University Music Students' Use of Cognitive Strategies in Transcribing Figured Bass Dictation and the Possible Influence of Memory Span on Their Performance

Thèse

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University Music Students' Use of Cognitive Strategies in Transcribing Figured Bass Dictation and the Possible Influence of Memory Span on Their Performance

Doctoral Dissertation

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Résumé

Les compétences auditives musicales développées, en partie, pendant les cours de formation auditive (FA), sont essentielles à la formation des musiciens afin d'accroître l'écoute intérieure (Rogers, 1984). Plusieurs auteurs s'accordent sur l'importance d'un bon développement de l'oreille comme base de tout progrès et activité musicale, telles que l'écoute et l'interprétation (Elliot 1993; Hallam et Bautista, 2012; Karpinski, 2000; King et Brook, 2016; Lake, 1993; Langer; 1953; McPherson, Bailey et Sinclair, 1997; Rogers, 1984; Rogers 2013; Upitis, Abrami, Varela, 2016). La transcription d'une dictée musicale étant l'un des moyens les plus utilisés pour développer l'écoute intérieure s'avère un défi pour de nombreux étudiants en difficulté (Cruz de Menezes, 2010; Hedges, 1999; Hoppe, 1991). Malgré l'importance de cette tâche, les processus sous-jacents à leur résolution ne sont pas encore bien compris, en particulier ceux reliés à la dictée de basse chiffrée. Cela pose un défi constant aux enseignants. Une meilleure compréhension des processus mentaux des apprenants engagés lors des tâches de dictée de basse chiffrée et de la façon dont les élèves les déploient pourrait apporter des solutions aux enseignants. De tels connaissances pourraient indiquer les approches pédagogiques à privilégier et les stratégies s'avérant efficaces pour aider les élèves à surmonter leurs difficultés. Afin de combler les lacunes dans ce domaine, cette recherche a été élaborée pour atteindre six objectifs principaux: a) énumérer les stratégies utilisées par les étudiants au début de leur formation universitaire; b) catégoriser les stratégies; c) identifier les stratégies les plus utilisées et les plus efficaces; d) analyser d'autres facteurs cognitifs qui peuvent influencer l'utilisation des stratégies, tels que la capacité de mémoire de travail auditive musicale et non musicale; e) analyser l'incidence de l'utilisation des stratégies et d'autres variables sur le degré de performance des dictées; f) vérifier si les stratégies et les résultats des dictées changent après une session de cours de FA. Pour atteindre ces objectifs, 66 étudiants débutant leur cours de musique universitaire ont participé à cette étude. Ils ont décrit les stratégies utilisées lors de la résolution de dictées harmoniques, passé deux tests de mémoire (musical et non musical) et répondu à un questionnaire afin de récolter des informations de base telles que leur sexe, leur instrument, leur style musical et la durée de leurs études musicales. D'une part, cette recherche a permis de répertorier et de catégoriser les stratégies utilisées pour résoudre les dictées de basse chiffrée de manière approfondie. D'autre part, à l'aide de corrélations, analyses de variances et de covariance, régressions et tests-t, cette étude a permis de comprendre le lien qui existe entre les stratégies et le degré de performance pour la résolution de dictées de basse chiffrée et de vérifier si l'utilisation des stratégies et les résultats des dictées ont changé dans le temps, après avoir suivi des cours de FA universitaire. De plus, nous avons vérifié la relation qui existe entre le degré de performance pour ce type de dictées et les capacités des mémoires auditives (musicale et non-musicale) et avec d'autres variables telles que l'instrument et l'âge de début des études musicales. Cette thèse est organisée en quatre chapitres : le chapitre 1 présente une revue de la littérature; Chapitre 2, la méthodologie; Chapitre 3, toutes les analyses qualitatives et quantitatives effectuées en réponse aux questions de recherche; et le dernier chapitre, discussion des résultats et conclusion.

Abstract

Music aural skills, partly developed during ear training (ET) courses, are fundamental to musicians' training in order to develop inner audition (Rogers, 1984). Authors agree about the importance of a good ear development as the basis for all musical progress and activities, such as listening and performing (Elliot 1993; Hallam & Bautista, 2012; Karpinski, 2000; King & Brook, 2016; Lake, 1993; Langer; 1953; McPherson, Bailey & Sinclair, 1997; Rogers, 1984; Rogers 2013; Upitis, Abrami, Varela, 2016). Musical dictation transcription, being one of the most used ways to develop inner audition is a challenge to be faced by many students in difficulty (Cruz de Menezes, 2010; Hedges, 1999; Hoppe, 1991). Despite the importance of this task, the underlying processes are not yet fully understood, especially those related to figured bass dictation. This poses an abiding challenge for teachers. A better understanding of students' mental processes engaged during dictation tasks, and how students deploy such processes, could provide teachers with solutions. Results might suggest which pedagogical approaches to privilege, and which strategies might be effective to help students overcome their difficulties. To fill the gap in this field, this research was elaborated with six main objectives: a) list and count the strategies used by students at the beginning of their university education; b) categorize strategies; c) identify the most used and the most effective strategies; d) analyze other cognitive factors that may influence the use of strategies, such as musical and non-musical auditory memory span; e) analyze the impact of strategy usage and other variables on dictation performance levels; f) evaluate whether the dictation strategies and dictation results change after one ET course session. To reach these objectives, 66 students starting first year university music courses participated in this study. They described their strategies used during figured bass dictations, took two memory tests (musical and non-musical) and answered a questionnaire to indicate their gender, instrument, musical genre, and details about the duration of their musical studies. Firstly, this research allowed us to list and categorize the strategies used to solve figured bass dictations in a thorough way; Secondly, using correlations, analyses of variance and covariance, regressions, and T-tests, this study enabled us to understand the relationship of strategies to performance in harmonic dictation; and to verify if the use of strategies and performance in dictation changed over time, after taking university ear training courses. Moreover, we verified the relation between the performance in dictation and auditory capacities, as well as other variables such as instrument and age at start of musical studies. This thesis is organized into four chapters: Chapter 1 presents a literature review; Chapter 2, the methodology; Chapter 3, all qualitative and quantitative analyses done in response to the research questions; and at last, the discussion of results and conclusion.

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I dedicate this thesis to my children, Maeva and Liam, who were born during my doctoral project and only added love and happiness to this journey. I also dedicate this thesis to my husband, Lucas, for all the support he gives me in my academic and professional life, and for being there for us.

