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Vocal Performance in Occasional Singers

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Abstract and Keywords

There has been increasing evidence that occasional singers can carry a tune (e.g., when asked to sing a known song or to imitate single pitches, intervals, and melodies). Occasional singers typically sing accurately, although most lack precision when repeating the same pitch or interval. Proficient singing, as is demonstrated by competent pitch perception and production, is supported by a complex functional architecture, including perceptual, motor, sensorimotor translation, and memory processes. This architecture is supported by a complex neuronal circuitry; the malfunctioning of components due to brain damage or congenital disorders may lead to poor-pitch singing. Research on singing proficiency in occasional singers still faces challenges regarding the choice of a standard set of measures for assessing abilities and of criteria to tell apart poor from good singers. An approach based on multiple tasks sharing common sets of measures, and with a relative criterion (within a normative group) is favored.

Keywords: singing, pitch perception, pitch production, poor-pitch singing, singing proficiency

Introduction

A good deal of research and substantial work in pedagogy has been devoted to professional singing, and to the improvement of vocal technique for both teachers and students (Gabrielsson 1999; Parncutt and McPherson 2002). Basic processes, such as breath control and managing resonance, and more advanced techniques, such as those leading to vibrato and expression, are critical to reach the artistry and virtuosity typical of professional singing (e.g., Davids and LaTour 2012; Peckam 2010). Teaching programs aimed at improving these processes and techniques have measurable effects on the acoustics and on the quality of the singing voice. Starting from the seminal work of Johan Sundberg and collaborators (Sundberg 1987), there has been a growing body of evidence on the acoustical features of professional singing. For example, differences have been found between professional singers and non-singers in terms of voice quality (Sundberg 2013). Partials falling in the frequency range of 2.5–3.0 KHz (the so-called singer's formant; Sundberg 1987) are much stronger in sung vowels than in spoken vowels. Increase of the intensity of the singer's formant, the presence of vibrato, and the maximum phonational frequency range are markers of expertise (Brown et al. 2000; Larrouy-Maestri et al. 2014; Mendes et al. 2003). In spite of this general interest in the acoustics of the singing voice, only a few isolated studies have focused on the accuracy of pitch production in professional singers (Vurma and Ross 2006; Zurbriggen et al. 2006). For example, when professional singers are asked to produce pitch intervals, they can be out of tune by 20–25 cents, with respect to the equally tempered scale, an error that is typically neglected by listeners (Hutchins et al. 2012; Vurma and Ross 2006). In addition, features like the accuracy of the first note of the melody and melodic contour play a role in motor planning, as it has been observed when singers prepare to produce a melody (Zurbriggen et al. 2006).

The relative abundance of research on professional singing may lead one to think that singing is the privilege of a minority. These individuals may be talented enough to undergo systematic vocal training and lessons. Moreover, it may be inferred that long-lasting and intensive training is mandatory to achieve proficient singing. These conclusions may lead to underestimating singing abilities in the majority. The layman, not used to receiving vocal training, may thus be treated as a poor singer when compared to professional vocalists. Interestingly, this view is quite widespread among nonmusicians and reflects the fact that people generally tend to underestimate their ability to carry a tune. For example, based on a screening questionnaire administered to more than 1,000 students at the University of Texas in San Antonio, almost 60 percent of them reported that they cannot accurately imitate melodies (Pfordresher and Brown 2007). In another study, about 17 percent of the student population self-define as tone deaf (Cuddy et al. 2005). As a consequence, relatively little was known about singing abilities in the general population and there was a paucity of studies on "occasional singers" until about a decade ago. One of the goals of this chapter is to contrast the general belief that singing is a privilege of the few, and to build a case to show that occasional singing is widespread and that it represents a fruitful model to shed light on the cognitive and biological processes underlying singing.

