Understanding an Original Method for Learning to Sing From the Broad Perspective of Behaviourist/Empiricist Neural Constructionist Learning Theory

Written by
Lindsay Davidson BMus(Hons), Dip. Mus.Ed, PGCE, PhD

Introduction

Singing is given a valued position in many cultures. It also features heavily in many school programmes as a central part of music learning. This essay will discuss learning to sing primarily from a neurological connectionist perspective (Greeno, Collins and Resnick, 1996) and seek to explore what is happening during the learning activities and understand what if any theoretical neurological underpinnings there may be to explain the effectiveness of this method. The teaching/learning method on which this discussion is based were developed by the writer through twenty years of of highly successful practice, and is derived from instrumental teaching. The writer considers it potentially valuable to consider this established music learning method within a neurological connectionist framework to attempt to incorporate aspects of this into general classroom/learning practice. During the course of reading for this essay it became apparent that some modifications can be made to make the method more effective. These are mentioned at the appropriate points in the text below.

When learning happens, an observable change must occur in the learner's behaviour. Therefore this discussion will assume that the learner is not what would commonly be called a 'naturally talented' musician; that is to say a person who does not sing in tune or create sounds commonly associated with being aesthetically pleasing without learning how to do so. The observed change is taken to mean singing more in tune with a voice timbre commonly associated with being aesthetically pleasing in the western art tradition.

The Method

The specific acquisition of singing skill as defined above is achieved through five steps described thus:

1. Sequence of basic instructions – isolation of individual specific muscle actions and training of sequence of these instructions
2. Grouping instructions – grouping/combining the above acquired actions into a complex blend
3. Add time – linguistically assign (using rhythmical solfah) fixed positions relative to a beat for each complex group of actions
4. Make the time even - arrange each beat at an equal time distance
5. Speed up – reduce the time between each beat

Each step is repeated correctly seven times in a row, with a token being moved from one position to another with each subsequent success. Any failure to reproduce a repeat of an action results in all tokens being returned to the original position.

This method was developed for teaching piano based on legends of Liszt's approach (Liszt moved coins from one end of his piano to the other when he played a passage correctly and put them all back again when he made a mistake, according to legend). In piano terms this would represent training the sequence of finger actions in each hand separately, then both hands together, then adding the idea of pressing and releasing keys in time controlled by saying rhythmical solfah (New French Method “tafatifi” or Kodaly's “tikatika”) and co-ordinating the upward and downward actions of the keys with this. Once the actions and words have been joined it only remains to say the words (and do the actions) rhythmically, then speed up. The method was later adapted for bagpipes, then drums, and then finally generalised for other instruments.

Singing has the additional problem of the person creating pitches from their own body, thus requiring 'audiation' (Gordon 2008-2012) and developing higher order kinaesthetic skills in working with non-constant states of the muscles involved in tone production.

Each of these steps will be considered in more depth from the perspective of understanding the learning that happens and examination of elements that may be present in making this method effective. Effective here is taken to mean that the desired changes in singing happen during and after an instructional period.

Step 1 – Sequence of Basic Instructions

In singing we produce a tone at a specific pitch and combine these with words.

