

THE MONOTONY-THRESHOLD IN SINGING BIRDS

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WHAT stimulates animal organisms is change; what deadens response is sameness, or persistent repetition. This is true especially of repetition at brief intervals; for with long intervals, the "attention span" is exceeded, there is fading of "memory" in the immediate or active sense. (Latent memory, conditioning with associative recall, is another matter; even in a bird it may span long periods; but we are speaking of what needs no recall, since it has yet to be forgotten.) With long intervals, brain cells perhaps revert approximately to their previous state, other activities intervene, and thus the tenth or hundredth occurrence of the repetitive factor is experienced in its contrast with these intervening events, or with a certain "freshness," and not as monotonously repetitive. If then there could be "intolerable monotony" for an animal, it would be produced by many repetitions unrelieved by substantial pauses. Applying this to bird song, we deduce that a bird which sings the same song over and over will probably have marked pauses between reiterations of the song, while birds without the tendency to such pauses will have at least several different songs and will avoid using any one of them over and over in direct succession. In other words, repetitious or "non-versatile" songsters must be "discontinuous," and continuous songsters must be versatile. Let us now define these terms more closely.

First, as to *versatility*: an individual may sing an identical song—neglecting seasonal changes and very slight or infrequent deviations—hundreds or thousands of times per day (or night); or, on the contrary, it may have a repertoire of several or many different songs or phrases sung in no fixed order, many or all of which are used in every performance lasting beyond a minute or two. Species each normal individual of which has a repertoire of four or more distinct songs or phrases (employed as just explained) we shall term "versatile." The majority of the world's most famous songsters are examples. Species essentially repetitious we shall term "non-versatile," especially if the song is brief and simple, relatively lacking in internal variety of pitch, rhythm, and so on, for example, the Prothonotary Warbler (*Protonotaria citrea*). Species intermediate in variety we term "semi-versatile," as for example, some of the wrens to be considered below.

Another way of singing we shall call the "eventually versatile" way. There is a repertoire of songs, but an individual sings each song a good many times before introducing another. In the short

run, then, such a singer does not differ much, if at all, from a non-versatile singer. Thus the Eastern Meadowlark (*Sturnella magna*) often repeats one song, at intervals, over and over; yet Saunders (1935, 1951) has noted 53 *different* songs from one individual within an hour and believes that the normal repertoire is 100! Probably most "non-versatile" species are, in mild degree, eventually versatile (two or three songs, taking a whole day and a whole season into account). For most of the purposes of this paper, eventual versatility is a species of non-versatility.

Continuity concerns the extent to which singing is free from interruption, during a normal "performance period" of a minute or more, by "substantial pauses," silences longer than those separating notes within songs or phrases. There is no wholly sharp line between such pauses and musical "rests," such as those separating the phrases in songs of some thrushes of the genus *Hylocichla*, which are integral to the musical pattern; but if a bird habitually sings several or many notes a second for two or three seconds, and then is silent for eight or more seconds, this is highly discontinuous singing. With such a singer there is *much more silence than song*, during any period longer than a few seconds. A Grasshopper Sparrow (*Ammodramus sava-narum*) may seem to be singing "steadily" for several minutes; but the four to six brief songs per minute, possibly one or two more in the early morning, occupy only from 8 to 12 seconds, leaving about 50 of silence. Thus the bird sings less than 20 per cent of the performance time; during the remaining 80 per cent, it may be watching the surroundings, listening to other birds, and the like. Now contrast this with the Brown Thrasher (*Toxostoma rufum*) which for minutes at a time pours out an almost solid stream of sounds. Such birds, during a normal performance, sing more than 50 per cent of the time. (During an entire day they may sing no more than some discontinuous singers; they tend to have longer gaps between performances.) These are the "continuous" songsters. Between the extremes are the "semi-continuous" ones, singing from 30 to 50 per cent of the performance period. (Reasons for choosing these ratios will appear presently.)