Strength does not come from physical capacity. It comes from an indomitable will.
Mahatma Gandhi

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Introduction

Ear training (ET) courses are part of most college and all university music programs in North America (Pembrook & Riggins, 1990; Wolf & Kopiez, 2018), representing about 40,000 students in the 1990's (Butler & Lochstampfor, 1993). Skills developed during ET courses are fundamental for: reading (Mishra, 2014); writing (Karpinsky, 2000); analysing, understanding, and appreciating (DeBellis, 2005; Elliot, 1993; Karpinsky, 2000); interpreting (Hallam & Bautista, 2012; Hallam & Prince, 2003; King & Brook, 2016; Lake, 1993; McPherson, 1995; McPherson, Bailey, & Sinclair, 1997; Papageorgi et al., 2010; Rogers 2013; Upitis, Abrami, Varela, Woody & Lehmann, 2010); jazz interpreting (Palmer, 2016), improvising (Després, Burnard, Dubé & Stévance, 2017); and creating music (Covington, 1992; Rogers 2013). An important skill developed in ET courses is analytical hearing, which enables musicians to know, spot and explicitly name what they hear, e.g., the difference between two melodies (Bigand & Poulin-Charronnat, 2006). This training enables students to perform the adequate motoric executions, such as singing or playing by ear or transforming music into a written score, as in melodic dictation tasks (Wolf & Kopiez, 2018).

ET's overall goal is the development of inner audition, which is fundamental to a musician's education (Cleland & Dobrea-Grindahl, 2010; Elliot, 1993; Gromo, 1993; Karpinski, 2000; Rogers, 1984; Rogers, 2004). Rogers (1984) defines inner audition as the ability to hear musical relationships with precision and understanding. Langer (1953) indicates more specifically that inner audition is a conscious activity of the mind arising from the musical memory of the person, using knowledge acquired in music (for example, rhythmic divisions, cadences, phrasing, dynamics). Overall, Rogers (1984) considers that ET encompasses dictation (rhythmic, melodic, figured bass and counterpoint), solfeggio, and other related activities. He explains that dictation and solfeggio represent ways to converge towards the same goal, that of developing inner audition. Rogers adds that musical dictation aims to educate listeners who can hear sounds to increase their understanding of the meaning of music. In the same way, Elliot (1993) explains that to understand and appreciate music, the listener should have the same knowledge as the performer. Thus, ET aims for thinking in sound, i.e., the ability to conjure sound mentally through inner audition.

This type of listening can guide the production of the sound aimed at by performers even before they play, as an internalized ideal sound. Karpinski (1990) states that regardless of the level of expertise of an individual in terms of instrumental or vocal dexterity, success depends on his or her auditory ability to discriminate and guide musical performance. This is confirmed by more recent studies which suggest that auditory abilities are a predictor of success in instrumental performance (Rogers 2013; Upitis et al., 2016). Experienced auditors are more likely to be autonomous than inexperienced listeners during artistic production of their work of interpretation, since they can more easily access the relationship between inner audition and actual listening

(Langer, 1953). Such links are specifically established during ET, which is a main reason why ET forms an essential part of the education of the future musician.

The two activities most often used in ET to develop inner audition are sight singing and dictation (Fry & Spencer, 2016; Rogers 1984). Despite its importance in ET, musical dictation represents one of the tasks in which students show the most difficulties (Cruz de Menezes, 2010; Hedges, 1999; Hoppe, 1991). Some participants experience extreme distress in any type of dictation (Frkovich, 1984); that is, they cannot find the answers and cannot solve the task. Turning to figured bass dictation, Murphy (1989) explains that learning how to transcribe a harmonic dictation is a frustrating task for many music students because it is very complex. The task often includes the writing of the soprano, bass, and possibly inner voices, as well as recognition of chordal function and overall analysis of the progression. Although ET teachers see the need for this pedagogical area to develop students' harmonic and multi-voice hearing, little research has focused on the underlying processes of solving musical dictations, especially with respect to harmonic dictation.

Chapter 1 – Literature Review

"Music dictation is not solely a memory problem: it is also a problem-solving task" (Cruz de Menezes & Moreno Sala, 2016, p. 214). The research reports presented in this literature review concern a) the study of strategies on musical dictation, as it is a problem-solving task; b) the role of working memory (WM) in performance and use of strategies, as working memory (WM) capacity is related to the use of more effective strategies and better performance (Cruz de Menezes 2010, Cruz de Menezes, Bissonnette, Moreno Sala & Guiton, 2009; Gonthier & Tomassin, 2015); and c) the importance of choosing an appropriate approach to collect information about strategies during a problem-solving task (Ericsson & Simon, 1993).

Since there are not many studies of strategies used on harmonic dictation, those few will be reported first, followed by studies of strategy usage in other types of musical dictation, such as melody in one or two parts and intervals either melodic or harmonic. These studies prove to be pertinent for the current research, since figured bass dictation is a complex task integrating melodic dictation, and writing soprano and bass melodic lines is normally required while transcribing figured bass dictations (Beckett, 1997; Murphy, 1989).

Studies in harmonic dictation

Up to now, two types of research on harmonic dictations have been done: the study of chord perception (Bigand, Parncutt & Lerdahl, 1996; Krumhansl, Bhachura & Castelliano, 1982; Rosner & Narmour, 1992); and exploration of students' use of strategies when resolving harmonic tasks (Alvarez, 1980, 1981; Murphy, 1989).

For chord perception, Bigand et al. (1996) attempted to evaluate the perception of chord tension. Participants (14 musicians, 14 non-musicians) heard 50 3-triad sequences in C Major. Participants evaluated the musical tension created by the second chord in the middle of the sequence (for example: C - F # -C), on a scale from 1 (low tension) to 12 (high tension). The authors suggest that tension judgments depended on convergent factors such as horizontal motion and hierarchical harmony. The relative importance of these factors varied according to the musical formation of participants. For example, according to the values of hierarchical harmony reported by Krumhansl (1990), the authors confirm that there was a negative relationship between perceived harmonic stability and musical tension. In other words, the most important chords in hierarchical harmony create lower tensions for listeners (p <.001). This effect was more pronounced among musicians (p <.01).

In two tests, Krumhansl et al. (1982) investigated the perception of tonal proximity between two chords. The first test, conducted with 16 individuals from the Cornell Summer School Community with at least 3 years of music studies (average 9.2 years), probed to what extent a chord is musically related to a second chord. The two tested chords were taken from two tonalities considered maximally distant (C major and F # major). The test chords were all possible ordered pairs of nonrepeating chords drawn from the set of 14 chords in C major and F# major (the I-VII chords of each of the keys). They were presented immediately after a three-chord cadence (IV-V-I) in one of three context keys, which were: G major (close to C major, far from F# major); A major (moderately far from both tonalities); and B major (close to F#, far from C). Participants were instructed to rate how well or poorly the second test chord followed the first test chord in the context of the three-chord cadence preceding the test chords. The authors found that harmonic relations between chords are mediated by a knowledge system that interprets chord functions according to tonality. During the first test, there was no significant individual difference between theoretical knowledge, or musical experience of participants, and the results obtained. In other words, there was no musician advantage for those with the most training compared to those with the least.

