in Europe], I had no problem with their A being tuned to 443. Y had a really big problem with it. I think when I grew up, well, Eastern countries, they all tune their As slightly sharper . . . somebody told me that in America, it's the only place that tunes A to 440.

**Different temperaments produce differently set perfect pitch abilities.** One informant, asked about listening to music in an Indian restaurant, said:

> They use different musical scales. The distance between the notes, it's not Western music . . . I have the Western scale, if you will, embedded in me . . . And what tends to happen is you hear that, ooh, it sounds a little weird. I mean, if I'm listening for the purpose of stating what the notes are, my thought is, 'oh, that's an A, it's a little sharp.' I'm basing it on the Western system.

**Pitch recognition may depend not just on pitch frequency but also on the presence of overtones.** Overtones are those higher-pitched frequencies which, because of the laws of acoustics, sound faintly when a pitch is played on instruments like strings and winds. One informant said it was hard to recognize the pitch of pure sine tones (electronically generated pitches that do not have overtones). This suggests that the overtones that accompany a pitch form part of the "sound shape" that gives the pitch its identity.

**Perfect pitch can be a "note thing" or a "key thing."** In talking about perfect pitch, my informants constantly flipped back and forth between discussing their ability to recognize individual pitches, and their ability to recognize key signatures. This distinction will become important in the last section where I discuss the meaning strategies that perfect pitch possessors use to distinguish pitches and keys. It is not hard to understand how the ability to recognize a single pitch grants the ability to recognize a key signature. A key signature is a set of pitches derived by applying a particular subset of our standardized pitch ratios to a particular standardized base pitch. The name of a key signature (e.g., D major or B flat minor) refers uniquely to this set of pitches, with the first part (e.g. D or B flat) naming the base pitch and the second part (major or minor) referring to the subset of pitch ratios with which the pitch set is derived. Though the ability to recognize pitches and the ability to recognize key signatures are closely related, they are practically somewhat distinct and are useful in slightly different contexts.[8]

**Perfect pitch can get better and worse.** As one informant said:

> Sometimes it goes off a little bit. It's not, like, so absolute. That's why I was always afraid to say that I had perfect pitch. There's been five years when I didn't play piano at all . . . once I got back in school I found that my A is a little bit off . . . I was surprised to find out about that, but now I think I'm getting it back.

**There is a reasonable amount of tolerance permitted in how exactly one hits a standard frequency.** "If somebody asks you for a note, you sing in the general area, you don't sing exactly in tune. That's what I think perfect pitch is." (Compare the issue of precision, discussed in Part I.)

**One's sense of what is perfectly correct can vary up and down from day to day.** "I know my pitch center, what I think A is. But it changes day to day. Sometimes I feel like A=440 is flat, some days I feel like A=440 is sharp . . . it depends on the day." **And the normal stresses of life cause mistakes.** "If I'm feeling really tired, or really stressed out, or even really caffeinated—I will sometimes give a sharp or flat pitch. If I'm asked to give a D flat, sometimes if I'm not focusing I'll give an E or a D."

**Recognizing a single pitch in isolation, or a key signature, is fairly easy, but when many pitches are played at once it gets harder.** I played a four-note F seventh or

[8] The key signature based on a particular base pitch includes pitches of essentially the same frequency as the overtones of that base pitch, which may be related to the fact that that one informant needed overtones to be able to recognize a pitch.

major seventh chord for five of my six informants, who agreed that they did not instantly recognize all the pitches in it. The bottom and top ones seemed to be the most salient; recognizing the middle two took more time and effort. I also asked how easily my informants could pick out pitches when they hear many pitches played at the same time. One said:

> if I was listening to something, like a barbershop chorus sing a chord, and I had to transcribe it, I'd be like "That's a D nine, a D nine chord, but what's the voicing?" and then I'll go back and listen to it again. I'll be like "OK, the F sharp's in the bass, and the E's in the soprano—OK, what's the middle part?" So I'll go back and listen to it. If it's a CD I can keep rewinding the track and be like "OK, this guy's singing a D, and this guy's singing an A" and I'll write it all down. OK, next chord . . . and that whole process will take about five or six seconds and I'll go on to the next one, and that's another five or six seconds. So a three minute song for barbershop choirs for four parts would probably take an hour to two hours.

Another informant said that while listening to (say) a G major chord during an orchestra performance, it would be easy to say that it was a major chord, but that "I don't think G major unless I'm trying to notate every note"; then, metaphorically speaking, "if I want I can pull out this drawer that gives me all the pitches." In general, while the minds of people with perfect pitch fill that mental drawer with pitch identities in an almost automatic way, it still requires a deliberate decision to pull out the drawer and pay attention to the pitches. And the more pitches one hears in a small amount of time, the greater the effort involved in paying attention becomes.