Something like a thousand species in the world are non-versatile, singing one song over and over dozens or hundreds of times in succession, and probably upwards of three hundred species are continuous; yet these two large classes (with scores of each of which I am familiar) seem scarcely to overlap in a single instance—among the true songbirds at least. Where is the Oscinine singer as repetitious as the Field or Vesper sparrows (*Spizella pusilla* and *Pooecetes gramineus*) or the

European Willow Warbler (*Phylloscopus trochilus*) and at the same time as continuous as the Brown Thrasher or the European Song Thrush (*Turdus ericetorum*)? Yet it ought, it seems, to be easier to repeat the same song over and over rapidly than to sing many different songs or phrases at an equal rate. Easier, except for the threat of monotony, at least to the listening bird, and to the singer if he is attending to what he is doing. Birds "adapt" quickly to continued stimulation of the same kind, that is, they turn their attention elsewhere. Only in two ways, it seems, can this "monotony-threshold" be avoided, either by varying the activity in question, here the singing, or by pausing long enough so that lapse of memory, and/or other activities, intervene.

It is to be borne in mind that singing is normally a deliberate or free performance. A bird can be driven by fear or a sense of urgency to fly faster or farther than it would otherwise fly, even to the point of great fatigue, as over a body of water. But singing is not urgent in the same immediate sense. Also, whereas flying serves primarily to transport the creature through space, the biological values of song are social and psychological, and thus the interestingness of the song, for performer and avian listener, is of its essence. Repetition carried so far as to inhibit attention and cause the activity to lapse into an automatism for the singer and a negligible stimulus for the listener (mate or rival) is scarcely compatible with the status of song in the bird's life.

If interest is maintained by pauses, rather than by versatility, how long must the pauses be? Our reasoning—which may be least correct with respect to very long or very short songs or phrases—is as follows. Most of the set songs or phrases are between one and three seconds in duration; few are more than five. The explanation seems to be that the span of attention, or of vivid memory, is about this length in most songbirds (Craig, 1943: 166). There is then a presumption that a longer song than usual means a longer memory span, and hence the need for longer pauses if each rendition is to be equivalent to a fresh start. Continuity, accordingly, is properly taken as a ratio. But what ratio will define "discontinuity," that is, pauses suitable for repetitious singing? It is clearly not enough that the pauses be slightly longer than the song, for this would mean that memory is only a little less than "vivid"; whereas a bird singing a unit a thousand times or more a day, as most of them do, must recover freshness virtually completely, must have almost *no* sense of what (from our point of view) it has just previously done. The pauses, then, must be *much* longer than the songs. Physiology or psychology

will eventually tell us a good deal, no doubt, about the sort of proportion we should expect here; but is it not reasonable that somewhat over twice the duration that can be grasped as a whole, as songs must be to be recognized, should be required for recovery of freshness? This is provided for by our definition of discontinuous singing as less than 30 per cent of the performance time, leaving at least 70 per cent of silence, or two and one-third times as much. This ratio was arrived at empirically, as an effort to make sense out of such facts as this, that many hundreds of repeated songs are between one and one-half and three seconds, while the shortest pauses for these range, with rare exceptions, between three and one-half and seven seconds, respectively, which our 70-30 ratio calls for. Or again this fact: as Craig (1943: 24, 25, 54, 62, 67, 72) showed, the Wood Pewee tends to sing his third, or special twilight, phrase an ever higher proportion of times as he changes from leisurely daylight singing to the many times faster rate of his "twilight" song; but this tendency is halted almost exactly at the proportion of 50 per cent for the preferred phrase. Why? Because, beyond this proportion, the phrase must sometimes be repeated immediately without intervention of either of the others, and the bird avoids immediate repetition of any phrase, above all this one, when its pauses are short, though it has no hesitation about repeating either of its daytime phrases many times over when singing with the long pauses (8 seconds or more, instead of 1) of its leisurely singing. We shall meet with other species that thus exhibit, through a dual mode of behavior, the difference between long pauses that make variety unnecessary and short ones that require it.

Consider the contrast between two species, the Ovenbird (*Seiurus aurocapillus*) and the Brown Thrasher. The Ovenbird has a song with little internal variety in each utterance, and the only variation from one utterance to the next is in the number of times the "teacher" occurs. If this three-second song were to be sung every five seconds or so, we human listeners, at least, would find the monotony very trying. But the bird seldom pauses less than 10 seconds, usually more than 20 (Hann, 1937; Nice, 1931). Now observe the Thrasher. He hastens on from phrase to phrase, immediately repeating most of them once or twice only, until, after a minute or two his repertoire has perhaps been exhausted and new items no longer appear, although the old ones may present themselves in new orders. Pauses are so short one can seldom time them definitely. A bird performing in this fashion is doing almost nothing but sing. It is his life, for the time being; he therefore puts into it whatever sense of complexity