Krumhansl, Bharucha, and Castellano's second test measured recognition memory of the chords and tonalities used during the previous test. Participants, 15 students from the Cornell Summer School Community, had an average of nine years of musical experience. The task was to recognize if two sequences of seven chords were the same. There were 660 different trials and 360 same trials. When the sequences were different, only the fourth chord was different, called by the authors the target chord. It was found that performance tended to improve when the chord sequence's tonality was closer to the target chord tonality than when they were distant ($F3, 42) = 41.711$, $p<.001$). The authors suggest that, generally, tonal context (in this case all the chords included in one sequence) is of great importance for adequate perception of harmonic relations. The exact perception of a chord is influenced by the distance between its tonality and that of the remaining chord sequence. The authors also noted that listeners with an average of nine years of music experience have a highly structured system of knowledge about the harmonic functions of chords in different tonalities and, thus, can evaluate the musical structure at the level of tonal centers.

Rosner and Narmour (1992) studied the perception of harmonic closure. They wanted to know if plagal and authentic cadences where perceived as closurally synonymous or rather alike. They also investigated if variables such as harmonic schema, scale step, soprano position, bass inversion, common-toneness, and outer-voice motion influence participants' perception of closure. Participants were 19 non-musicians, between 20 and 40 years old who listened to 66 pairs of selected two-chord progressions. The participants had to decide which progression sounded the most closed. Each progression in a pair was a variant on V-I, IV-I, III-I, or VI-I. A V-I progression was always significantly preferred to any alternative (III-I, IV-I, or VI-I). No equally strong pattern of preference emerged concerning III-I, IV-I, VI-I. Plagal cadences and VI-I progressions were never preferred to III-I chord pairs. Inversion was never preferred over root. V-I was preferred over all root sequences. Differences in scale step and soprano position generated nonsignificant preferences. No effect of common-toneness was observed.

As shown in the previous three studies, understanding a listener's perception of levels of tonal tension is important for the study of harmonic musical dictations. Perceiving tensions and resolutions in music is essential for musical understanding and the realization of harmonic dictations. This understanding is one of the objectives in ET, to help students better solve the required tasks. Krumhansl et al.'s (1982) results could guide teachers in choosing the chord sequences to use, depending on the level of ET, given that trained musicians perceive the important chords (in the harmonic hierarchy) more easily. Other authors have studied precisely the use of writing strategies (Murphy, 1989) or procedures to identify primary harmonic function (Alvarez, 1980; 1981) when resolving harmonic tasks.

Murphy (1989) studied task orders and chord function patterns in figured bass dictation by means of two experiments with second-year students enrolled in music theory programs. In the first, exploratory, study (*N* = 37 at Ohio State University), Murphy studied the impact of only task order on harmonic dictation accuracy (which included notation of the soprano, the bass, chord function, and chord quality by Roman numerals with inversion figures). The four written tasks were: a) chord quality identification (Q); b) chord function (F), i.e., whether the chord was the tonic T, subdominant S, or dominant D, of the tonality; c) notation of soprano (S); and d) notation of bass (B). Murphy created and programmed a set of 24 progressions for this study, all of them consisting of 7 chords. Each participant heard a subset of 6 dictations selected at random by the program. The author instructed participants to take dictation using different orders of the four cited tasks. Analysis was done with straightforward statistics based on averages and percentages. The results revealed that task Q's order (chord quality) had no impact on harmonic dictation accuracy. For the other three tasks, doing task F first (function), followed by S first (soprano) and B first (bass), were associated with better results. In addition, the underlying progress of the chord function seemed to affect the harmonic dictation results. Participants were less successful in progressions that did not start on the tonic. Also, primary triads (I, I_6, $I^6{}_4$, V, V_6), were easier to identify than secondary triads (ii, ii_6, iii, iii_6T, iii_6D, vi, vi_6, $vii^o{}_6$). The subdominant (IV) was almost evenly divided between correct and incorrect.

Murphy's second study (1989) was conducted with 43 participants from Ohio State and Youngstown State Universities. Given that the Q task had no impact on results in study 1, Murphy designed this second experiment to see if there would be an optimum order of the three remaining tasks (F, S, and B) for improvement of harmonic dictation accuracy. The main element added in study 2 was manipulation of function patterns of chord flow (tonic T, subdominant S, and dominant D). Murphy also added 12 new 7-chord progressions to the 24 used in the first experiment, from which the program would randomly select six progressions. The author examined the results for not only task order, but also for the comparative impact on accuracy of chord quality vs. function patterns. Murphy further studied the influence of participants' genres and instruments, and the interaction between the order of the three written tasks and the function-pattern types of chord progressions. Participants heard six randomly selected 7-chord progressions, notated S and B, and provided the chord quality and function F in Roman numerals with inversions. The results indicated that the order of tasks had no significant effect on harmonic dictation performance ($p > .50$), although the FBS, FSB, and BFS orders produced somewhat higher results. The results of students from the two universities were not significantly different ($p > .05$). The main instruments and genres of the students had no significant effect on the results ($p > .05$). A significant gender difference was observed, with men performing better than women ($p < .05$). This might simply mean that women had access to music education later than men in 1980's. The function-pattern order of the chords had a significant effect: TTDTSDT progressions yielded better results ($p < .05$), and SDTTSDT progressions yielded poorer results ($p < .05$). There was a significant interaction between task order and the function-pattern type of progression ($p < .01$), which might mean that, depending on the structure of the progression, a specific order of task is more likely to be effective.

Murphy's two studies on harmonic dictation inform us about the order in which writing strategies were used and their effectiveness. However, the results indicate that the writing order had no influence on dictation performance. Of much greater influence was the function-pattern order of tonic, subdominant, and dominant chords. Independent variables in both Murphy (1989) and Beckett (1997) were imposed from without by the researchers, i.e., they did not emanate from the participants' own practices or strategies. In Beckett's (1997) study, participants' personal strategies acted as a control condition and were not exhaustively manipulated, described, explored, or analyzed.

Alvarez (1980) compared the effectiveness of using two different strategies: scalar or root harmonic aural perception. Seventy-two (72) seventh- and eighth-grade general music students (middle school) were taught to identify primary harmonic functions by using either a scalar or root harmonic aural perception procedure. They received treatment for 10 30-minutes periods. The students who were taught the scalar procedure attended to the seventh and eighth scale degrees in the progression, whereas the students who were taught the root procedure attended to the root movement of the bass line. An aural identification test battery was used to measure the effectiveness of the two techniques divided into two subsets: the first one presented only chords in root position (50 test items), while the second presented chords in root position and in first inversion (50 test items). The author gives an example of a harmonic sequence of four chords, but does not specify if all the sequences were of the same number. He specifies that internal consistency of each subtest was determined by using the Kuder-Richardson-20 formula. There was no statistically significant difference between the scalar and root techniques on the root position subtest (scalar group $M = 26.2$; root group $M = 24.2$). On the contrary, the scalar technique yielded statistically significant higher mean scores on the root/inversion subtest ($F(1, 68) = 17.16$, $p < .05$; scalar group $M = 24.4$; root group $M = 18.4$). Thus, the scalar technique appears to be a more effective procedure in teaching general music students to identify primary harmonic functions.