Pitch is controlled by causing the vocal folds to open and close (hereafter oscillate) at a certain frequency. Prior to learning the physical manifestation of the pitch (frequency of oscillation between open and closed positions of the vocal folds), the student must learn to 'register' and recognise fixed pitches (with or without a name/symbol), recall and compare them to pitches, generated within their own body or not, which they hear concurrently. In Simpson's (Simpson 1972) taxonomy of the psychomotor domain it is clear that the point of entry for order of thinking here is at 'guided response', and as such the teacher will be required to describe inaccuracies and advise on corrective action. In doing so the teacher needs to ensure that instructions are meaningful – 'sing at a higher pitch' means nothing to a person who is unfamiliar with musical terminology. Rather, the teacher should establish a varied approach to explaining such problems – using spatial means (demonstrate relative pitch with hands as in Kodaly/Curwen), logical explanations of frequency (assisted with graphics), kinaesthetic explanations of muscle oscillation) and the Madeline Hunter direct instruction model to give as a wide an opportunity as communicating the ideas involved as possible. Once single pitches can be attained adequately, they must be labelled. These labels may be note names (learning absolute pitch), solfah (training relative pitch) or words in songs (pragmatic approach for specific songs). Use of labels may assist uniting declarative memory with non-declarative memory; combination of these two aspects of memory logically gives the possibility of creating perfect pitch within the learner; if spatial and the personal intelligences are deployed during labelling of accurate pitch creation then there is also a greater possibility of this being reinforced during sleep (Backhaus and Born et al., 2007). Furthermore, the implications of research by Hupbach et al (Hupbach et al 2007) suggests that reconsolidation of the episodic memory of singing correctly through presentation and overt labelling of pitches with varied tone colours (different instruments) will contribute to the construction of semantic memory which could then be further extended to include the skill commonly known as perfect pitch. Kitahara, Goto and Okuno (2005) discuss the relationship between pitch and timbre on specific instruments, and their findings (considering their discussion was in an computerised context) on this contribute to the assertion that using the sound characteristics of instruments and their partial dependence upon pitch can contribute towards developing perfect pitch in humans. Demany and Semal (2002) also concluded that pitch discrimination is to a certain extent timbre specific.

Stewart and Walsh (2002), in investigating amusia, have noted that pitch perception without verbal context is more difficult for some subjects, and in extreme cases functionally impossible. Whilst on one hand this gives the unfortunate diagnosis that the term 'tone-deaf' has some grounding in biological reality, it also gives some hope that through sol-fah and Kodaly/Curwen hand signals, to a limited extent, it may be possible to overcome pitch perception difficulties. Experimentation would be needed in this specific direction to investigate to what extent this can be achieved.

A study by Laguitton et al (1998) asserts that there may be a correspondence between right and left handedness and accuracy of tonal perception, although this was not supported in general cerebral domination. This would suggest 'musicality' is profoundly linked with proprioception. It also suggests that perhaps left handed people should learn instruments that produce fixed tones, rather than singing. To temper this comment it is worth noting that the sample group was relatively small and the experiments should be replicated over a wider range of subjects to be able to have more confidence in this assertion.

Hyde, Peretz and Zatorre (2008) comment that fine pitch resolution is not fully understood in neural terms. Their assertion that musical pitch processing is mainly assigned to right auditory cortical structures but language pitch processing is preferentially assigned to left auditory regions on account of speed of processing may suggest an insight as to what is happening when a person learns to sing. Perhaps the complex of tasks involved in singing are being assigned to both regions, in which case the solfah, or an essentially linguistic strategy for learning pitch would make sense. Furthermore, the method described above, in that it specifically isolates pitch/tone production and allows the learner to acquire this as a single unified skill without the context of words (but through linguistic tools e.g. solfah) would appear to be be supported by constructionist theories as effective. The logical implication of this is that from a neurological constructionist perspective, other kinds of learning can be delivered through combining mixed approaches.

The role of emotion in learning should be considered here. The OECD 2007 report concerning the brain comments that emotions play an integral role in learning, and that the complex interaction between emotions and other aspects of cognitive functioning when learning a new activity make it practically impossible to remove the emotional component from learning. Thus, it seems vital that the emotions invoked when moving the token (Liszt's coins above) as a reward for success are always the same, to maximise the likelihood that similar neural networks will be fired as a result of the activity.

Critical here is the decision by the singer to recall physical sensations which correlate to a pitch. One purpose of taking lessons and practising must be to enable the singer to respond accurately to stimuli (either symbols representing notes on a page or sounds being played to be copied, or imagination/recall of musical works committed to memory). One measure of the success of the training programme will be that the singer can produce the desired pitches quickly and accurately. Musicians generally consider what they do to be 'automatic' response to stimuli. That is to say musicians do not identify and internally name each and every element they see in a score, but give an instant response to the stimulus. It follows that the musicians must therefore rely upon nondeclarative or procedural memory. Given that this type of memory is often associated with the prefrontal cortex, as are emotions, it follows that use of emotions in associating broader semantic recall are a potential key to developing skilled pitch response to stimuli.