**People with perfect pitch also** use different pitch labeling strategies, and they are affected socially and educationally by perfect pitch in different ways. I'll explore this variation implicitly in the rest of the paper.

### *The struggle to develop relative pitch*

Relative pitch, as opposed to perfect pitch, is the ability to name and reproduce intervals—frequency ratios—but not particular frequencies. Anyone who can hum a melody has the ability to match frequency ratios; learning to recognize, label, and reproduce them takes more effort, but it is a skill that can be learned.

If we play a middle C (261.63 Hz) on the piano, and then the E above (329.63 Hz), a blindfolded listener whose relative pitch sense is good enough and who knows the names of the standard intervals will be able to say that the two pitches together constitute a major third (the name for an interval with a frequency ratio of approximately 5:4). Given a C as a reference pitch, and asked to sing a major third above it, someone with good relative pitch will be able to sing the E. But unless our blindfolded listener had perfect pitch, they would in neither case be able to tell us that the two pitches were C and E.

For people with absolute pitch, what stands out first is the identities of the pitches. Many people with absolute pitch are actually not very good at recognizing intervals. If asked to do so, they figure out the interval using their automatic awareness of the pitch identities—an awareness which they are in fact virtually unable to suppress. Someone with perfect pitch would respond to the test mentioned in the preceding paragraph by picking out the identities of the C and the E, analyzing the relationship between C and E (perhaps while visualizing a keyboard), and remembering or calculating that that relationship forms a major third. As one informant said, “Instead of listening to the quality of the association, we know the notes, so we figure out [the interval].”

I found this out by playing a C and an E on the piano for four of my informants, and asking whether as listeners in such situations they were aware first of the interval between the two pitches or of the identities of the two pitches, C and E. Three of my informants said that the pitch identities stand out first. The fourth informant said

> They come at exactly the same time for me now. I think early on, the pitches came first. But due to musical training, after really learning about intervals in the years of theory I've had, I've actually made myself learn to hear intervals as opposed to pitches, because it just makes musicality and everything easier.

What this informant knows is that relative pitch, the ability to sense and name intervals, is in some contexts more useful than perfect pitch. In fact, in a few situations people with perfect pitch are at a real disadvantage compared to people without it. This accounts for why perfect pitch is sometimes thought of as a disability—or at least an *in*ability (see Miyazaki 1993).

My informants regularly discussed two areas where they struggled to develop good relative pitch and suppress the effects of their perfect pitch. These were choral singing, and playing pianos with nonstandard tuning.

When a choir goes out of tune, singers who do not have perfect pitch may not notice as long as the choir is in tune with itself. As long as the blend of the different voice parts still fits the ratios standardized by our temperament system, it doesn't matter to most listeners whether they keep to the 440-Hz-based standard tuning system.

People with perfect pitch, though, remember not just the intervals in a piece of music but also the absolute pitch identities and exact pitch names. When a choir goes out of tune—especially by an entire half step, from one standard pitch category to the next—a conflict develops in the mind of the perfect pitch holder between the name of the pitch they know they're supposed to sing, and the name of the pitch that the other people in their voice part are actually singing.[9]

People with perfect pitch differ in their ability to handle this sort of situation. A couple of my informants said that they could cope if it was just a matter of singing slightly flat or sharp in the same pitch categories, but that a change from one pitch category to the next was more difficult:

> Informant: You can hear a note and you can say, well, that's C. And it can be a little sharp, but it's more C than it is C sharp, OK? Or you can hear a note that's a little flat and it's more C than it is B . . . I can, you know, bend my identification of the sounds to a certain degree. Until, you know, at some point it flips over and becomes the next half step . . .
> IW: OK, so let's say we're this choir singing along in C, and then it starts to get flat and all of a sudden, for you it flips over to B.
> Informant: Mm-hm. I'm up. Like in poker, I'm up.

Another said "I could cope with it, as long as I don't have the music." A fourth informant —the same one who said that after long experience intervals and pitch identities now come at the same time—said:

[9] Vocalists with perfect pitch are thus frequently caught in a conflict between two social compacts. They know the notes of the piece as it was written, and they want, and hope, to sing exactly those notes. They want to do so in conformity with the pitch standard that generally applies in our society, which was reaffirmed from the piano or the pitch pipe or the tuning fork at the beginning of the piece, and which they have in fact built into their own minds as "perfect pitch." At the same time, they also want to be faithful to the momentary tuning compact established dynamically by the singers in the group. Indeed, a choir out of tune exerts tremendous social pressure on each of its members to follow—because, after all, it is entirely in tune with itself, and it sounds bad only if it is compared with the beginning of the piece or with some general standard. A choir out of tune has set a standard of its own.