In his second study, Alvarez (1981) investigated the effectiveness of scalar or root procedures, inductive or deductive content sequences, and kinetic or verbal coding processes on identifying harmonic functions. His sample consisted of 48 college music students enrolled in ET courses. An aural identification test battery was created to measure the effectiveness of scalar and root procedures divided into two subsets: the first presented only chords in root position, while the second presented chords in root position and in first inversion. The sample was divided into two experimental groups. Each group was taught for a total of 10 50-minute sessions to use the scalar or the root procedures. Among the variables, only the main effects of the procedures (scalar and root) were found to be significant on the multivariate test. Separate univariate analyses indicated that the scalar procedure group obtained significantly higher mean scores on both conditions: root $F(1, 38) = 6.41839$, $p <.016$, and root/inversion $F(1, 38) = 19.98210$, $p < .001$. Thus, a scalar classification system appears to be once again a more effective procedure for teaching the aural identification of harmonic functions.

In his book, Karpinski (2000) presents ideas drawn from his literature review of aural perception research studies, some of them his own (Karpinski, 1990). He explains different methods to take harmonic dictation: part writing, arpeggiation, gestalt, bass as the basis of harmonic function, inversion, chord quality, and leading voice. Part writing consists of writing all the voices separately and analyzing them to conclude the chords. It is more like several melodic dictations than a harmonic one. Arpeggiation consists of arpeggiating the notes chord per chord. This could work with a slow harmonic rhythm. Both of these methods are considered reductionist, that is, they conclude the whole chord on the basis of its smallest detailed parts (Rahn & Mackay, 1988).

Gestalt involves identifying chords as complete entities, thus whole-harmonic recognition. It can be the result of other techniques, after a certain time of training and labeling, so that a chord would be instantly recognizable. Karpinski's (2000) method of bass as the basis of harmonic function is a traditional concept whereby listeners should focus their attention on the bass line. He explains that "bass line dictation is simply another form of melodic dictation (…) and any harmonic inversion will take place after (or in lockstep with) perception of bass voice" (p.121).

To identify inversion, two ways are possible. Some people who hear voices separately analyze and write the chord function and inversion. Others who hear in a gestalt way normally hear the 3d degree on the basis, and 1st on the upper voice. No studies have examined how this atomizing can be carried over to contextual inversion identification.

Another approach to solving harmonic dictation consists of identifying intersections between the bass line and chord quality. Once again, this is an atomistic approach and is insufficient. Listeners should rather apply a hybrid approach that combines bass scale degrees, chord quality, and inversion.

Voice leading and harmony involve developing a perception of voice leading and its relationship with harmonic function. Listeners follow and write the bass and trace certain voices at specific crucial locations to draw conclusions about chord functions. This approach seems to be the best one, because "tracing the motions of voices above the bass is precisely what figured bass is" (Karpinski, 2000, p. 127). All these interesting methods discussed in Karpinski's book were studied through literature review rather than his own empirical study.

To the best of my knowledge, to date, no studies have examined in detail the cognitive strategies used by students to solve harmonic tasks (there are studies of strategies used in problem solving; see below); nor have any studies yet explained the underlying reasons for success in this type of task. In order to fill this data gap, it is necessary to examine in depth some of the cognitive processes involved in the dictation process in order to understand the underlying reasons for student success or failure in the task.

Cognitive Processes and Strategies

Understanding the cognitive processes used by students in a musical task remains essential to improve their results (Cruz de Menezes, 2010). Nevertheless, it is first necessary to establish the definition of a cognitive process in order to be able to organize its study well. Van Someren, Barnard, and Sandberg (1994) explain that a cognitive process can be defined as a series of successive states of information being processed by working memory (WM). This includes perception, metacognition (strategies used), recovery of knowledge in long-term memory, and construction of new information in WM, among others. Two aspects of this definition will be the center of our interest: the strategies used, and working memory (WM) as related to success in harmonic dictation.

Other domains offer a number of definitions of strategies. For example, in school learning, Bégin (2008) explains strategy as a category of metacognitive or cognitive actions used in a learning situation, oriented for the purpose of performing a task, and used to perform knowledge operations according to specific objectives. In the same field, Fayol and Montreuil (1994) explain strategy as an integrated (more or less lengthy and complex) cognitive sequence of mental procedures selected for a purpose to optimize performance. Lemaire and Fabre (2005) give a more summary definition of strategy as a series of the deliberating processes an individual uses to accomplish a cognitive task. Lemaire and Fabre stress the difference between cognitive process and cognitive strategies: cognitive process may or may not be aware, while strategies are. In research on musical improvisation, Després et al. (2017) define cognitive strategies in musical improvisation as "a sequence of cognitive processes undertaken by the musician to ideate, evaluate, select or realize one or several musical aspects (form, harmony, notes, rhythm, timbre, etc.) of his improvisation." (Després et al. 2017, p. 144).

Studies on cognitive strategies for melodic dictation

One-part melody

Concerning the use of cognitive strategies in the resolution of melodic dictations, the author's own previous work has provided knowledge and categorization of many strategies used (Cruz de Menezes, 2010; Cruz de Menezes et al. 2009; Moreno Sala, Brauer, Cruz de Menezes, & Bissonnotte, 2008). Several studies were done with a single dictation melody and the same 49 participants in all studies. While transcribing the melody used in these various studies, participants were asked to write down their detailed strategies used to find one note or a group of notes before writing the note names (e.g. C) and without writing the notes on the staff used (Cruz de Menezes, 2010; Cruz de Menezes et al., 2009; Moreno Sala et al. 2008). First, the strategies were always categorized into two main categories: non-tonal and tonal. Tonal strategies were defined as those strategies outlined by the subjects who identified the notes by their association and/or comparison with the tonal context of the dictation, for example, descriptions of tonal pillars as tonic, as well as descriptions of scale degrees. Non-tonal strategies were defined as the strategies outlined by the subjects to identify the notes of the dictation, regardless of each note's function and tonal context, for example, comparisons of intervals played in the dictation with various songs to facilitate interval identification (Cruz de Menezes & Moreno Sala, 2016). In this regard, our findings showed that participants who took dictation more accurately used more diverse tonal strategies ($r_s = .321$, $p < .05$), used them more often ($r_s = .374$, $p < .05$), and used both better tonal ($r_s = .453$, $p = .05$) and non-tonal ($r_s = .635$, $p < .001$) strategies than participants who had difficulties (Cruz de Menezes, 2010; Cruz de Menezes, et al., 2009; Moreno Sala, Cruz de Menezes, & Guiton, 2016). Moreover, the number of strategies used to solve specific intervals of a melodic dictation was related to success. The more strategies individuals used in identifying intervals, the better were their chances of success ($r_s = 52$, $p < .001$). Success in interval identification was also related to the use of tonal strategies. Analysis showed that to solve intervals, the use of any one tonal strategy leads to success. Any combination using any tonal strategy also leads to success (Cruz de Menezes, 2010; Cruz de Menezes, Moreno Sala, & Guiton, 2016, 2009).