It should be noted here that in many traditions (Germanic Baroque, Scottish bagpipe, Indian ragas) individual pitches and scales have symbolic meaning which refer to concepts beyond strictly musical matters. In this regard the assertion that pitch names may have more semantic significance is justifiable.

Gudmundsdottir (2010) points out that research findings on learning to read music are currently insufficient to propose a teaching method based on theories and experimental observations. She also points out that reading music and responding to it requires both reading and mechanical skills and that reading pitch cannot be separated from reading time in the real-life context of being a musician. Here we have a problem that learning narrowly defined skills in isolation may not guarantee being able to apply those skills in different contexts. Doing so will require higher order thinking in the psychomotor domain, moving from guided response to adaptation. Adaptation will also be necessary as muscles do not exist in a constant state. Professional singers rarely rehearse early in the morning as the vocal folds are not physically in a state that is comparable to the state in which they typically perform in the evening.

Baddeley, Sala and Robbins (1996), though in a different context, have revealed how difficulties may arise in the process of learning to sing from written pitches due to issues of poor working memory. In this scenario, the semantic aspect of the note symbols should be taught separately, perhaps linking with instrumental performance (thus creating a bridge through pitch, which can be made more adaptive by using different instruments, varying colour and allowing the mind to isolate the pitch component more exactly). The pitches should become part of long term memory before attempting to link to singing. This approach is supported in theory by Cowan (2005) who asserts that working memory is a facet of long term memory.

This takes a connectionist, or as Greeno, Collins and Resnick (1996) put it, a behaviourist/empiricist perspective of learning to sing a given pitch. It may not be possible to view this from a rationalist perspective. The reason for this is that this perspective allows us to consider what the student has learned *about* pitches or about singing pitches, as opposed to actually being able to sing them. In meta-cognitive terms there is a place for discussing this with the student as an understanding of the processes involved, as problem solving procedures and planning are not only higher order thinking processes, but are also part of the learning how to sing process. Indeed, discussion of this prior to step 2 may have particular value as it is in step 2 that it is so difficult to identify exactly what is happening inside the learner. Constructivism in learning how to sing has the potential to synthesise the connectionist and rationalist approaches. This can happen through deliberate conceptualisation of the learning process combined with behaviourist feedback during activities - (a big smile together with praise and moving the token) and implicit analysis. Emotional response in this context would act as a common point to unite these competing philosophies and thus maximise learning.

For 'knowledge' to be conveyed via the above method, and be available for recall, it seems necessary to organise this knowledge as Case (1992, cited in Greeno, Collins and Resnick 1996) suggested, as associative networks and procedures (just like the pitches with semantic significance as mentioned above), and those associations should refer to a variety of tasks/approaches (as when using hand signals to improve pitch learning).

Raising these points also raises the possibility of experimentally investigating what is happening and therefore eventually to create tools to select learning approaches to suit individuals. Given that we are fairly confident that we know which parts of the brain show increased activity when processing emotions, we could conceivably teach someone to sing as above with significant emotional responses and someone else with limited emotional responses and compare the dynamic images from a fMRI scan to understand how emotional activity relates to apparent learning of singing. Ideally the students would be scanned during interviews about their previous musical experience and perceptions, and during the instructional period to see which parts of the brain are active as the concepts are being formed, and then again when displaying or recalling their learning at a later date. This would hopefully allow us to understand more clearly which type of 'knowing' (behaviorist/empiricist, cognitive/rationalist or situative/pragmatist-sociohistoric perspectives) (Greeno, Collins, Resnick, 1996) are most appropriate at changing phases of the process of learning to sing.

Step 2 – Grouping the Instructions

It is in this phase of learning that the basics of singing aesthetically are refined – the basic skills have been acquired, the cognitive phase has passed in step 1 and the associated responses have been established and now they are becoming autonomous according to Fitts's (1954) discussion of the acquisition of motor responses.