he possesses. The sharp separation of song perch from feeding area on the ground is symptomatic of his concentration. The Ovenbird, on his lower perch, seems to be taking his much simpler song in his stride, so to speak, while largely intent on other things. His occasional flight song, with its extra variety, shows that his capacity to act in complex ways (which may not equal the Thrasher's) is not normally expressed to the full in his singing. The tendency toward very short pauses in the "singing" of various insects suggests that in their case the simple repetitive patterns (katy-dids, however, are somewhat versatile) may come closer to being a measure of the creature's capacity. Many of the lower orders of birds may be a little nearer to this level than the songbirds are.

The monotony-threshold, or limit of tolerance for repetition, thus doubtless varies from species to species. We may also reasonably suppose that a creature which is satisfied by small or poorly defined contrasts *within* its basic song-pattern will feel less need of variation in successive utterances of the pattern. Purer musical tones define more definite contrasts; a creature which nicely contrasts two or more relatively pure frequencies each time it sings will be more likely to feel the need for contrast between one utterance and the next, or for substantial pauses. We shall see that the striking cases of disproportionately low versatility relative to the continuity are furnished by species whose lack of sensitivity to the value of contrast is shown by the song they repeat as well as by the mode of repetition.

Three families of North American birds are outstanding in continuity of singing: the mockingbird-thrasher family or Mimidae, the thrushes or Turdidae, and the vireos or Vireonidae. Scarcely a member of these is less than semi-continuous. It is equally difficult to find one that is less than semi-versatile. For the Eastern United States it almost suffices to refer to the diagrams of the songs of representatives of these families given by Saunders (1935, 1951) in his unique *Guide to Bird Songs*. (Where not otherwise stated, each horizontal half inch in Saunders' diagrams stands for a second of time.) In a few cases we need to supplement his information. For the Veery (*Hylocichla fuscescens*) neither versatility nor continuity can be determined from the diagrams. We are told that "ordinarily" a bird sings the same song over and over, though sometimes it alternates two songs. In Cheboygan County, Michigan, I found that Veeries usually sang at least two distinct songs and avoided repeating the same song more than a few times without introducing a contrasting song. The songs were shorter than those described by Saunders—2, 3, 4, occasionally 5, downward slurs, instead of 5 or 6. (These

very probably constitute regional differences, as does the fact that the songs of most Vesper Sparrows in Cheboygan County *descend* in pitch after the opening note or two, instead of rising, as all the books say.) Songs were commonly at rates of 7 to 12 per minute, lasting about 1.5 seconds. This is scarcely continuous singing, and the versatility is similarly middling. (I once thought I heard an individual at sunset sing 10 times in 30 seconds, singing several sharply contrasting songs. If I was misled by two birds singing close together, the continuity and versatility were alike illusory.) Hermit Thrushes (*Hylocichla guttata*) have the most variety of the genus, considering the intricacy of the phrases; and while the pauses are mostly of about the same length as the phrases, approximately 2.3 seconds, the continuity is really almost 100 per cent, for the phrases are variations on a theme, with striking and never-failing contrasts of key, proving that the relation between a phrase and its successor is essential. Thus there is not so much a succession of brief songs as one complex song lasting half a minute or more, and then another such prolonged song after a pause more pronounced than those within the songs. Similar remarks, with suitable qualifications, apply to other members of the genus. The Robin (*Turdus migratorius*) has less effective variety in proportion to his continuity than other thrushes, and this is in keeping with the lack of musical sensitivity shown in the phrases themselves. The Bluebird (*Sialia sialis*) is somewhat (but not greatly—see Saunders, 1935) inferior to the Robin in versatility and not quite so continuous.

Going outside the region covered by Saunders, we have the Varied Thrush (*Ixoreus naevius*), which sings a prolonged, sometimes quavering note on five or six different pitches in no fixed order (Bent, 1949: 91). Continuity and versatility seem fairly high in this most unusual song. Intervals between sounds are said to be a second, and as I recall the notes they last about this time. This would make 120 notes in 4 minutes. Ninety-five were heard (Bent, 1949: 91-92) in less than this time, but the notes were given in series with longer pauses marking the end of a series, and since the same pitch was seldom used twice in succession, the intervals within a series may perhaps be considered integral to the music. Counting a harsh note now and then, the quavers or trills, and the ever-varying order of pitches, the variety seems no less impressive than the continuity. Townsend's Solitaire (*Myadestes townsendi*) sings without pause, usually for about 20 seconds (Hoffman, 1927: 252), very long for a single burst of sounds; there is, as I recall it, marked internal variety. The variety from one utterance to another would be difficult to as-

certain without instrumental analysis; nor has anyone reported what the usual intervals are.