The competition between these two standards—one general, the other fleeting—forces the person with perfect pitch to make a choice. Although fidelity to the general standard is more right and correct, and although it would be nice to try to pull the whole choir back to it, it is not usually possible for one person to change the tuning of an entire choir. Yet singing out of tune is difficult for people with perfect pitch and feels wrong to them. The choice they face is similar to the dilemma of a high school student whose friends choose to break the law in some way. Do you go along—out of fidelity to the norms of the group at the moment—or do you stick to what you consider a broader set of norms, and try to pull the smaller group back? This dilemma confronts people with perfect pitch in almost every choir practice. Developing good relative pitch means learning to be able to shed the more general standard and adapt to the local, momentary, standard of a choir out of tune.

Choristers without perfect pitch, however, are *not even aware* of the general standard. They cannot tell whether they are out of tune. They may be able to tell whether people in the choir are out of tune with each other, but they cannot mentally summon any pitch standard beyond that existing at the moment in the choir. They thus do not face the same choice.

> This is an everyday problem for me. If the choir in an *a capella* piece starts to go flat, what I have to do is first, I have to hit the note, and then I have to make myself sing flat. I have to kind of turn that little part of my head off . . . it gets difficult, until they fall the whole half step, because then I just can transpose it.

This informant is unusual: transposition is not easy for everyone with perfect pitch. This quote also highlights the categorical nature of pitch standardization, since it shows how the informant handles deviance from a standard that does *not* cross a category boundary in a different way from deviance that *does* cross a category boundary (see Sloboda 1985 for more on this issue).

Unexpectedly, four of my informants mentioned having played pianos which were in tune with themselves, but were tuned to a different reference frequency (e.g., A=400 instead of A=440). A person without perfect pitch might not even notice this. But for all of my informants it was a cognitive shock to see a very familiar instrument, which nevertheless disrupted the relationships between pitch and pitch label that they have built into their minds. For three of these four it was quite a struggle:

> I literally could not look with my eyes open and play supposedly in the key of E flat when the sound of G was coming out.
>
> I was supposed to play for a friend's wedding, and the piano was completely flat. So I was so nervous, my mom was yelling at me for not playing right, and for not practicing the piece. But the fact is, I practiced it. It's just that, A, A flat, I couldn't do it. Because the thing is written in A, and playing A flat, and I just couldn't transpose fast enough.
>
> [The piano's] C key is actually B. It's off a whole half step. And I can't play it. I just can't, cause it's not C. The piece is in C, and if it's in B, it sounds like B.

For people with perfect pitch, who are aware of what key a piece is typically played in, a piece which is usually in C is just not the same piece when it is transposed into B.

For a fourth informant the same situation was unexpectedly easier, but this was partly because of having time to adapt. “I noticed within a few hours, my pitch had redefined what C was, and I didn’t think I was going to be able to do that.”

A fifth informant did not mention having played a piano tuned to a different standard, but did say that changing keys unexpectedly on a normally tuned piano had gotten easier with practice:

> When I’m accompanying, if I’m asked by the singer to play a step up, it gets a little tedious . . . instead of hearing [the pitches] I have to look at my hands . . . I hear them in one key and play them in another . . . [but] it gets easier with time and with all the musical training I’ve had so far, it’s something I can do easily now . . . but it was one thing that I really did work at.

### *Discovering that one has perfect pitch*

As with other unusual aspects of one’s identity, perfect pitch possessors learn only rather slowly that they are different from other people. Since perfect pitch is a rather interior and invisible ability, the process of discovery can take many more years than the discovery that one is significantly taller or less athletic or differently hued than one’s peers. I asked each of my informants when and how they had discovered that they had perfect pitch and that most other people do not. The range of responses was surprisingly diverse.

Two informants had dramatic, light-bulb stories of a specific moment of revelation:

> Informant: I was a freshman in high school and I was singing in the choir, and we were singing outdoors a capella, thus meaning the choir director had to give the pitch on the pitch pipe. He played A flat, and I’m saying to myself, “no, this is wrong, it should be A.” . . . [later] I’d told him “you know, you played A flat instead of A.” And he said, ‘How’d you know?’ And I said “What do you mean, how do I know? I—it is!”

> IW: That's really interesting.
> Informant: Yeah, it's like green is green. You know, how do you not know green is green.
> IW: So what happened next?
> Informant: He went over to a piano and . . . he played a note and I would tell him what it was, he'd play another note, and I'd tell him what that was. And I guess what it felt like to me was an open book test. You know, if someone's asking you a question, and the answer is right there in front of you.

> I was in a music camp in grade school, it was grade six or something. And I don't think I had any previous theory training, but at the camp we had theory . . . Somehow I realized that I knew what the names of the pitches were because I could hear them. And somebody said, "Well you must have perfect pitch." And I said, "What's that? Don't you have it?" I just thought everybody did.