Singing is one of the richest sources of information regarding the nature and origins of musical behavior. It emerges precociously and it is a universal and socially relevant activity (Mithen 2006). Singing is as natural as speaking for the majority (Dalla Bella and Berkowska 2009; Dalla Bella et al. 2007; Pfordresher and Brown 2007). It is likely that humans are hardwired for singing. As soon as during the first months of life, babies produce vocalizations that are likely to be the precursors of adult singing (Papoušek 1996). These first vocal productions emerge spontaneously by imitation of maternal singing (e.g., Trehub and Trainor 1999), and act as the building blocks of future singing skills (see also the chapter by Trehub and Gudmundsdottir in this volume). For example, by repeating short musical phrases, eighteen-month-old children start producing recognizable songs (e.g., Ostwald 1973). Based on these elementary examples of singing skills, vocal performance slowly develops over time thanks to exposure, spontaneous practice, and in some cases early musical tutoring (Welch 2006, for a review), toward the proficiency characteristic of adult performance (Berkowska and Dalla Bella 2013; Pfordresher et al. 2010). Finally, it is unlikely that singing has emerged as a cultural accident, an amusing "vocal cheesecake" crafted to tickle our auditory sensation (to rhyme Steven Pinker's comparison of music to "auditory cheesecake," intended to underline its biological uselessness; Pinker 1997). Rather, singing and vocalization, far from being a mere cultural frill, are likely to have played a role during evolution. For example, it can be observed across cultures that people enjoy singing in particular when acting in a group (e.g., during religious ceremonies, in the military). Because singing is inherently a participatory activity, it is thought to foster group bonding (see also the chapter by Davidson and Faulkner in this volume). Favoring group cohesion is one of the reasons, together with sexual selection and mood regulation, why music may have had some adaptive value during evolution (Huron 2001; Mithen 2006; Tarr et al. 2014; Wallin et al. 2000).

In sum, there is a strong motivation to examine singing abilities in the majority (i.e., occasional singers) as a way to shed light on a widespread and likely biologically rooted human ability. This chapter reviews experimental results obtained in the last decade on occasional singing in adults, coming from both experimental psychology and the neurosciences of music. It focuses first on the Song System, with a particular attention to the mechanisms supporting proficient singing in the majority and to their neuronal underpinnings. In this context, I mostly build on a schema referred to as the "Vocal Sensorimotor Loop" (VSL; Berkowska and Dalla Bella 2009a; Dalla Bella et al. 2011) which we proposed a few years ago, and which was further developed and integrated more recently by including categorization of pitch information (e.g., pitch classes based on tonality representation) and category-to-motor translations (Pfordresher et al. 2015). In the second part of the chapter I pay particular attention to the issues inherent in measuring singing proficiency in occasional singers (e.g., how to choose the appropriate metrics to define accurate and precise singing, and the cut-off criteria to qualify somebody as a good or a poor singer). Because the vast majority of studies have focused on the pitch dimension (though see, for example, Dalla Bella and Berkowska 2009; Dalla Bella et al. 2007, 2009), I will focus selectively on vocal production of pitch, without considering the time dimension. Although the question of poor singing abilities is inevitably raised throughout the chapter, the focus will remain on proficient singing (for a detailed discussion of poor singing and tone-deafness, see the chapter by Wise in this volume; for a discussion on intonation see the chapter by Sundberg, also in this volume; and for a discussion on the pedagogy of teaching "the non-singer," see the chapter by Knight in this volume).

The Song System

How singing works

The ability to sing proficiently is supported by physical mechanisms, which are governed by a complex and dedicated neural network (Berkowska and Dalla Bella 2009a; Brown et al. 2004; Zarate 2013). This is referred to as the "Song System." The lungs provide the air supply needed for vocalization; phonation is made possible by modulation by the vocal folds of the airstream coming from the lungs. The vocal tract conveys to sound the spectral and temporal features typical of sung voice (Titze 1994; Sundberg 2013). Thus, the core physical mechanisms of the Song System are respiratory, laryngeal (i.e., the vocal folds), and articulatory structures (i.e., the vocal tract). The coordination of these mechanisms is responsible for the quality of the vocal output, and allows us to distinguish a professional singer from an amateur or a novice (Sundberg 1987, 2013). In spite of their relevance for vocal performance, these physical components are not further described in the present chapter, which is more centered around the functional and neural mechanisms underlying the Song System (for reviews, see Doscher 1994; Titze 1994).

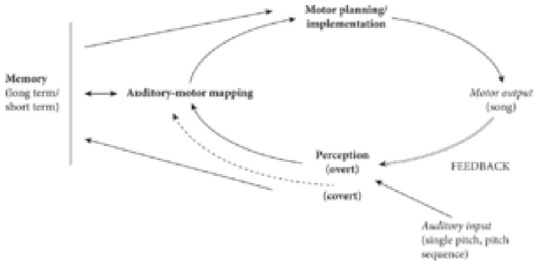

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Figure 1 Schema of the vocal sensorimotor loop (Berkowska and Dalla Bella 2009a; Dalla Bella et al. 2011). SMA = supplementary motor area; ACC = anterior cingulate cortex; dPFC = dorsal prefrontal cortex; SPT = cortex of the dorsal Sylvian fissure at the parietal-temporal junction; DLPFC = dorsolateral prefrontal cortex

(adapted from Dalla Bella 2015, with permission).