Saunders attributes "considerable" variety to some individuals of the Warbling Vireo (*Vireo gilvus*). I timed a bird in Cheboygan County which gave 6.2 songs per minute; the length was about that reported by Saunders (3.2 seconds) giving a continuity of 33 per cent. There was some versatility: variations in length, and in beginnings and endings of songs. Bell's Vireo (*V. bellii*) is at times rather continuous, giving its song of 1.5 to 2.5 seconds (Saunders, 1951) 9 to 17 times a minute (Mumford, 1952: 230). This frequency, however, is poorly sustained; hourly records being low (Nice, 1928: 13). Moreover, versatility is considerable, the song having two basic forms, each with now a rising, now a falling, inflection ("like question and answer"). All four versions seem to be used even in a rather short sequence though there is also a fair amount of immediate repetition (Nice, 1929: 13). If there is here a slight disproportion between continuity and versatility, it is in accord with the lack (noted by all observers) of clear musical contrasts in the basic theme.

The same can be said more emphatically of what is probably the most repetitious member of the family, and one of the most repetitious oscinine birds anywhere, Hutton's Vireo (*V. huttoni*) which reiterates its kitten-like "me-ow" (said of the subspecies *stephensi*) or its "qui-id" about once a second for minutes at a time (Willard, 1908: 232; Bent, 1950: 246-47). Yet, even here, Bent quotes an observer who noted a "change of key" every minute or two, a phenomenon rare among birds. Also, for all one can tell from the accounts, the actual singing of the phrase, evidently as unmusical as any vireo's, occupies no more than one-third of a second. The most continuous vireo is presumably the Red-eyed (*V. olivaceus*), which often sings considerably faster than a phrase a second, though also often but 30 per minute. Saunders puts the number of different phrases for each bird at 20 to 30! The Black-capped Vireo (*V. atricapillus*) sings 30 times per minute and has "extraordinary variety" (Nice and Nice, 1931). The White-eyed Vireo (*V. griseus*) has "eventual variety" only, and (combining data from Nice and Nice, 1931, and Saunders, 1935) its continuity is 27 to 35 per cent—normal for this type of singing. Yellow-throated and Blue-headed vireos (*V. flavifrons* and *V. solitarius*) have far fewer phrases than the Red-eyed, though perhaps with more effective contrasts, and are less extreme in their continuity.

Nearly all the mockingbirds and thrashers have both high continuity and high versatility. (See Bent, 1948, and Saunders, 1951.)

A bird with a recognized tendency toward continuous singing is the Ruby-crowned Kinglet (*Regulus calendula*). I have watched this species in the Upper Peninsula of Michigan singing with fervor, its crest gleaming, with little pause for minutes. But the singing exhibited more versatility than one might guess from the literature. The ending of the song I particularly listened to was a "rub-a-chee" repeated, now four, now three, now two, now one and a half times. (A good many species practice this numerical juggling, as we shall see.) There were, I think, other modes of variation; at any rate the impression was not one of monotony. Nor has the bird impressed others as monotonous.