Buonviri (2014) explored successful melodic dictation strategies employed by six sophomore undergraduate music majors. After dictation work had been done, he asked in subsequent interviews what strategies participants had used to successfully complete a melodic dictation. The interviews were guided by structured questions. This qualitative study organized participants' reported strategies into three themes: attention direction, task prioritization, and skill coordination. In attention direction, Buonviri reported the importance of focusing their attention on what they deemed most important while ignoring distracting aural information. Participants described keeping an open mind in preparation for the first listening, heightened attention to missing information, and recognizing patterns. Concerning task prioritization, Buonviri reported that the plan of attack seems to have been set from the beginning, with alterations when necessary, for example, whether participants focused on pitch or rhythm, on the beginning, middle, or end of the melody. Usually, participants focused on what they thought was the most difficult aspect. They clearly chose their plan beforehand. About skill coordination, Buonviri observed that participants used musical skills learned through performance and academic studies to process musical percepts accurately and coordinated cognitive skills when checking their completed work. For example, two participants reported being able to hear notes internally and sing them back later. Inner singing or silent singing was the primary mode of checking work for most participants. Participants also discarded wrong possibilities in search of the correct pitch or rhythm.

Other less recent studies concerning melodic dictation also investigated strategies. Hoppe (1991) aimed to document in detail the procedure used by musicians to transcribe a melody and to identify patterns of pitch and rhythm errors. He studied 75 subjects (25 first-year university students, 25 second-year students, and 25 professional musicians). The task was to transcribe six melodies in G major always presented in the same order, three known melodies and three other melodies generated by software, whose metrics were 2/4, 3/4 and 6/8. The melodies were written in treble clef or bass clef and no ledger lines were used. Software was developed to administer the tests to participants. In addition, a questionnaire was distributed for information about their name, gender, musical practice (including improvisation and composition), and possession of absolute pitch, among other variables. All the musical procedures were tested in a pilot group of high-level music students. Participants in the study were familiar with the procedure before taking the test. The results of Hoppe's (1991) study suggest that the scores of first- and second-year students' transcriptions were very similar. Seven participants with absolute pitch used, for the most part, sketches of notes and rhythms preceding the writing of the dictation itself. Just a small percentage did sketches only of rhythm. One main strategy favored by 68% of participants was writing the dictation continuously, from the beginning to the end of the dictation. In addition, this choice of writing strategy, writing the dictation from beginning to end, was similar among both professionals and students starting university. Similarly, this way of proceeding to transcribe melodies has been observed among composers and non-composers. Hoppe also observed a separation between the writing of the rhythm and that of the notes (48% of the subjects). In addition, he also reports some physical strategies used to solve the dictation, such as marking the beat or its subdivision and vocalizing the melody. The author also studied the most common errors in dictation. First, he reports that students tend to write more correct notes at the beginning of the dictations (92.2%) than in the middle (85.5%) or at the end (84.2%). In the final transcript, the tonality was mid-identified by 12% of the participants. Among other common errors, Hoppe reported that 53% of participants wrote a wrong note, but a correct interval and the correct outline. In addition, some participants (2%) got the first note of the dictation wrong, while others (7%) omitted or added a few more notes (2%). In general, participants with absolute pitch and those who improvised or composed, or frequently transcribed melodies in their daily lives, all solved the transcriptions more accurately. As for the total time used by the subjects to complete the transcripts, Hoppe specifies that an average of five playings over 11 minutes was necessary for each transcription. Nevertheless, professional musicians took an average of five minutes less than students, and they transcribed more accurately.

Potter (1990) studied participants with very high levels of musical auditory development: a professional symphonic oboist who also taught, two members of Indiana University (IU) music faculty, ten doctoral students, five master's students, six students close to the end of the baccalaureate, and a student starting university studies but possessing a varied and exceptional musical history. The subjects listened to four melodies similar to typical melodic dictations used in IU auditory training courses. Melodies were 4 – 8 bars long and were played on the piano. Tonality and metric information were provided to the subjects for three of the four melodies.

Essentially, the author concluded that subjects who seek to identify scale degrees in a given tonality perform better than those who proceed by identifying intervals. He also reported that “the best dictation-takers have a whole box of tools to work with” (Potter, 1990, p. 69), which means that they have a holistic approach, using different strategies simultaneously during dictation. However, all the results are presented only descriptively, not analytically, i.e., the author did no statistical analysis that could help readers better understand the possible scope and meaning of the results. In addition, Potter reports little about the strategies used by students with difficulty.

Dowling (1986) analyzed how sensory information is stored in memory. He did three experiments with 30, 32, and 25 participants respectively; including together inexperienced listeners, moderately experienced listeners, and professional musicians. Although this research is not about musical dictation, it determined experimentally the strategies used by students to memorize melodic sensory information. To do this, Dowling presented new melodies. Each melody was surrounded by a harmonic context, four chords before and one chord after the melody, to allow the interpretation of the notes by scale degrees, an approach which differed from the strategies typically used by participants (intervals versus degrees). He reasoned that changing the harmonic context may change the interpretation of degrees but not the identification of interval patterns. The melodies were composed of six notes followed by a harmonic cadence (ending with the tonic or dominant chord). The task was to distinguish between exact transpositions of the melodies and "imitations" where there was a small change—either one of the notes, the last chord of the cadence, or both. The basic task for experiments 1, 2, and 3 was the same and consisted of responding positively to exact transcriptions and rejecting altered imitations, while ignoring harmonic context. Dowling’s results suggest that listeners with different levels of musical training demonstrate differences in perception and memorization of melodies. Inexperienced listeners perform as well in the recognition of exact transpositions as in the recognition of "imitations", regardless of harmonic context. Auditors with moderate experience perform well in a same harmonic context, but randomly when the harmonic context changes. The professionals perform equally well regardless of harmonic context. Professionals probably used the representation of degrees in their identification, but they can use other recognition strategies when the task requires it; thus, they have a flexible system of strategies. Dowling’s results also revealed that two kinds of strategies were most used in identification of melodic information: interval strategies and scale degree strategies.