To describe the main functional mechanisms affording proficient singing I focus on an account we proposed to explain singing in tasks such as imitation (e.g., pitch- or melody-matching tasks), and singing from memory of a familiar melody (the Vocal Sensorimotor Loop—VSL; Berkowska and Dalla Bella 2009a; Dalla Bella et al. 2011; see also Zarate 2013). The purpose of the VSL is to identify the main processes in the Song System underlying pitch production during singing, and to lay out their connections. They include perceptual, motor, auditory-motor mapping, and memory components (see Figure 1). The role of these components can be elucidated by considering specific vocal tasks. The most common task is to sing a familiar melody from memory. To accomplish this task, the pitch information of the melody to be sung, which is stored in long-term memory, is retrieved and sent to motor planning/implementation mechanisms. It is at this stage that instructions to implement a given articulatory program and commands eventually leading to phonation are executed. Note that the VSL is a typical close-loop system, namely involving the analysis of the motor output which itself affects in real time the plan of the future events in the melody. Feedback analysis, and in particular auditory-motor mapping, is a crucial aspect for accurate vocal performance (Pruitt and Pfordresher 2015). These processes allow the corrections of errors that can occur during vocal performance. Indeed, when the percept of the produced melody is compared to the memory representation of the intended melody (e.g., by referring to an inverse model of the auditory-vocal system; Pfordresher and Mantell 2014), a discrepancy is detected, and thereby the motor plan is subsequently modified. Similar processes are engaged during imitation of single pitches or of more complex sequences. Imitative tasks, however, rely more heavily on working memory and less on long-term memory than singing from memory. The VSL is underpinned by a complex neuronal network which has been detailed elsewhere (Brown et al. 2004; Dalla Bella et al. 2011; Pfordresher et al. 2015; Zarate 2013), including sensory areas (e.g., the superior temporal gyrus/sulcus), motor areas (e.g., primary motor cortex and the Supplementary Motor Area), and auditory-motor integration regions (e.g., area SPT, cortex of the dorsal Sylvian fissure at the parietal-temporal junction; Pa and Hickok, 2008) (more information may be found in the chapter on the neuroscience of singing by Kleber and Zarate in this volume). An understanding of the functional and neuronal architecture of the Song System is critical for explaining poor-pitch singing. This condition can result from the disruption of one or a few components of the VSL, due to a brain insult (Ackermann et al. 2006; Berkowska and Dalla Bella 2009a; Gordon et al. 2006; Marin and Perry 1999; Stewart et al. 2009) or neurogenetic (i.e., congenital) disorders (Ayotte et al. 2002; Dalla Bella et al. 2011; Dalla Bella et al.

2009). Different sources of impairment can lead to poor singing such as impaired perception, poor motor control, sensorimotor mapping errors, or inefficient memory retrieval (Dalla Bella et al. 2011, 2012; Hutchins and Peretz 2012; Pfordresher and Brown 2007).

One peculiarity of the VSL is that it includes two parallel pathways for pitch perception. The overt pathway is engaged in those tasks where explicit judgments of pitch differences are demanded, such as in pitch discrimination tasks, or same–different tasks with melodic material. The covert pathway accounts for cases in which singers, in spite of being very inaccurate in judging pitch differences, do still exhibit proficient singing (Dalla Bella et al. 2009; Griffiths 2008; Loui et al. 2008). This condition is possible only under the assumption that pitch differences can be computed covertly by a separate mechanism. More recently (Zarate 2013), overt and covert pathways have been more specifically associated with dedicated neuronal substrates based on neuroimaging evidence (Zarate and Zatorre 2008; Zarate et al. 2010). The covert pathway is linked to the activity of the auditory cortex and of the inferior frontal gyrus, while the overt pathway involves the auditory cortex, the intraparietal sulcus, the anterior insula, the anterior cingulate cortex, and the dorsal premotor cortex.