With other informants the discovery that they were different was not as dramatic. They knew as children that they were musically talented, and some had peers or teachers who also had perfect pitch. One said, "my second piano teacher could also do this. He'd turn his back to the piano and I would play notes for him and he would, like, spit out the names. So I sort of had the idea that because he could do it and at least a few other people, that it wasn't all that special." Another went from third grade on to a specialized music school where almost all the kids had perfect pitch "or else they had really really good relative pitch."

Even though these informants became aware of their own abilities fairly early, it still took time for them to fully realize that most people in the world do not have perfect pitch. One informant was tested by a music teacher and told about having perfect pitch at the age of eight, but it still didn't really sink in that other people didn't have the same ability until later on: "When I began to teach [in ninth grade] I realized that hey, there are people who will not be able to do this . . . I was asked by my teacher to do sectionals, like, just take the basses in a room, and teach them their part. I was so frustrated, and then it just hit me, I really shouldn't waste my time because I really think now that not everybody can do this." The informant who went to the specialized music school says "I never knew that somebody out there could not pick out a note if I play it . . . until I got into high school, when I took the rudimentary theory class. The teacher started talking about it, and I had a drummer in my class and he couldn't pick out anything . . . And then it didn't really hit me until college. Some of my classmates were complaining about how hard the tonal dictation exam was, and they just couldn't do it. I told them, just listen for these notes, and they said that they had absolutely no idea."

Another informant had a slightly different story:

> I just knew that I was more sensitive than other people. I got a perfect score in music courses every time. It wasn't even a thing that I needed to work on, it just came naturally that I knew the pitches. But I didn't know that it was called perfect pitch until the music teacher introduced somebody who had it. Because they kept saying that it was so rare . . . I didn't want to, you know, stand up and yell "I have it too!," so I kept it to myself.

### *The social and educational consequences of perfect pitch*

I was curious to find out the small ways in which perfect pitch changes your life. One of the fun aspects of having perfect pitch is that environmental sounds come to have extra meaning, because you associate them with particular pitches:

> Like if my computer started beeping a half step off, I wouldn't use it.

> It's like a D sharp and an F sharp for the doorbell . . . I remember once it was broken, and I knew it was broken, and my parents didn't know it was going to go . . . it was like a half step flat, and I said "That doorbell's going to go" and my dad's like "What? It's fine" . . . and the next day it died . . . When the battery runs low, the pitch goes flat.

> Sometimes when I hear like, a fire truck passing by, I tell my husband that, this is such and such a pitch. He is like "Are you crazy?" but it's just that it's kind of second nature for me to translate things into pitches.

Music students with perfect pitch have many advantages. The ability to hear exact pitches in one's head—i.e., the ability to subvocalize musically or sing to oneself in standard pitch—helps students with theory and composition exercises. (As one informant said, "if I'm really, really bored in a dry history lecture, I can decide to write a little madrigal or something, just to pass the time, and know what it sounds like before going to the piano.") The ability to recognize pitches is useful in music theory and fundamentals courses, especially when students are asked to comment on sample pieces of music in class. But one informant considers this "cheating," saying "Since my theory isn't that great, I usually just figure out all the notes, take down all the notes, then figure out the function of the chord," whereas people without perfect pitch "will actually listen to the chord progression," because they are aware of intervals rather than exact pitches. Perfect pitch thus becomes both an advantage and a disadvantage, "because I don't listen to the progression at all sometimes. We're supposed to learn what it sounds like and I really haven't."

Most of my informants said that they had been used as a human pitch pipe while singing in choirs, and one informant mentioned having been asked to help with overtone tuning by the choir director. Most informants seemed to enjoy the special attention that comes if you have perfect pitch.[10]

Two of my informants, however, felt that having perfect pitch had negative social and educational consequences. One informant, who reported having been "always taught not to trust perfect pitch as giving an instant indication of someone's musicality," said:

> If people know I have it I then sometimes turn into this sort of human pitch pipe, which I don't really like. I don't mind if you just need a reference, but if you could

[10] When I sang in a choir, there was an informal social gathering after practice on Wednesday nights at a local pizza parlor, during which we would sing university songs. Usually no one brought a pitch pipe, so we would always ask one of the choir members with perfect pitch to give us the opening note of the piece. If we hadn't done that, we might have started on a different note that would have caused us to go out of range at some point during the piece. People with perfect pitch thus become very useful to the groups they are in.

> just as easily get the note from something in your pocket, then you know, why bother me . . . I don't advertise it. And only a few people know, and it's usually from people who know people who know me [i.e., not because of having told people directly].