Baddeley (2000) proposed an episodic buffer; by using previously acquired isolated skills (pitch production as one unit, and word/tone colour production as modifications of mouth shapes as a second unit), these previously isolated units can be brought together. Anderson (1993) discusses at length the various mechanisms that will be happening as the student essentially goes through a trial and error process in bringing these elements together. Critical to success in this context is the strength of definition of the skills being brought together. Here the factor which may cause failure is that when we sing, we do not say words in the same way as when we speak. The aesthetic demand of 'attractive' tone production requires the shapes inside the neck and mouth to be different to those we use when speaking. Reconciling Baddeley and Anderson, the logical approach would be to base our longer term learning of singing skills on a course of particular songs (these will be the episodic memories that will be used for later recall) as opposed to each and every lesson being sought in memory being remembered. In short, we would learn singing skills through songs, as opposed to songs through singing skills. This would establish a different and new set of neural connections associated with learning to sing as opposed to using those connections associated with speech.

Tadlock (2005) has proposed an alternative method for this step which could be compared to mathematical differentiation – or trial and error and modification based on implicit analysis. This conforms to the traditional approach of learning musical activities (informally known as 'grunt and slap'), although in this singing method (which is not comparable to traditional approaches as it breaks the process into stages not traditionally isolated) the effect would not be directly comparable to a traditional approach because the context is fundamentally different.

Discussion of meta-cognition here may contribute significantly to the success of the learning process. Greenberg and Verfaellie (2010) comment that interdependency between semantic and episodic memory may be greater than previously thought, which would suggest that conscious attempts to extract generalisations concerning the skills being trained in any given song or exercise, particularly in combination with emotional activation, may facilitate faster construction of neural patterns in semantic memory. This also supports the assertion above that the cognitive/rationalist approach can be partially reconciled with the connectionist perspective. Shanks (1997) discusses in length and detail the flaws in experimental method which may cast doubt on the dissociation of episodic and procedural memory. His argument demonstrates the importance of student awareness of the general context of the task and this explicit statement of goal (abstraction of specific elements of singing success, marked by emotional responses and tokens). Extending from the arguments made by Shanks regarding the inability of subjects to decrease reaction time in a pseudo-random sequence recognition and those presented by Perruchet and Amorim (1992, experiment 1, cited in Shanks 1997) that training on sequences leads to faster results, it follows that singing students must be explicitly aware of what they are doing and why in order to maximise assimilation to memory, again partially supporting the above assertion that we could adapt this method for generalised classroom practice. Unfortunately, without appropriate and extended experimentation, we would be unable to ascertain with any level of certainty what type of memory is being activated and through which stimuli.

Research based on functional MRI scans by Wagner et al (Wagner, Desmond, Glover and Gabrieli, 1998) points to the importance of the prefrontal cortex in episodic memory which further supports this argument that any actions likely to make use of this brain region should help the general learning process in singing. This essentially locationist suggestion concerning emotion should be tempered, however, bearing in mind that the use of a token and the reliance on positive emotions in teaching will require us to examine brain activity more through natural kind and complex psychological constructionist approaches, as argued indeed by Humeny, Kelly and Brook (2012). In this teaching method, we are seeking to control core affect in combination with conceptualisation, two functions asserted in Lindquist et al (2012) to be shared in the ventromedial prefrontal cortex. Deshpande et al (2012) further demonstrate the need for functional MRI scans during musical performance and learning to deepen our understanding; their comments may lead us to the conclusion that rather than being controlled by emotion, however incompletely, it may be the case that music-making itself should be understood in a connectionist context as an emotion. Hodges (2005) suggests that music may be a way of knowing; perhaps it is, and that this manner of knowing is deeply linked to emotion. Further, this concurs with the argument that we can adapt this method for different types of learning, such as fact memorisation and comprehending language.