In a recent schema of the functional architecture underlying singing accuracy (Pfordresher et al. 2015) the components of the VSL are integrated with another proposal (the Linked Dual Representation Model; Hutchins and Moreno 2013). The proposal by Pfordresher and collaborators, an outcome of the Seattle International Singing Research Symposium (17–19 October 2013, Seattle), underscores the link between more fundamental sensorimotor processes and higher-level categorization mechanisms involving long-term memory representations, which were only vaguely indicated in the VSL.

Singing accuracy and precision in occasional singers

During the last decade a few studies have been devoted to quantifying singing proficiency in occasional singers (for a review, see Dalla Bella et al. 2011). I focus here on evidence from studies where vocal performance was analyzed with quantitative acoustically based methods (e.g., Dalla Bella et al. 2007, 2009; Murayama et al. 2004; Pfordresher et al. 2010; Terao et al. 2006). Acoustic analyses of vocal renditions yield metrics of singing proficiency in terms of both accuracy (i.e., the difference between the sung and target pitches or intervals), and precision (i.e., consistency in repeating the same pitch or interval) (Berkowska and Dalla Bella 2013; Dalla Bella 2015; Pfordresher et al. 2010).

A variety of tasks can be used to test singing proficiency. A common task, which can be easily mastered by occasional singers, is to sing a well-known song (e.g., "Happy birthday" or "Brother John") with lyrics from memory (Berkowska and Dalla Bella 2013; Dalla Bella et al. 2007, 2009). Differences can be observed when the singing of a melody is performed with lyrics or on a syllable, with the last condition typically favoring better performance (Berkowska and Dalla Bella 2009b, 2013). Another possibility is to use imitation of a single pitch, an interval, or a short novel melody, using a vowel or a syllable (pitch matching). Single-pitch matching is quite widespread (Goetze et al. 1990; Hutchins et al. 2010; Pfordresher and Brown 2007), and is treated as a core task for assessing musical talent (Watts et al. 2003). However, imitation of melodic patterns as opposed to simpler patterns or individual pitches is also a quite common task (Pfordresher and Brown 2007; Berkowska and Dalla Bella 2013; Rutkowski 1990; Rutkowski and Miller 2003). A variant of these tasks consist in presenting additional auditory feedback, when during the imitation of a pitch sequence the correct pitch or melody are delivered as one sings (Pfordresher and Brown 2007; Tremblay-Champoux et al. 2010).

Although one may be tempted to choose one of these tasks as ideal to assess singing proficiency, different tasks are likely to reflect the activity of partly independent components of the Song System. Melody imitation in the presence of augmented feedback, or singing on a syllable of a well-known song, put less demands on memory as compared to imitation of novel pitch sequences. Thus, depending on singing skills, occasional singers variably perform on different tasks (Berkowska and Dalla Bella 2013). If the goal is thus to obtain a thorough profile of singing abilities, especially in occasional singers, where there are important individual differences, the use of a rich set of tasks is highly advised (for a discussion, see Dalla Bella 2015). This approach has been adopted in recent studies, in which batteries of tests have been proposed such as the Sung Performance Battery, which includes tasks ranging from single-pitch matching to imitation and production from memory of complex pitch sequences (Berkowska and Dalla Bella 2013), and the Seattle Singing Accuracy Protocol (SSAP; Demorest et al. 2015), which includes a smaller set of core tasks.

First reports of singing accuracy (i.e., the discrepancy between the produced and the target pitch or interval) in occasional singers suggested that around 85–90 percent of the general population can sing in tune (Dalla Bella and Berkowska 2009; Dalla Bella et al. 2007; Pfordresher and Brown 2007). In one of the first studies, for example, we tested singing proficiency of a group of sixty-two occasional singers in Montreal (twenty university students tested in the lab, and forty-two participants recruited in a public park). Their performance was compared to that of four professional singers (Dalla Bella et al. 2007). Participants sang the refrain of a well-known song with lyrics. Occasional singers were less accurate in producing pitch intervals (average deviation from the correct intervals: 0.6 semitones) than professional singers (deviation of 0.3 semitones). Interestingly, occasional singers typically sing faster than professionals, a phenomenon linked to lower pitch accuracy. Reducing performance tempo had a positive effect on the performance (i.e., it increased pitch accuracy) in most of the cases. The finding that the majority can sing in tune has been confirmed by further studies, where singing from memory and imitation were compared (Berkowska and Dalla Bella 2009b, 2013; Dalla Bella and Berkowska 2009). Note, however, that the number of proficient singers can vary as a function of the measure of singing proficiency and also as a function of the task. For example, when considering pitch precision (i.e., the consistency of repeated attempts to produce a pitch) instead of accuracy, the percentage of proficient singers decreases to about 45 percent (Pfordresher et al. 2010), a value which varies as a function of the tasks and of the pitch dimension taken into account (e.g., intervals vs. pitch height, Berkowska and Dalla Bella 2013; Dalla Bella 2015). This finding suggests that precision may be considered for judging our own performance instead of accuracy. This possibility may account for the very high percentage of individuals self-reporting that they are poor singers.