The Short-billed Marsh Wren (*Cistothorus platensis*) is said to sing as many as 12 songs per minute (Bent, 1948: 272), which with 2 seconds per song gives a continuity ratio of 40 per cent. I have heard one sing 15 times per minute in Cheboygan County; but this individual, which was in plain sight, sang at least 6 versions of his brief song, changing every few times. He juggled the numbers of notes in the latter part of the song, 2, 3, 4, 5 or more, he doubled the tempo of this part, or cut it in half again. This is medium-high versatility, almost equal to the continuity of 50 per cent. Again we have a slight lag in a bird whose basic theme is somewhat unmusical. The same remark applies to the Long-billed Marsh Wren (*Telmatorhynchus palustris*) which sometimes averages 25 songs per minute "when contesting for sites or when females arrive" (Welter, 1935: 11). According to Saunders (Bent, 1948: 258) songs last 1.2 to 2 seconds; supposing the average is 1.6, this gives a continuity of 66 per cent! Saunders also says that individuals vary their songs "considerably," and speaks of "five different songs from one individual." I have listened to one of these birds singing rather discontinuously and using two versions of his song; but I have also heard one with a higher rate (15 per minute) which kept making perceptible changes in pitch, tempo, and number of notes; and a day later, at the exact spot, presumably the same bird sang 16 to 20 times per minute with definitely still greater contrasts between successive songs. The House Wren (*Troglodytes aedon*) notoriously impresses people as monotonous. However, playing a recording at slow speed, one finds a song so complex (and not ill-constructed) that the impression of obviousness disappears. There are reasons (for some of which see Ansley, 1954: 39) for supposing that this is closer to the way the bird hears its song. According to Saunders (Bent, 1948: 132) the songs last from 1.4 to 2.6 seconds, and this agrees roughly with my own few timings and those of Kendeigh (1941: 22). Let us say 2.3 on the average.

Kendeigh finds 11 or 12 songs per minute to be near the maximal rate; I have heard 9 to 11. Thus the maximal continuity is about 45 per cent, not comparable, for example, to the Long-billed Marsh Wren. And the versatility? Kendeigh (1941: 23) tells us that when females arrive, the time of most energetic singing, the bird "intersperses" its territory song with the mating song. Timing with a stop watch, as carefully as possible, one giving 9 songs a minute, I got a spread of lengths even greater than Saunders gives for the species as a whole. I cannot think that more than half of this variability was due to my inaccuracy. Also, on the Cornell Recordings of American Bird Songs, Volume II, slow playing and careful listening disclose at least one definite variation in one of the four songs, which I think came from one individual. Bewick's Wren (*Thryomanes bewickii*) sometimes sings somewhat continuously, up to 18 times per minute (Miller, 1941: 88), averaging 10. Fish (1953: 254-255) made an instrumental analysis of a series of songs from an individual singing 8.7 songs per minute with an average length of 2.4 seconds, barely semi-continuous. Fish found the songs identical, except for "detailed variations" in the couplets (4 to 6) forming the third or last part. The Nices (Nice and Nice, 1931), however, report 10 "different types of song from one individual." The remaining wrens in North America, I believe from experience, all fit well into our scheme.

Two great American groups consist largely of highly repetitious singers which, as our theory requires, are also highly discontinuous: the "sparrows," finches of the subfamily Emberizinae, and the wood warblers or Parulidae. In most cases they have short set songs which are merely reiterated, at least in any one usual performance of a few minutes. Rates are as a rule between 5 and 7 per minute, with a maximum of 9 or 10, which, with the brevity of the songs, means a usual continuity of about 20 and a rarely exceeded maximum of 30 per cent. Exceptions are instructive. Thus the Lark Sparrow (*Chondestes grammacus*) is in my experience the most continuous singer in either of the two groups, and it is easily the most versatile. Saunders (1951: 301) says: "A bird sings one song after another, no two of them alike." He recorded 6 different songs from an individual, each occurring but once, and during this time others were sung that he lacked time to record. The versatility of Bachman's Sparrow (*Aimophila aestivalis*) is well-known, but definite information concerning its continuity is lacking. Descriptions of the Brewer's Sparrow (*Spizella breweri*) imply marked continuity and variety (Hoffman, 1927: 331; Swarth, 1930: 255-56). The Song Sparrow (*Melospiza melodia*) of course has wonderful variety (6 to 24 songs in each

individual repertoire), but of the eventual kind only, each song being sung a number of times—on occasion as many as 70—before another is used (Nice, 1943: 124). In a “highly stimulated state,” a singer may reach 10 times per minute, using the same song for two or three minutes (p. 115). This is semi-continuous singing (45 per cent); the cumulative approach to monotony, one may surmise, causes the bird to draw on his repertoire, whereas a species without this recourse, but otherwise comparable, must gain more complete refreshment from slightly longer pauses as he goes along. Mrs. Nice (1943: 122) gives evidence to show that birds in the prime of life repeat a song more times than old or young ones: there is “sustained effort.” Effort implies resistance, the inhibiting tendency of unrelieved repetition. Perhaps the most problematic of the finches, from our point of view, is the Dickcissel (*Spiza americana*) which appears to reach semi-continuity (Nice and Nice, 1931; Saunders, 1951). However, an individual probably varies the number of “dicks”; also this is one of those species that is subnormal *both* in variety (or adequate pauses) in the succession of utterances, *and* in musical contrasts within each utterance.