This informant also told the following story of negative rewards for having perfect pitch:

> When I took a music history course, I had a teacher who was very stern about musicians that had this advantage [perfect pitch], and when people were identifying a piece, she didn't want them to use perfect pitch as a way of getting points on knowing what the piece was. I remember there was a C.P.E. Bach symphony . . . music that people aren't going to know. A fresh piece. She had us write things about it. And what she was after, because it was a history course, is the way the phrases are, the grammar of the music, where it's going, where it's coming from . . . And I just happened to write down "oh, and the piece is in F sharp, which is strange" . . . I got the paper back, and she wrote down, "I'm giving you credit for having identified the key, but not because you identified the key, but because you identified it as strange." Cause F sharp wouldn't be a very good classical key . . .it would be out of tune with all the instruments they had at the time.

Another informant felt that having perfect pitch raises one's own standards and expectations: "You set up a very high standard for yourself, because you know that you have an ability that other people probably don't have . . .it becomes very frustrating sometimes. You think you should do better than others . . . Sometimes I think that I'd rather not have it, so that I could consider myself, like, ordinary."

### *Meaning strategies and the cognitive differentiation of pitches*

One of my informants told me that

> Once I was trying all the notes on the piano, like, one by one, and really listening to them, and they're all different. It's really fun to experience that.

I would like to be able to experience that difference as well, but I cannot and never will be able to. Like other people with some relative pitch ability, I could try out all the *intervals* on the piano, one by one, and really listen to them. They are all different; I can (on a good day) recognize some of them without looking; I know their names; I can feel the difference between them; and as I play them, I can think of tunes that start with each distinct interval—a fourth for "Hark the Herald Angels Sing," an octave for "Over the Rainbow," and so on. Each interval has a distinct character, a personality. But no individual pitch has a distinct character for me. I can tell that an A is higher than an A flat, and I can tell that they are not the same pitch, but they are not different for me in any meaningful way.

An empirical goal of my interviews was to learn about the way in which people with perfect pitch perceive the differences between pitches. I asked my informants questions like, "if you hear an A and an A flat, what is different about them? How can you tell that they are what they are? How does their identity stand out?" In some cases this turned into a issue of keys rather than notes, and my question became something like "how is the key of A major different for you than that of A flat major? How does its identity stand out?"

The skeptical reader might say at this point, "Well, it's obvious. A and A flat have different frequencies. That's what's different about them." But I do not think that simply the difference in frequency is enough to fully separate the *concepts* of A and A flat in the mind of someone with perfect pitch. I believe that what really gives the different pitches identity and character are the labels and associations that perfect pitch possessors develop for each pitch. By labels, I mean names and other tags. By associations, I mean memories and feelings. (There is a fuzzy boundary between labels and associations: associations can serve as labels and labels can have an associative quality.)

Take the analogy of letterform. We might as well ask, what is different about an A and an H? It is easy to respond "It's obvious, look at them, they are different shapes." But the fact is that the distinction between A and H is conventional. A and H are both combinations of two uprights with a horizontal line in between, and it is only by virtue of the social fact of the alphabet that we consider them as different. As one of my informants mentioned above, the differences between colors seem obvious too: "How do you not know green is green?" But in fact there is a great deal of conventionality in our culturally perpetuated distinction of green from blue. Similarly, nothing in nature says that we absolutely must think of a pitch of 440 Hz (A above middle C) as significantly different from one of 415 Hz (A flat).

I propose—and my interviews support—the idea that the conceptual distinctness of each conventional letterform and pitch is founded on its graphical or acoustic character, but then actually supported by the web of labels and associations that each entity carries. The letters of the alphabet carry a lot of associations for anyone who knows how to read. We know the name of each letter, we know where it comes in the alphabetic order (and we have even have a cute song to help us remember), we can think of lots of words that each letter occurs in (A is for apple, after all), and some people even come up with memory systems where each letter is associated with a color or a gender.

What memory systems, then, do people with perfect pitch use to keep the pitches apart in their minds? On top of the simple fact of recognizing the differences in frequencies, what extra associations and links do people build into their understanding of pitch? What contrastive symbols (in the broad sense of the term) do people attach to each pitch?

I asked all of my informants questions about the way they feel pitches differ for them. I probed hard, and tried to come to an understanding of this abstract and complicated issue. Several different meaning strategies emerged.

**Pitch names.** All of my informants referred to the different pitches and key signatures by their conventional names (A, A flat, etc. for pitches, A major, A flat minor, etc. for key signatures). It is easy to take this for granted, but it is important to recognize that these names provide an easy labeling system which distinguishes one pitch from the next in some way beyond mere frequency. Also, since the convention of pitch names is so widely shared, they make it easy to communicate the identity of a pitch to another person.

Though the *do-re-mi* system is more often employed for relative pitch labeling, one informant used it as a set of absolute pitch names: "I had trouble with moveable *do* . . . like, if it's D major, you start the *do* with D, and I had so much trouble with that, because D is D to me, it's not *do. Do* is C—to me."