Other studies targeted vocal imitation abilities. Poor performance was initially observed in single-pitch matching (Amir et al. 2003; Murbe et al. 2002; Ternstrom et al. 1988). Nonmusicians typically deviate by 1.3 semitones on average as compared to 0.5 semitones for musicians (Amir et al. 2003; Murry 1990; Murry and Zwiner 1991; Ternstrom et al. 1988). More recent studies indicated, though, that low accuracy in imitating pitch does not characterize all individuals without musical training (Estis et al. 2009). Morever, poorer performance in nonmusicians may partly result from using pure tones as models for imitation. Imitation of synthesized voices or sung performances led to higher accuracy, with pitch deviations of 0.5 semitones or less (Pfordresher and Brown 2007; Wise and Sloboda 2008; see also Berkowska and Dalla Bella 2013; Watts and Hall 2008). It follows that accuracy in pitch matching depends on the acoustic features of the stimulus to be imitated, showing a general advantage for the human model (Granot et al. 2013; Lévêque et al. 2012). Target stimuli which share acoustical properties with the vocal production are particularly well-suited to facilitate mapping onto sensorimotor representations, thus favoring higher accuracy.

Imitation of stimuli of increasing complexity (i.e., from single pitches to short novel melodies) has been assessed systematically more recently (Berkowska and Dalla Bella 2013; Pfordresher and Brown 2007; Pfordresher et al. 2010). For example, Pfordresher and Brown (2007) asked a large sample of university students without musical training to imitate various pitch sequences (i.e., a single repeated note, a sequence including a single change of pitch, and short four-note melodies). Most of them imitated sequences with renditions within one semitone from the target pitches. Yet they were less accurate when they imitated short melodies as compared to single pitches (as in Wise and Sloboda 2008; but see Berkowska and Dalla Bella 2013). That most occasional singers are quite accurate in imitating short unfamiliar melodies was replicated by Pfordresher et al. (2010). Nevertheless, it was found that the majority was imprecise (i.e., the standard deviation of the fundamental frequency for renditions of the same pitch class or interval exceeded one semitone). More recently, the distinction between precision and accuracy in imitation tasks as well as in singing from memory tasks has been addressed with the Sung Performance Battery (SPB; Berkowska and Dalla Bella 2013; see also Dalla Bella 2015). A group of fifty occasional singers tested with the SPB provided measures of accuracy and precision on a set of five tasks, based on the ability to reproduce target pitches (i.e., absolute pitch) or target intervals (i.e., relative pitch) presented isolately, or in the context of novel and familiar melodies. Occasional singers were more accurate and precise when imitating or reproducing from memory well-known songs than when imitating target pitches, intervals, or short novel melodies (as in Pfordresher et al. 2010). In addition, occasional singers were systematically more accurate and more precise when singing well-known melodies on a syllable than with lyrics. This finding may result from reduced linguistic memory load when singing on a syllable or to rhythmic factors due to the regularization effect of repeating the same linguistic unit (Berkowska and Dalla Bella 2009b; see also Dalla Bella et al. 2012). Note that rhythmic processing may mediate vocal performance on the pitch dimension. Better performance in a rhythmic task, such as moving to the beat of an auditory stimulus, and low rhythmic variability during singing are associated to greater singing proficiency on the pitch dimension (Dalla Bella et al., 2015).

To summarize, systematic assessments of singing accuracy and precision in occasional singers reveal that the majority is accurate across a variety of tasks. Accuracy decreases with increasing sequence length and complexity, and when the pitch material is not familiar. Even though occasional singers are quite accurate in imitating pitches, however, they may still be not very consistent over repetitions.