Many wood warblers are typical repetitive-discontinuous songsters. The Black-throated Green (*Dendroica virens*) sings from 5 to 8 times per minute (Nice and Nice, 1932: 169–71); and many others similarly space out their brief and relatively unvarying songs—as I have observed at various times of day and season in Northern Michigan.

In sharp contrast is the Yellow-breasted Chat (*Icteria virens*) the most consistently continuous, or near-continuous, singer in the family, and the only consistently versatile one. Usually 7 different phrases, in no fixed order, are used (Bent, 1953: 593) at a rate of 10 phrases in 25 seconds (Saunders, 1935: 213). Phrases are short, giving a continuity of perhaps a little over 40 per cent. Considering the extreme simplicity of most of the phrases, versatility seems also medium high. The American Redstart (*Setophaga ruticilla*) is noted for its versatility; in Cheboygan County, usually at dawn, I have often heard it singing 12, and sometimes 13, 15, or even 17 times per minute, also 9 times in 30 seconds. The last three rates, which constitute semi-continuous singing, were from the same individual, to judge by the location and the most distinctive of the songs. I saw this individual sing 12 times in a minute at 10:50 A.M., July 14. I think there is no mistake about the 15 and 17 counts: had I been taking two birds for one I should have gotten 19, 20, or more, since it was the energetic dawn singing, when no rates below 10 were obtained. These high rates were with conspicuously versatile singing,

although, as Saunders (1935) remarks, Redstarts sometimes sing the same song over and over. When they do so, the rate is generally 7, 8, or 9, occasionally 10 or 11; but when they (irregularly) "alternate" two or more songs, the rate, while sometimes low, is more commonly 9, 10, 11, sometimes 12, and up to at least 17 per minute. Thus the average for versatile singing seems about 2 and the maximum about 5 songs per minute, higher than for repetitious singing. Moreover, a bird has several times shifted, as I listened to him, from repetitious to versatile, or from versatile to more versatile singing (by the addition of one or two more songs to the shuffle back and forth), and therewith the rate per minute has also risen. Thus my 17-a-minute bird once, late in the morning, sang five times in one minute, using two songs, but then added a third, his most distinctive song, by which he could be recognized, and sang 8, 12, and 11 times during the following three minutes. (Perhaps he saw me and got excited.) Another observer, James M. Hartshorne, watching the nest from a blind heard six distinct songs from this individual, probably an unusual one both in versatility and in continuity. When Redstarts sing repetitiously, they are apt to give the song a kind of finale (Saunders, 1935)—as though to emphasize the separateness of each utterance, the lack of continuity! One such song sounds like, "see, see, see—Splash!" Time a bird singing exclusively like this, and you are not likely to get a rate higher than 9 a minute. Sturm (1945: 191) gives only 9.6 for "short intervals of active singing": this, I presume, was an average for a number of minutes; otherwise I cannot understand his getting no higher rate for the species, and even then it seems dawn singing must have been omitted. Or is a remarkable regional difference involved?

The two types of singing, repetitious-discontinuous and versatile-continuous, are illustrated even more clearly by the Canada Warbler (*Wilsonia canadensis*). Kendeigh (1945: 159) mentions a rate of six songs per minute: in mid-June, 1954, two individuals near the Station sang quite repetitiously at this very rate; and at the same spot in early July one sang eight times per minute, also without variations. On other occasions of unvaried singing the rate has been no higher. Yet one of the two heard in June began, before I left, to sing with obvious variety at a rate of eleven per minute, which is semi-continuous singing (songs 1.8 seconds). This renewed my confidence in a recollection from the previous year of an individual of the species at this spot singing once about every four seconds, using several contrasting songs. Toward the end of June, I managed to get to the swamp edge at or before sunrise. A Canada rewarded

me with almost fully continuous and amply versatile singing—9 times in 30 seconds and maintaining approximately this rate for several minutes, chipping or “tsacking” rhythmically between songs. I have heard no other species of warbler sing so continuously, nor—considering the complexity of the songs—so versatilely. The versatility has been noted by Saunders (Bent, 1953: 652) and the continuity by Allen (Bent, *loc. cit.*). What has not been noted is the sharply dual personality of the bird, combining two very different modes of singing.