These arguments seem to suggest that this method of firstly training specific skills in isolation and immediately contextualising them in particular songs is supported by various theories as being highly effective and further, that the curriculum should be conceived to teach a series of specific skills through individual songs, as opposed to learning general skills which will then be applied across a number of songs. That is to say each song should be treated as a study of a range of carefully defined learning objectives, and the overall goal of becoming a technically competent and aesthetically pleasing singer should be achieved through a fixed course of songs, as opposed to learning a series of techniques.

Again, organisation of material to be learned into units of organised units (with ever more 'nests' of organised units extending from here) of learning, which could be conveyed and recalled through a complex of permanently associated recall routines would suggest that this method of learning can be extended to accommodate the cognitive/rationalist perspective within the connectionist viewpoint. Perhaps this is why so many rugby players have routines when kicking conversions?

Step 3 Add Time

Platel (2005) reports that melody is more important in long term recall of music than rhythm. He also notes that different parts of the brain are active in responding to familiar music and non-familiar music. However, his claims regarding the nature of the meaning in musical semantic memory is far more helpful. Platel asserts that musical semantic memory consists of a lexicon of familiar phrases. How and under what conditions these phrases can be reclassified as semantic as opposed to episodic, or even if the episodic existence of a memory is exclusive from its co-existence as a semantic memory is not addressed.

This relationship is important because in this step of the learning process, we are essentially seeking to manipulate a series of existing musical semantic memories by binding the order of their recall to a verbal framework. This verbal framework would logically be controlled by those areas of the brain more typically associated with language. Platel states that there is some, but not much, overlap between the musical and verbal active brain areas with subjects who are not trained musicians when working with semantic musical memory. Active application of words to the pitches may represent a wider range of cognitive stimuli, justifying the assertion that a varied lingual/musical approach is relevant in learning to sing. In activating more brain regions we are increasing the chance of accurate recall for a wider range of people who display varied learning strategies and preferences. By combining Curwen hand signals with rhythmical solfah and a token based reward system we are increasing the likelihood of each training session being more similar to the previous, and if combined with overtly stated goals and knowledge of metacognition, we are logically increasingly the likelihood of rapid transfer/addition from working and episodic memory to long term semantic memory. That is to say we may achieve our goals of becoming aesthetically pleasing singers more rapidly.

If the semantic memories can be viewed as a representation of interactions with the environment, we then open the possibility to reconcile the situative (Greeno, Collins and Resnick, 1996) perspective of learning with connectionist and do so with the application of a modified version of the above method.

Step 4 Make The Time Even – Music-Making Is Predicative

However, there is a weakness in this argument based on the fact that singing is also predicative and not merely about recall. Research into acoustic short term memory by Grimault et al (2009), whilst interesting, does not comment specifically upon the role played by imagination in tone perception and production. This role is considered to be central to audiation by the likes of Gordon (2008-2012) and is considered by musicians to be the key to successful singing in tune. It would seem that imagination in music-making needs to be further investigated and researched in terms of neural networks.

Pantev et al (1996) present research from which a tool to teach and experimentally measure musical imagination of pitch could be derived. They key here is that identifying virtual pitch – pitch constructed by the mind from spectral components could potentially be taught using simple behavourist methods (in the manner of Pavlov's dog). With control groups – trained singers/musicians and non-trained and receiving no training could be compared to an initially non-trained but later trained group to examine the ability to fuse spectral elements (presented binaurally or not) into a virtual pitch. The speed and intensity of imagining pitches can also be measured and a before and after comparison can be made. In such a way, we can then understand more exactly what neural processes are involved in imagining music and whether or not (and if so, how) we can influence them. This could then be explored to modify the method for general non-musical learning.