Two-part melody

Beckett (1997) studied whether performance in transcription of two-voice dictations improved according to the order of writing, by first writing the rhythm and then the pitch, or the opposite, by first writing the pitch of the notes and then writing the rhythm. To do this, she compared three writing strategies according to the instruction given to the subjects: the notation of the rhythm before the pitch, the notation of the pitch before the rhythm, and the undifferentiated notation without specifying in which order the subjects should transcribe the dictation, being the control condition. Thus, all subjects in this study (60 undergraduate students) spent three dictation sessions, one for each type of writing strategy. Their dictation score was calculated by the average of the rhythm and pitch performance of the notes for each session. The results of this study indicate that the order of writing had a significant effect on the overall performance of the participants' dictation. Greater accuracy was observed at the *rhythm* level when the rhythm was written before the pitch of the notes. Thus, prioritizing the writing of the rhythm seems to increase rhythmic precision ($p < .0001$) and overall accuracy ($p < .0001$). The writing-pitch-first treatment led to 43.7% success in two-part dictation; the participants' own usual methods, 48.0%; and the writing-rhythm-first treatment, 49.3%. The conclusions of the study therefore suggest that: doing rhythm first, in as few repetitions as possible, might free students to spend the rest of the time concentrating on pitch perception. Beckett (1997) did not focus on the implied harmonies, which surely existed between the two contrapuntal melodic lines. There was no harmonic strategy, and there was no analysis to evaluate the effect of implied harmony on pitch accuracy or overall accuracy. It could be suggested that some of the difficulty participants experienced with pitches in the 1997 study was precisely because the harmonic element was not explicitly addressed; harmony may have been causing difficulty for participants at some unconscious level, perhaps acting as interference in pitch perception (C. Becket, Personal communication, April 16, 2019).

Working Memory

Complex tasks are more difficult because they involve more cognitive operations than simpler ones (Kluwe, 1995). Therefore, working memory requirements increase, at least proportionally (Jassen, 2000). As harmonic dictation is a complex task (Murphy, 1989; Beckett, 1997), investigating the role of working memory proves to be highly relevant to this research.

Working memory (WM) processes and maintains short-term information, retaining an average of around seven items, with a retention time of about thirty seconds (Miller, 1956). Many approaches conceive that working memory has two basic structures: a general one, dedicated to processing information; and a supplementary one dedicated to storage of short-term information. Baddeley's model (1986) conceives working memory in a modular way: storage of information is realized through visual and verbal short-term memories (Barrouillet & Camos, 2007). A 2006 study confirms that the capacity of working memory depends mainly on two mechanisms: one general for the processing of information, the other dedicated to the maintenance or storage of information depending on specific resources—verbal vs. visuo-spatial (Alloway, Gathercole, & Pickering, 2006). Thus, according to the preceding models, short-term memory would be considered part of working memory: that part which comprises the mechanisms of storage of information, whether verbal or visuo-spatial (Alloway et al., 2006; Baddeley, 1986; Barrouillet & Camos, 2007; Colom, Rebollo, Abad, & Shih, 2006; Cruz de Menezes, 2010; Unsworth & Engle, 2007).

It is known in other non-musical domains that learning difficulties can be explained in part by limitations in working-memory capacity (Lépine, Barrouillet, & Camos, 2005; Unsworth & Engle, 2007). Success in student learning has been examined in relationship with working memory (Conway, Cowan, Bunting, Therriault, & Minkoff, 2002; Daneman & Carpenter, 1980; Daneman & Merikle, 1996; Kail & Hall, 2001; Kyllonen & Christal, 1990; Lépine, Barrouillet, & Camos, 2005). Researchers have been able to demonstrate in areas of learning such as reading comprehension (Daneman & Carpenter, 1980; Kim, Cho & Park, 2018) and reasoning (Giofrè, Donolato, & Mammarella, 2018; Kyllonen & Christal, 1990) that individual differences are explained, in part, by personal storage capacity of working memory. In general, these studies have found that performances involving high-level cognitive tasks are correlated with span of working memory. In fact, the larger the capacity of a person's working memory, the higher the performance in learning tasks. Fayol and Montreuil (1994) analyzed the use of strategies in relation to certain mechanisms in the human cognitive system and reported that strategies could be especially influenced by the capacity of retention and manipulation of short-term information, i.e., working memory.

In music, the author's previous studies yielded first findings that link the use of strategies with memory capacity (Cruz de Menezes et al., 2009, 2008; Cruz de Menezes, 2010; Cruz de Menezes & Moreno Sala, 2016; Moreno Sala, Cruz de Menezes, & Guiton, 2016). Studying the most successful dictation takers in melodic dictation, Cruz de Menezes and Moreno Sala (2016) reported a correlation between efficacy of using tonal strategies and both auditory ($r_s = 0.373$, $p < 0.05$) and visual ($r_s = 0.466$, $p < 0.01$) memory tests. This strongly suggests that the best-performing students have a larger short-term memory span that allows them to make greater use of their tonal strategies. By studying the least successful dictation takers—a group of subjects with the most difficulty in solving a melodic dictation—a link between visual memory span and the effectiveness of non-tonal strategies was found (Cruz de Menezes, Bissonnette, Guiton, & Moreno Sala, 2008; Cruz de Menezes, 2010).

These results suggest that memory can play an important role in solving the transcription of musical dictations. Karpinski (2000) explains that remembering a portion of a dictation is difficult because of the aural distraction of ensuing sections of the melody. Beckett (1997) points to the limitations of working memory as one of the factors that can hinder the success of ET tasks and suggests that students should focus their attention to avoid cognitive overload. Therefore, the study of memory capacity is as important as the study of cognitive strategies involved in solving a musical dictation.

The relationship observed between working memory and performance in language tasks (Barrouillet & Camos, 2007) and in musical dictation tasks (Cruz de Menezes, Moreno Sala, & Guiton, 2008; Cruz de Menezes & Moreno Sala, 2016; Moreno Sala et al., 2016), along with the fact that in humans the processing of auditory information such as language and music involves the same brain area, the temporal lobes (Zatorre & Belin, 2001), suggests the possibility of links between memory and performance in certain musical tasks. The analyses done to verify the relationship between working memory and figured bass dictation performance will be reported in Chapter 3.

Studies of non-musical and musical auditory memory

In studying auditory working memory and its storage capacity in humans, especially in relation to music, researchers have distinguished two types of memory systems: non-musical auditory memory, and musical auditory memory. Non-musical auditory memory refers to the number of non-musical sounds that a person can retain, while musical auditory memory refers to the number of musical notes in a tonal system that a person can retain. This second type of auditory memory—musical—clearly entails explicit or implicit musical knowledge and the person's familiarity with a particular tonal system (Trehub, Schellenberg, & Kamenetsky, 1999). Some authors have developed tests to see if there are differences between the two types of auditory memory systems (Jordan & Shepard, 1987; Shepard & Jordan, 1984; Trehub, Schellenberg, & Kamenetsky, 1999).