Measuring singing proficiency in occasional singers: present methodological challenges

Even though we have witnessed an increase of interest and of quantitative research on singing abilities in occasional singers, there are a few challenges that deserve particular attention. Here I will focus on two methodological issues that hinder the measurement of singing proficiency and the qualification of an individual as a good or poor singer. Even when singing proficiency is measured based on acoustic methods, a panoply of metrics can be extracted from the recorded signal (e.g., pitch interval deviation, signed note error, absolute note error, note accuracy and precision, interval accuracy and precision, contour errors, pitch errors, and so forth; Dalla Bella et al. 2007; Pfordresher and Brown 2007; Pfordresher et al. 2010). Because of the diversity of metrics, there is little agreement on the measure(s) that allow one to characterize an individual's singing abilities. Another issue concerns the criterion to adopt for teasing apart poor from good singers (Berkowska and Dalla Bella 2013; Dalla Bella 2015). For example, participants are considered to be proficient singers if their productions do not deviate from a target pitch (e.g., in a pitch-matching task) by more than a fixed value (e.g., one semitone or a quarter of tone), or by a relative criterion (e.g., with regard to a comparison group) (for a discussion, see Dalla Bella 2015). Again, there is little consensus about this criterion. These two issues are addressed in turn below.

Metrics of singing proficiency

Measures of singing proficiency based on acoustical analyses of vocal performance can be organized, for simplicity, in terms of absolute pitch (i.e., absolute difference in pitch height) and relative pitch (i.e., interval difference) metrics (see Dalla Bella 2015). Absolute pitch metrics are, for example, the mean signed note error or the mean absolute note error (Berkowska and Dalla Bella 2013; Hutchins et al. 2010; Pfordresher and Brown 2007; Pfordresher et al. 2010). The difference between the two metrics is that only the first reflects the direction of the error (i.e., whether the produced note was higher or lower than a model). Relative pitch metrics are based on the difference between two subsequent pitches (i.e., sung interval) relative to the interval in the notation, such as the absolute pitch interval error (e.g., Pfordresher and Brown 2007; Pfordresher et al. 2010; see also pitch interval deviation; Dalla Bella et al. 2007, 2009; Dalla Bella and Berkowska 2009). The aforementioned metrics vary on a continuum, expressed in cents or in semitones. More discrete measures of errors can also be computed such as the number of interval errors, defined based on a given criterion (e.g., interval departing from the target interval by more than 1 semitone), and the number of contour deviations (e.g., Dalla Bella et al. 2007, 2009). Finally, measures of accuracy and precision can be calculated for absolute and relative pitch metrics (for equations, see Pfordresher et al. 2010; Berkowska and Dalla Bella 2013; see also Dalla Bella 2015), thus providing a multidimensional profile of singing abilities.

Due to the diversity of metrics that are indicators of singing proficiency, there is little agreement on the measure(s) that allow one to characterize an individual's singing performance. Low pitch accuracy has been treated as an indicator of poor-pitch singing (Dalla Bella et al. 2007; Pfordresher and Brown 2007; Pfordresher et al. 2010). However, considering this metric in isolation may lead to overestimating singing proficiency, because the prevalence of poor-pitch singing is higher when considering precision instead of accuracy (Pfordresher et al. 2010). Indeed, different metrics (i.e., accuracy vs. precision, in terms of absolute or relative pitch) can lead to discordant assessments of singing proficiency and of the prevalence of poor-pitch singing. This problem can be circumvented by adopting a set of metrics based on accuracy and precision, estimated in terms of both absolute and relative pitch, as a way to obtain a thorough profile of singing abilities (Dalla Bella 2015; see also Berkowska and Dalla Bella 2013). These metrics have the advantage that they can be applied to different tasks, including imitation and singing from memory tasks, thus allowing between-task comparisons.

Criteria for telling apart good and poor singers

A second issue pertains to the choice of a cut-off score to determine if a performance is typical of a good or a poor singer. The criterion can be absolute or relative. An absolute criterion applies when a production deviates on average from a target pitch (e.g., in a pitch-matching task) by more than a fixed value. Cut-off values can range from one semitone (100 cents = one-twelfth of an octave; e.g., Berkowska and Dalla Bella 2013; Pfordresher and Brown 2007; Pfordresher et al. 2010), to a quarter of a tone (50 cents; Berkowska and Dalla Bella 2013; Demorest and Clements 2007; Hutchins and Peretz 2012; Hutchins et al. 2012). The semitone cut-off is motivated by the fact that this interval is the smallest pitch difference between two subsequent tones in Western music. However, because the acceptable range of performance around the target pitch is 200 cent (e.g., see Hutchins et al. 2012), this criterion may lead one to qualify as good singers individuals who instead are poor-pitch singers. The more stringent ±50-cent cut-off is thus proposed, which corresponds to the acceptability threshold for sung tones to be considered in tune (Hutchins et al. 2012).