The cardueline finches, for example, the Goldfinch (*Spinus tristis*), are fairly continuous and likewise fairly versatile singers. (The very different European Goldfinch also has both continuity and variety.) The Purple Finch (*Carpodacus purpureus*) has a tendency toward continuous singing (Saunders, 1935), and when indulging this tendency it also practices systematic variations on its rather complex song, as one could observe from the doorway of Blanchard Laboratory at the Biological Station. The method is to break the song into fragments, and string these together with the full song in various delightful ways. The Holarctic Pine Grosbeak (*Pinicola enucleator*) is reputed by various American and European authors to sing both continuously and with variety.

The cardinal grosbeaks and their allies are in much the same class, especially the Cardinal (*Richmondia cardinalis*), a species which seems intermediate between the eventually versatile and the immediately or fully versatile types. An individual practices variations upon its groups of slurred notes (Saunders, 1935: 241), but there is a tendency to reiterate each group a number of times. The continuity seems also intermediate. The Rose-breasted and Black-headed grosbeaks (*Pheucticus ludovicianus* and *melanocephalus*) have moderately complex songs with somewhat short pauses, and Saunders says of the first that an individual sometimes varies the last half of its song.

The family of troupials, Icteridae, has in the United States no highly continuous singers. It also has no highly versatile ones, except the two meadowlarks (*Sturnella*) but these employ their versatility in the eventual manner. The western species (*S. neglecta*) has more notes and stronger contrasts in each song, but apparently no such number of diverse songs as Saunders has found in repertoires of the Eastern Meadowlark (*S. magna*), and hence it may be comparable in versatility. The Bobolink (*Dolichonyx oryzivorus*) achieves a certain variety, partly through the “strumming” of its sometimes banjo-like instrument or singing of small song-fragments between full songs; and its pauses are often rather short pauses for the length

of its song. A typical repetitious-discontinuous singer, on the other hand, is the Red-wing (*Agelaius phoeniceus*). The orioles (*Icterus*) have comparable pauses and perhaps a bit more variety.

Among the true songbirds known to me, perhaps the most marked apparent exceptions to the generalization, "no highly repetitious highly continuous singing," are the Chipping Sparrow (*Spizella passerina*) and the White-breasted Nuthatch (*Sitta carolinensis*). In these cases a rather unmusical two-note phrase (not clearly discernible as such to the human ear because of speed or slurring) is reiterated; and the reiterations are definitely grouped into series of rather variable length constituting "songs." Pauses between songs may be of discontinuous magnitude, but the Chippy in early morning may use pauses "as short as or shorter than the song" (Saunders, 1935); and I have heard the Nuthatch singing, as near as I could tell without a stop watch, 40 per cent of the performance time. The lack of a fixed number of phrases in each song and the variations in the length of pauses, constitute the only versatility. The fact that the basic simple phrase is merely repeated means that the procedure can be carried out automatically, as in the act of walking or flying, while attention is largely elsewhere. The Chippy, at least, sings with little intensity compared, for example, with the Ovenbird. In both cases, the lack of what seems adequate contrast (or pauses) between successive utterances of the phrase matches the poverty of well-defined variety within the phrase.

More drastic "exceptions" to our anti-monotony principle occur outside the oscinine suborder and are more extreme cases of the same characteristics. Thus the Least Flycatcher (*Empidonax minimus*) in the early morning repeats an unmusical "ti-beck" or "chebec" almost without substantial pauses, though not without slight modulations of rhythm, hundreds of times. It is a species which lives about clearings, pairs being close together and in fairly good view of one another. Probably sight is playing a greater rôle than in the typical singer. Nor, so far as I know, has it been ascertained that the "song" is more than a "position call" for the mate, in which case it need not have constantly high stimulus value, for performer or listener. If the mate needs, at any time, to know where the bird is, it has only to listen. The Eastern Phoebe (*Sayornis phoebe*) sings a dawn song consisting of two mildly contrasting phrases, alternating irregularly, "phoebe" and "phoebleet." It is a musically dull performance, in the themes as well as in their excessive reiteration, yet in both respects superior to the Chebec. And I have heard what I took to be a song duel between rivals. In sharp contrast to

the foregoing egregious repeaters is the most musical non-oscine species in North America, the Eastern Wood Pewee, which excels not only in the musical sweetness and effective contrasts within and between its three principal phrases, but also in the optimal variety, as already pointed out, in the order of their occurrence.