Trehub, Schellenberg, and Kamenetsky (1999) studied musical and non-musical auditory perception. Their study had two research components: the study of the perception of babies aged between 8 months and 15 days and 9 months and 15 days; and the study of 21 adult students in an undergraduate psychology program. Four experiments were done, the first two dedicated to babies and the next two dedicated to adults. For purposes of this thesis, we will focus on the adult studies, as our participants were also adults.

Trehub, Schellenberg, and Kamenetsky (1999) asked participants to detect erroneously placed notes in note sequences. In the first adult experiment, they assessed participants' ability to detect errors in three types of scale, one tonal and two atonal: the major traditional scale; an unfamiliar scale with the octave divided into 7 equal intervals (from Jordan & Shepard, 1987; Shepard & Jordan, 1984); and a second unfamiliar scale with the octave divided into unequal intervals designed for this experiment. Sinusoidal stimuli had durations of 400 ms, with 10 ms linear rise and decay times. In each trial, the adults listened to two scales in ascending-descending format, forming a pair of scales. They had to distinguish whether the two scales were the same or different. In the "identical" test, the second scale of the pair was identical to the first (without having a different note), but it was transposed 2.5 semitones higher. In the "different" test, it was the 6th degree of the second scale that was moved 0.5 semitone higher.

Randomly, 7 adults from the 21 participants were selected for each condition (major scale, unknown scale of 7 equal intervals, and unknown scale of unequal intervals). Each condition presented 50 similar tests and 50 different tests. Participants were asked whether the second range had the same or different structure. Participants used a computer key to begin each test and to give their answers.

Participants' performance was above chance for perception of all three types of scale. An ANOVA confirmed that differences between the conditions were significant, with performance higher for the major scale than for the 7 equal interval scale (Tukey's HSD test, $p = .0002$) or the unequal interval scale (Tukey's HSD test, $p = .0002$). Performance did not differ when comparing the two unfamiliar scales ($p = .9910$). In summary, adults were more likely to detect changes in the major scale than in unknown scales. These results suggest a familiarity effect, with higher perception of the known (major) scale than the unknown scales.

Trehub, Schellenberg, and Kamenetsky's second 1999 experiment with adults was conducted in order to verify the generality of the results from the previous experiment. This time, the researchers assessed participants' ability to detect a different note on the 5th degree below, instead of on the 6th degree above as in the previous experiment. The scales used were the same except that another new, unfamiliar scale of unequal intervals was created. This new scale was formed by seven tones from an octave subdivided into 11 equal intervals, with adjacent tones in the resulting scale separated by single or double subdivisions. The procedure used was identical to that of the previous experiment. The authors found the same results as in the previous experiment. Regardless of whether the different note was the 5th or 6th degree, whether the change was made up or down, or whether the structure of the scale was known or unknown, the determining factor for success was familiarity with the known (major) scale, which led to higher performance.

Trehub, Schellenberg, and Kamenetsky (1999) explain that since music and its perception are influenced by cognitive constraints, one might expect to find a number of similar characteristics across cultures. As an example, the authors indicate limitations of working memory as a factor that constrains the number of musical notes in any musical scale (Dowling & Harwood, 1986), and which, in turn, limits melodies derivative from such a scale. To further support the link between memory and musical perception, Trehub, Schellenberg and Kamenetsky argue that musical scales among cultures typically have 5 to 7 notes, consistent with the capacity of working memory (Miller 1956). This limited number of notes allows listeners to perceive each note as different from the others.

The few studies that have examined strategies for melodic dictations have mainly used certain methodological approaches: retrospection (Buonviri, 2014); behavioral observation when performing the task through video or audio recordings (Hoppe, 1991; Potter, 1990); or the obligation to use a strategy pre-established by the researcher for each test situation (Beckett, 1997; Paney, 2016; Pembrook, 1986). The use of retrospection to study the cognitive strategies used to solve a musical dictation has the disadvantage of providing very general and inaccurate results, as it focuses on participants' memories, i.e., is a method not activated during a task. The retrospection approach does not permit the study of a large number of individuals at the same time, making the results difficult to generalize. The approach of behavioral observation when performing the task using video or audio recordings and taking notes provides only externally observable facts, such as the order of writing, the length of time needed to do the dictation, or the changes individuals make (Hoppe, 1991; Potter, 1990). Therefore, these studies do not provide explanations of how participants articulate their thinking to solve the task. The approach requiring use of a pre-determined strategy does not permit emergence of all the possible strategies participants could use nor analysis of those strategies' relative effectiveness. In contrast, our previous studies did categorize a large variety of strategies (Cruz de Menezes et al., 2008; Cruz de Menezes, 2010; Moreno Sala et al., 2008) because we asked the participants to write down the strategies used during a melodic dictation while they were in the course of doing the dictation. However, the current study is the first time that exhaustive research has been done on the strategies used during harmonic dictation.

By looking in depth at the above approaches that facilitate access to human reasoning, we see that many aspects must be considered in studying cognitive strategies, and we are further convinced of how essential it is to have an appropriate research approach in order to produce valid, reliable data about cognitive strategies used during such a complex task as figured bass dictation.

The Think Aloud Approach

The "Think Aloud" approach (TA) was first used and described in psychology and computer science (Van Someren, Barnard, & Sandberg, 1994). The heart of the method consists of asking participants to articulate aloud their thoughts in real time as they work on a problem-solving challenge of any sort. As it is not the only way to access participants' thought processes, considerable attention is devoted here to explaining why TA was thought most appropriate for the current research.

Up to now, studies of musical harmonic tasks studied mainly procedural strategies (such as whether a specific writing order is better than another) or isolated elements (such as the level of chord tension). How people really think when solving figured bass dictations is not yet known; therefore, studying how participants think is essential to better understand their processes, strategies, and performance differences.

Many approaches exist to access people's cognitive processes, such as cognitive strategies and recovery of long-term memory knowledge, while they are solving a task. To understand even better how they work, it is essential to explore the nature of problem solving.

Problem solving

According to Ericsson and Simon (1993), problem solving aims to answer a question for which the person does not yet have the answer (unlike tests of memorized materials). This implies that (a) the problem is exposed in the form of questions; (b) problem solvers are able to infer information about the question, and about/from their own knowledge already stored in memory; (c) the interaction between the problem and its related knowledge produces possible solutions; and (d) people are able to distinguish wrong answers from correct ones.