**Dot-and-bar notation.** All of my informants were obviously comfortable with this alternative system of pitch labeling; they could all "read music." The quote (above) from the informant who could keep up with a choir out of tune as long as the music was not there illustrates how powerfully the dot-and-bar notation cues people with perfect pitch to think about particular pitches. Though my interviews don't give specific evidence of this, I imagine that the reverse is true as well: that many musicians with perfect pitch imagine notes on a staff when they think about the music they are listening to. Just like pitch names, the different configurations of dot-and-bar notation stand for each pitch in a classically Saussurian contrastive way.

**Visualization of an instrument.** It would have been worth asking my informants about this strategy (suggested to me by Ruth Simpson). I know that when I think about the identity of an interval, I might visualize it on the piano (C to C for an octave, C to G for a fifth, C to E for a third and so on). It may be that during the process of recognizing a pitch, people with perfect pitch visualize it in its place on the piano keyboard, or on any other instrument that they happen to be familiar with.

**Reference to familiar pieces of music which use the same pitch(es) or the same key signature.** I was struck by how often my informants mentioned that part of having perfect pitch is knowing the pitches and keys of music that they are familiar with. With one informant, for example, I wound up playing a game where I would play a few notes on the piano and the informant would think of a song that included those notes:

> IW: Let's try more . . . I'll pick this sort of at random. (*Informant looks away. IW plays* G *then* C *sharp.*)
> Informant: There's a Schumann gondolier song. (*Plays song whose melody starts with* G *then* C *sharp.*)
> IW: Wow. You're not giving me just the intervals, you're giving me the exact same pitch . . . Does this pop into your head pretty quickly?
> Informant: Yeah, yeah, I don't think . . .

A person without perfect pitch would be able to play the same game, but would only be able to give answers where the *intervals* match but the actual pitch identities might be different. In other words, if I played G and C sharp (a tritone) for a person without perfect pitch they would probably give me musical pieces with all sorts of tritones in it (C and F sharp, A and E flat, F and B, and so forth). A person with perfect pitch, however, would be able to give me answers with the absolutely matching pitches of G and C sharp.

This means that for people with perfect pitch, part of their memory of a musical song is what key it is in and what pitches it uses. And the reverse is true too: part of the understanding of what a pitch or key is and is not, is its association with pieces which use that pitch or are played in that key. These two quotes from the same informant illustrate this both at the pitch and key signature level:

> If I hear a pitch, I'll know it's a D sharp, because I can hear it in relation to various songs that I just happen to know. Music is always running through my head, so if I hear, like a certain pitch, I can put it in relation to a song that I'm thinking about and I'll know right away that it's that note.
>
> With keys, I will relate it to songs that I know as keys . . . for instance, if I hear something in G major, I'll instantly think of (*plays familiar Mozart melody*). The G major Mozart . . . when I was extremely little, the first piece I knew was, that was G. And G minor . . . there's this (*plays chord*) there's this thing we do in church all the time, this massive creation by this guy . . . I forget his name now . . . Murray Hayden, I think (*plays tune on the piano*) and I just recognize G minor, from things like that, just things that float through my head.

Taking this one step further, it seems that people with perfect pitch can also mentally link two pieces in their repertoire which use the same exact key or the same sequences of pitches.

Indeed, for people with perfect pitch a tune is simply not the same tune when it is played in a different key:

> IW: So could you sing *Brothers Sing On* [normally in A] in E flat?
> Informant: No. I never thought of it in E flat.

People *without* perfect pitch generally don't "think of" songs in any particular key signature at all, unless they have memorized a song's fingering on their instrument. But people with perfect pitch may fix a song in memory as in one single key. It is this fact that makes it very difficult for them to transpose or to keep up with choirs that go off by at least a full pitch category:

> Let's say they sing the melody in another key. You know, I'm going along. [And] what happens is, I've hard coded [it] like, wrong [for the new key] . . . and all of a sudden, boom, I sing a note [in the regular key], it has nothing to do with what anyone else is doing and I'm oh my god so embarrassed.

The informant who had identified the C.P.E. Bach piece on a classroom test told me that the key of a piece is one of its most salient features, one of the ways that one remembers a piece and makes it important. Look back at that quote and notice that this informant also brought up the issue of genre, saying that "F sharp wouldn't be a very good classical key." Different key signatures have been more or less popular at different points in history and for different types of music, so key signatures may come to be associated with an entire style of music as well as with particular pieces.

To sum up, people with perfect pitch think of (for example) a pitch of 293.66 Hz not just as a D or as a particular configuration of dots and bars, but also as a pitch which occurs in particular places in particular pieces that they know. Their concept of "D-ness" is linked to all the places that they have seen D occur. People without perfect pitch, on the other hand, can barely even begin to form such links, because they are aware of the identity of a pitch or a key signature only when they have a keyboard, a score, or a piece-name that gives it away (like the "Mass in B Minor") in front of them.