Even though a fixed criterion may appear as uncontroversial, it does not do justice to the fact that norms for singing proficiency likely depend on the tested group (e.g., musicians vs. nonmusicians, individuals with vocal training vs. without training, adults vs. children). For example, on average a musician with vocal training is likely to exhibit higher singing accuracy than a nonmusician (Dalla Bella et al. 2007). To determine if a musician or a nonmusician is a good or poor singer, different standards should be adopted. Hence, a criterion to determine singing proficiency should rather vary for different population groups (i.e., it should be a relative criterion). In addition, average singing accuracy and precision are affected by task factors (with worse performance in imitation tasks than singing from memory, Berkowska and Dalla Bella 2013). With a variable criterion the performance of an occasional singer is compared to that of a comparison group. A variable cut-off value can correspond to two Standard Deviations from the average of a comparison group (e.g., Berkowska and Dalla Bella 2013; Dalla Bella and Berkowska 2009). Assuming that measures of singing accuracy and precision are normally distributed, this procedure limits the incidence of poor-pitch singing to a constant percentage of individuals showing particularly poor performances.

There is currently no agreement as to whether singing proficiency in occasional singers should be assessed with an absolute or a relative criterion. It is obvious that the same performance may score as “in the normal range” with a tolerant criterion (e.g., a variable cut-off), while it will fall beyond a more stringent cut-off (e.g., 50 cents) and accordingly treated as “poor-pitch singing.” The effect of different cut-offs on the assessment of good and poor-pitch singing was recently examined in fifty occasional singers with the SPB (Berkowska and Dalla Bella 2013). Three cut-offs were compared, namely two fixed (100 and 50 cents) and one relative criterion (2 SD from the average of the group). The 50-cent criterion is definitely too stringent, leading to estimates of poor-pitch singing up to 84 percent and 64 percent of the participants. Lower incidence of poor-pitch singing is naturally observed with the 100-cent cut-off. This criterion, however, allows identifying very few poor-pitch singers based on relative pitch. Notably, the incidence of poor-pitch singing varies as a function of the task and metrics. The variable cut-off provides a more realistic estimate of poor-pitch singing, with an incidence of 28 percent across tasks and metrics. This criterion, in addition, is well suited to uncovering individual differences among poor-pitch singers. Because of these advantages, the variable cut-off relative to a given normative population is preferred over a fixed criterion (see Dalla Bella 2015, for further discussion).

Conclusions

The majority of individuals without musical training, defined here as occasional singers, have been the object of a growing number of studies during the last decade. There is converging evidence that most occasional singers can sing accurately, although they may display low precision. Hence, proficient singing is widespread in the general population and not confined to a small group who received vocal training. Singing in tune is underpinned by functional and neuronal architectures that emerge naturally during development and engage processes ranging from auditory perception, sensorimotor integration, motor planning, and memory. These mechanisms must be functional in order to support accurate and precise singing, an ability that manifests itself across a variety of tasks and using measures issued from acoustic analysis of sung renditions. The malfunctioning of at least one of these mechanisms leads to poor singing. Identifying the origin of poor singing in the architecture of the Song System (i.e., the locus of impairment) is an important step to explaining individual differences among occasional singers. Moreover, it may play a critical role for devising remediation strategies which are theory-driven, and targeted to a particular component within the song system (e.g., Anderson et al. 2012; Tremblay-Champoux et al. 2010).

This endeavor is not free from methodological challenges, though. Two of them concern the quantitative measures of singing accuracy and precision, and the choice of a criterion to tease apart poor from good singers. Because poor-pitch singing is a rich and multifaceted phenomenon, its assessment cannot be confined to a single task, and to the use of a single measure or criterion of singing proficiency. I suggest that the assessment of singing abilities should be based on a variety of tasks aimed at targeting the different components of the Song System and with the same set of metrics (e.g., accuracy and precision). The choice of the cut-off criterion is also critical to telling the difference between a poor and a good singer. I expressed a preference for a relative criterion (e.g., 2 SD from the average of a normative group), which takes into account both group and task factors. This multidimensional approach to singing abilities provides a detailed profile for an individual's singing abilities, and paves the ground to individualized remediation strategies for poor-pitch singing.

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