Palmer and Van de Sande (1995) note that the two extremes views of management of rhythm – as an immediate and localised feedback response system (where in the case of some instruments reactions may need to occur as quickly as 40ms) or as a global system (a whole piece) which may involve working and controlling immense amounts of information simultaneously are probably wrong and that the most likely reality is that the musician breaks the whole piece into varied episodes and manages them as smaller units (subprograms, see 'units of organised units' above). They go on to discuss at length what these episodes may be and the implications of that on learning (and specifically mistakes). On one side, the implication of their discussion is that the method above corresponds very highly with the mechanisms they propose, and as such would appear to be intrinsically effective. On the other side, there is a suggestion that the size and range of performance material contained in each 'subprogram' needs to be defined not according to consideration of the musical score, but according to the learner themselves – the range of which unfortunately will unfortunately be impossible to prescribe. However, there are other observations in this paper which are informative regarding learning to sing. This study was based on polyphonic keyboard music but it is also possible, in musical terms, to think of solo singing as a polyphonic act by considering each performance element as a separate voice. This leads back to the initial step in the method, demanding careful definition of each element, and implies that when grouping the instructions in step 2 the teacher should observe how much material can be put together and rather than work in phrases or bars, work in ranges of material that correspond to observed difficulties. This may result in deeply unnatural and illogical divisions of musical material, but indeed may, in light of Palmer and Van de Sande's research, lead to more effective learning.

Step 5 Speed Up

Demany and Semal (1999) comment that "In order to compare two sounds separated by some delay - *D*, it is of course necessary to memorize the first sound during the delay. Two modes of memory operation were distinguished by Durlach and Braida (1969). In one mode, called the ''trace mode,'' the sensation produced by the second sound is compared to the sensory trace left by the first sound. This comparison may benefit from an overt or covert rehearsal of the trace by the listener ~Keller *et al.*, (1995), but its accuracy will strongly depend on *D*." (quoted from Demany and Semal, J. Acoust. Soc. Am., Vol. 106, No. 5, November 1999, p2805). Any speeding up of music-making inevitably depends upon the ability to imagine the pitches to be created, and their relative length, with increasing speed. Again, the relationship between episodic memory and long term or semantic memory becomes important. It is clear that it is necessary to be able to draw upon long term memory as much as possible in order to create pitches in tune on demand.

Lapidaki (2000), in concluding her paper, recommends that teachers allow students to find their own tempo, as in her discussion she argues that some inherent quality of music leads to a broad consensus between subjects of what 'correct tempo' is for any given piece. The question of perception of time in music, as viewed by music philosophers, has been a contentious issue for hundreds of years. In practical terms, the interaction between the range of material in the subprogram discussed above, semantic memory (established pitches) and working memory (the task in hand), and the nature of the music itself will control the speeding-up process, and all of these elements should be driven by the student's implicit analysis of their own work. In this regard, as indeed Lapidaki suggests, the more a student actively listens to music and the more extensive experience they have, the easier it will be to acquire singing skills. It should also be commented that listening to music can be undertaken as a memory based task, as many of the experimenters mentioned above have involved tasks that are based on part listening and part remembering as aspects of the experimental process and have commented that repetition of this task leads to faster and improved results.

Conclusion

This essay set out to discuss an original method of teaching singing; the broad context was behaviourist/empiricist neural constructionist learning theory (Greeno, Collins and Resnick, 1996), with reference to relevant brain theory. In doing so, it has become apparent that much research that has been published to date, specifically that based on fMRI scanning has been far removed from the particular context of actually learning to sing. This is perhaps inevitable in attempting to first isolate whether or not music-making can be described in terms of correlated brain activity. We are clearly still a long way from researching questions of the type ”Can we measure the effectiveness of a music learning technique in terms of brain activity?” and there are clear gaps in some basic questions we need to ask before we get there. These include the whole element of rhythm – what is it, is there a specific correlation with neurological activity, how do we acquire 'rhythm' and manipulate the process of acquisition?

From a neural constructionist perspective, it would seem from the above discussion that procedures and physical tasks comparable in some way to music may be taught and learnt with an analogous method to that described. In other words, for some types of learning, the foregoing discussion supports neural constructionist theory, and the learning/teaching method discussed may be useful for other kinds of learning from the perspective of situative learning theories and to a lesser degree a cognitive perspective, as defined by Green, Collins and Resnick.

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