The Whippoorwill (*Caprimulgus vociferus*) has a *slightly* musical phrase (slow playing of a record does not improve one's opinion of it, as it does with many species) of five notes (the human ear misses two), and this phrase is repeated, sometimes hundreds of times, in fairly quick succession. The arrangement of the three chief pitches, 2-1-3, that is, a fall and a sharp rise, seems to call for the drop to the opening note as the tonic, and so the thing seems to keep itself going musically with almost hypnotic effect. In this case, and in that of the Chebec, there is some rhythmic modulation, the bird pausing ever so slightly here and there, making a break in the mechanical precision of repetition.

It may be no accident that such continuous reiteration occurs chiefly, if not exclusively, in sub-oscine species and not commonly even there. A slightly lower order of sensory-emotional sensitivity, not just of vocal organs, is probably involved.

However one views the seeming exceptions to the rule against repetitive continuous singing, in the main the rule stands. This could, I think, be shown for other families than those considered and for other parts of the world. The exceptions are probably merely extreme or limiting cases, songs of such meager musical content that they are little more than definitions of rhythm, their slight variety (which may well be more apparent to the birds—with their faster tempo—than to us) consisting in changes in the number of notes between pauses and in the length of the pauses. Such songs are rather rhythmical frames for a pattern of activities, than a pattern important in itself. A Vesper Sparrow's song, to take a contrasting example, is too complex and intense in musical form to function readily in this secondary manner.

To consider the possible reasons in the respective life-cycles for the modes of singing of various species, whether versatile-continuous, repetitious-discontinuous, or eventually varied and discontinuous, lies beyond the scope of this article. Such reasons do not, in general at least, suspend the sway of the anti-monotony principle opposing the union of continuity and repetitiousness.

The most basic conclusion from the evidence presented is perhaps this: birds, like ourselves, though in their own very limited fashion, are subject to the great principle of beauty, "unity in variety." (See

Saunders, 1929: 125–131; Craig, 1943: 67–69, 144–177.) Song may have developed from simple calls and/or random warbling to more complex and definite patterns whereby contrast is sharpened and made more effective; such patterns are then repeated, either with variations or at intervals long enough to allow the fading of vivid memory. Rarely indeed are patterns simply repeated over and over with scant pauses. This avoidance of mere repetition is what the principle of beauty demands, equally with the avoidance of mere change.

Although such views may seem “anthropomorphic” to some readers, will they not to others seem the logical way to include human reactions within the biological scheme? Man (especially in his non-verbal reactions) is not wholly unprecedented in nature; his traits have more or less primitive analogues in the lower orders. One such analogue has been the subject of this paper.

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SUMMARY

1. Variation, both of behavior and of stimuli, is a biological necessity. This explains many facts about bird songs.

2. Song-behavior has gradations of “versatility” and of “continuity”: the first concerns the number of different songs, variations, or phrases, and the extent of contrast between them; the second is the ratio between the amount of singing in seconds, and the total “performance period” as inclusive of “substantial pauses,” if any.

3. Discontinuous singing (pauses over 70 per cent) need not be versatile, for (it is argued) the pauses exceed the span of vivid memory; singing lacking versatility and yet highly continuous (pauses less than 50 per cent) is least likely to escape the “monotony-threshold,” and hence not likely to occur. Actually it is rare.

4. The threshold is a variable, depending inversely upon level of nervous organization. Indicative of a low level—a high threshold, great tolerance for monotony—is a lack of clear musical contrasts within the basic song pattern, as well as in its reiteration without ample pauses or variations. The second deficiency is found only in association with the first.

5. Families in which continuous singing prevails—thrushes, thrash-

ers, vireos—are also prevailingly versatile; the prevailingly non-versatile groups, Parulidae, Emberizinae, are prevailingly discontinuous, and the few continuous members of these are also the most versatile. Groups or species intermediate in one respect are intermediate in the other.

6. "Exceptions" are few and not inexplicable in terms of the same principles.

7. Song-development exhibits a trend toward "unity in variety," i.e., beauty, which is to be expected if human nature is a further unfolding of tendencies pervading all life.

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