**Metaphoric associations.** Four of my informants were able to assign an adjective or a feeling to particular keys. Different keys were called *warm, sharp, happy, bright, clear, nice, military, dark, smooth,* and *indifferent and boring*. In some cases these seemed to be associations with the types of pieces that get written in a particular a key. Others seemed to be comments on more ineffable qualities shared by a group of keys that are neighbors on the musical circle of fifths (such as "all the flat keys" or "all the sharp keys"). The following quote shows an informant using a mixture of metaphoric and genre-based associations to distinguish sets of keys grouped according to their position on the circle of fifths:

> IW: You mentioned that chords have their own quality. And I was wondering if you could expand on that a little more.
> Informant: Well, I've always been partial to flat keys. I don't know why. I just, I just like them, they're just . . .
> IW: What's different about them? Are they brighter or darker or greener or . . .

> Informant: Warmer—warmer.
> IW: Warmer?
> Informant: Warmer, yeah, it's just something—
> IW: What are the keys that you think of in particular.
> Informant: Oh, B flat is one of my favorites. I don't know why . . . B flat, E flat, E flat's nice, yeah. A flat. OK, then it's getting towards, part of it may be the genres that these keys tend to fall into because, let's say D flat is a very popular Romantic key. And I'm not terribly into Romantic music . . .

These sorts of associations are common across various semantic domains, especially sensory domains (see e.g. Marks 1978, who reports some universals such as the association between brightness and high pitch). Unfortunately, I did not probe my informants' metaphoric associations very deeply or compare them carefully for common themes.

**Direct color associations.** Two of my informants had a distinctive color tag for each individual keys or notes. In neither case did I have the time to do a full transcription or exploration of these color labeling systems but I did take the basics down. For one informant colors were linked primarily to keys. Some of the assignments were:

> D major, yellow; B major, neon white/hot pink; C major, red; C minor, darker red; D minor, royal purple; A flat major, darker blue; C sharp minor, brown or deep red or dark green; D flat major, darker yellow; C sharp major, lighter yellow.

For this informant a key change, or something as simple as the resolution of a suspended fourth to a major third—is accompanied by a sense of changing color.

The other informant's sense of color was more tied to pitches, but it was also partly a "key thing." This informant played chords based on each pitch while summoning up the color of the pitch, and said that when associating a color with a piece, or a part of a piece, it has to do with the key signature the piece is in over the course of several measures—not with specific notes. When asked whether the color sense was "something that has more to do with notes or with keys," the informant said:

> Both. I guess it's more associated with keys, but I must say it really does stem from the fact that, well I really don't know. I think a certain note first…If you think what color a certain sound is, then another sound has to be a different color and what color would that be. And then so on. So you first of all figure out what color the notes are themselves and then you check it with say for instance a note, I mean, a chord, that has that as its base. For me, a C is white and C major is white. Now C minor, since it's still C, is a, is a tint of white, or is a little off-color white, or a tiny bit gray or something like that. And on the other side of things, G flat or F sharp is very dark, so is a dark color. Perhaps the darkest color, where C is the whitest color.

This informant mentioned the following color associations:

> C, white; C minor, off-white; D, blue; E, yellow; E flat, golden; F, green; F sharp, black; G, brown (?); A, couldn't think of a color; B, orange.

These two informants are textbook examples of a phenomenon that has been recognized in psychology of perception literature for decades, and which typically gets discussed under the sometimes misleading and inappropriate heading of "synesthesia" (see http://www.ncu.edu.tw/~daysa/synesthesia.htm for a bibliography and a short list of composers who had similar color systems). I will not discuss here the competing theories of where these associations come from, except to mention that such links appear less strange when one thinks that we already use color as a tagging system for notes in other contexts, e.g., for harp strings. Perfect pitch possessors with built-in color systems for pitches and keys have simply preserved an internal labeling system for pitch in addition to the more conventional, intersubjectively shared ones mentioned at the beginning of this section.

This section has reviewed six ways in which people with perfect pitch can effortlessly, even automatically endow a particular conventional pitch category with meaning and distinctiveness. Pitch names, the contrastive configurations of dot-and-bar notation, the visualization of instrument fingering, reference to pieces, metaphoric associations, and color tags all endow a pitch with contrastive identity that goes far beyond simply its characteristic frequency. What is special about people with perfect pitch is the speed and automaticity which with they have access to these distinctive associations. Some of these meaning systems are internal and subjective: they define a thought community of just one person. But those meaning systems which have become widely shared, intersubjective social conventions make it easier for perfect pitch holders to communicate about pitch with the rest of us.

### *What is it like to have perfect pitch? A concluding analogy*

Though few perfect pitch possessors actually have color tags for each pitch or each key, the idea of a color system is a very good way for those of us without perfect pitch to understand what perfect pitch is like. Anyone who is not color blind has the ability to discriminate a finite number of standardized color foci and to refer to them with names like *red, gray, brown,* and even *pink, tan,* or *teal.* If we see a slide of a yellow tulip, followed by a slide of a red tulip, we are able to say that the color of the tulip has changed, and we can also say how it has changed: from yellow to red. We are also able to remember various contexts in which we have seen particular colors, and we can to attach meanings, moods, and memories to colors, whether those are individual or cultural.

Take a person without perfect pitch, though, and seat them in the audience of, let's say, a musical theater performance. During one of the numbers, imagine that the music plays a melody, then modulates into a different key, and plays the melody again—a pretty frequent occurence in musical theater. A person without perfect pitch, such as myself, will be able to sense the key change; perhaps they may be able to say as well whether it is up or down, and a person with some musical training and decent relative pitch might even be able to say how far up or down. Now, going back to the example of the yellow tulip and the red tulip, this is like having "relative color": like being able to say only that the flower changed in color from one slide to the next, and that the second tulip was darker.

A person with perfect pitch, though, will be able to label the original key and the key that the music modulated into. Not only that, they will have *sensed* this almost automatically, and, if they chose to pay attention to this sensation, they will have been able to think of other pieces which use the same keys or modulations, and they will be able to summon up all the various labeling devices they use for these keys. The key change thus takes on a wider meaning to them, and relates to their other musical memories. Now, this is less strange than it looks. After all, it is just the same as our ability to see the absolute difference between the colors of the two tulips, to categorize them almost automatically and label the categories as "yellow" and "red," and to pay further attention to those identifications if we wish, by for example thinking of other things that are yellow and then red (say, traffic lights).[11]

A person with perfect pitch has the same abilities with music that almost all of us have with color. They sense change, they can tell us exactly what something is changing from and to, and they can name names. Their experience of listening to music is, thus, potentially much richer than that of the rest of us, because music fits into a web of

[11] I don't want to give the impression that pitch is the only conveyor of meaning in music. The signifying power of intervals, minor and major keys, melodies, rhythm, loudness, expression, and so forth is much greater. Indeed, one of the reasons that exact pitches and key signatures are not much used to convey meaning in music is probably because so few people have perfect pitch and can thus pay proper attention to them. What prejudice there is against perfect pitch proceeds partly from the fact that perfect pitch holders sometimes tend to figure out these other meaning systems through a mechanical calculation based on pitch identities.

meanings, gestures, history, and patterns that is specially accessible to them through their ability to label the pitches whose frequencies are standard in our society.

## *CONCLUSION*

Perfect pitch depends on pitch standardization. There would be no pitch categories to label unless the set of potential frequencies was limited by the social coordination of tuning and temperament.

In this way, having perfect pitch is similar to being able to read. You hear a pitch, and immediately you assign that pitch to a culturally conventional category and into your mind pops the culturally conventional label for that category, and the associations you have with it. When you read, you look at a shape, and immediately you assign that shape to a culturally conventional category, and into your mind pops the label for that category, and the associations you have with it. In both cases, pitches and shapes combine with other pitches and shapes to create larger conventional symbols. It's just that in one case the category is of pitch, the label is something like "C sharp," the broader associations are of pieces with C sharp and what C sharp does in a piece, and the combined symbols are chords. In the other category letterform is at issue, the label is the name of a letter like "ay" or "bee," the associations are with other words that have A in them and what kinds of sounds A stands for, and the combined symbols are words.[12] But the abstract thing that is going on is the same. The only difference is that we think of people who don't have perfect pitch as "normal," whereas we stigmatize people who can't read, perhaps unjustly, as "illiterate."

[12] See my 1997 term paper, "The Classification of Letterform."

Imagine, though, that some people had "perfect pitch" for vehicle speed. That just by looking at a car they could tell exactly what speed it was at: "That's 31; that's 42; that's 8 miles per hour." Or imagine that some people had an absolute sense of temperature: they could tell you exactly how hot or cold it was around them, to the exact degree Fahrenheit. As far as I know, no one is able to do this. You might ask, why not?

Although speed and temperature are measured on a conventional unit system, the different speeds we see and the different temperatures we experience do not clump together. A speed of precisely thirty-five miles per hour is no more common than an speed of any other value between thirty-four and thirty-six. Pitches come in frequency clusters, but cars really do reach every speed along a continuum as they accelerate. Temperature varies along all the infinitesimal points of the continuum too. (Also, speed is not something that you need to recognize and reproduce, one can't reproduce it in a car and perceive it at the same time, the different speeds don't mean as much as different pitches do, and children probably don't observe examples of different speeds as closely as they do of different pitches.) So we all have relative speed perception, and relative temperature perception, just as most of us have relative pitch perception. Absolute perception depends on a categorical presentation of the stimulus. And in the case of perfect pitch, the categories are social ones.

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