For Jonassen (2000), finding the unknown is the process of problem solving, and the ability to solve problems is a function of the nature of the problem, the way that the problem is represented to the solver, and a host of individual differences that mediate the process. To solve a problem, the solver first represents mentally the situation, which is known as internal mental models or problem space. This representation consists of structural knowledge, procedural knowledge, reflective knowledge, images and metaphors of the system, and executive or strategic knowledge (Jonassen & Henning, 1999). Second, the solver engages in an activity-based manipulation of the problem space. Conscious meaning-making is engaged by activity, so there is a reciprocal regulatory feedback between knowledge and activity (Fishbein, Eckart, Lauver, van Leeuwen, & Langemeyer, 1990). Jonassen explores the literature about aspects of problems, then proposes a typology of problem-solving that will be presented after problem factors.

Smith (1991) distinguished between internal and external factors in problem solving. External factors are the variations in problem type and representation. Jonassen (2000) explains that problems vary in terms of structuredness, complexity, and abstractness (domain specificity). In terms of *structuredness*, there are two types: (a) well-structured problems (that require the application of a finite number of concepts, rules, and principles being studied in classrooms in a constrained problem situation); and (b) ill-structured problems (kinds of problems whose solutions are not predictable or convergent and are encountered more often in everyday and professional practice).

Problem *complexity* depends on the number of issues, functions, or variables involved in the problem; the degree of connectivity among those properties; the types of functional relationships among those properties; and the stability among the properties of the problem over time. The most complex problems are dynamic, that is, those in which the task environment and its factors change over time (Funke, 1991).

The *abstractness* of problem solving refers to domain-and-context-specific skills. That is, problem solving depends on the nature of the context or domain. Solving problems within a domain relies on cognitive operations that are specific to that domain (Mayer, 1992; Smith, 1991; Sternberg & Frensch, 1991). Another important external factor to problem solving is how problem designers *represent* problems to a problem solver. They have to make decisions, for example, about whether the problem has to be solved in real time, or if it takes cooperation or competition.

Internal factors are those that describe variations in the problem solvers and may affect problem solving: familiarity, domain and structural knowledge, cognitive controls, metacognition, epistemological beliefs, affective and conative elements.

A strong problem-solving ability involves the solver's *familiarity* with the problem type. Experienced problem solvers have better developed problem schemas, which can be employed more automatically (Sweller, 1988). Probably a stronger predictor of problem-solving skills is the solver's level of *domain knowledge* or *cognitive structure*, that is, the organization of relationships among concepts in memory (Shavelson, 1972).

Individuals also vary in their *cognitive styles and controls*, which represent patterns of thinking that control the ways individuals process and reason about information (Jonassen & Grabowski, 1993). Learners with higher cognitive flexibility and cognitive complexity should be better problem solvers than cognitively simplistic learners because they consider more alternatives (Stewin & Anderson,1974) and are more analytical.

Flavell (1979) described *metacognition as the* awareness of how one learns, the ability to judge the difficulty of a task, the monitoring of understanding, the use of information to achieve a goal, and the assessment of learning progress. Metacognitive actions are regarded as a driving force in problem solving along with beliefs and attitudes (Lester, 1994). The development of metacognitive skills enables students to strategically encode the nature of the problem by forming mental representations of it, to select appropriate plans for solving the problem, and to identify and overcome obstacles to the process (Davidson & Sternberg, 1998). Indeed, problem solving requires both cognitive and metacognitive processes (Jonassen, 2000).

Learners' *epistemic beliefs* about the nature of problem solving also affect the ways in which they naturally tend to approach problems. William Perry (1970) discusses stages of intellectual development theory of epistemic beliefs: absolute belief when students should assimilate what the teacher knows; multiplicity, when there is an acceptance of different perspectives about expertise; contextual relativistic, when evaluative thinkers accept the role of judgment and wisdom in accommodating uncertainty, and that experts may provide better answers.

Problem solving also requires affective and conative elements (Jonassen & Tessmer, 1996). *Affective* elements, such as self-confidence in ability (belief in one's abilities to solve the problem), will also predict the level of mindful effort and perseverance that will be applied to solving the problem. *Conative* (motivational and volitional) elements, such as engaging intentionally, exerting effort, and persisting in the task, also affect the effort that learners will make in trying to solve a problem.

The typology proposed by Jonassen (2000) presents a description of problem types. Among all problem solving, there are the following elements: logical, algorithmic, narrative, rule-using, decision making, troubleshooting, diagnosis solution, strategic performance, case analysis, design, and dilemmas. These categories are not independent and there are similarities among them. Some of them are specific to mathematics, live performance, creating something new, and so on. Therefore, I will explain only those that seem to be part of harmonic dictation solving: decision making and troubleshooting.

Decision-making problems typically involve selecting a single option from a set of alternatives based on a set of criteria. Mullen and Roth (1991) describe decision making as a process that includes recognizing problems and analyzing values, generating alternative choices, evaluating choices, and binding the will (committing to choose) and ignoring sunk costs (effort already expended). The primary purpose of troubleshooting is fault state diagnosis. That is, some part or parts of a system are not functioning properly, thus resulting in a set of symptoms that have to be diagnosed and matched with the user's knowledge of various fault states.

As Jonassen (2000) explains, some more complex, ill-structured problems require well-structured prerequisites. He gives the example of case analysis, which requires decision making and aspects of troubleshooting. After this overview of aspects of problem solving, we can classify harmonic dictation as a well-structured and complex problem that requires decision making and troubleshooting.

There are five distinct approaches to examining cognitive processes through collecting verbal reports: retrospection, introspection, dialogue observation, questions and incitement, and "think aloud" or TA (Ericsson & Simon, 1993; Ericsson, 2006; Van Someren, Barnard, & Sandberg, 1994). A main challenge for all of these approaches is that they are considered reliable only when the subject does not, in recounting events, change the sequence of cognitive processes that were involved in solving the problem. In this respect, TA is the only approach that meets this criterion of reliability. The other approaches are not considered reliable, because verbalization inclines the subject to change the sequence of processes normally used during a task, simply in order to retrieve and verbalize certain information requested by the researcher (Ericsson & Simon, 1993). Because it is done *in the moment*, the TA approach is the most reliable approach, enabling the researcher to learn and understand the cognitive processes involved in a given task.

According to Ericsson (2006), TA makes it possible to know at any given time what is going on in a person's mind. To do this, the researcher or teacher asks the persons to verbalize aloud what they are thinking ***as*** they solve the problem. Developed from introspection, TA differs from introspection by avoiding any kind of interpretation or filtering regarding verbalizations of cognitive processes related to verbal or non-verbal information. TA is considered by experts in the field of problem resolution to be the best approach to reflect the cognitive processes involved. The approach allows researchers to obtain very rich and detailed verbalizations, because it is carried out, unfiltered, during the activity of resolution, and not *a posteriori* (Ericsson, 2006; Van Someren, Barnard, & Sandberg, 1994).

Verbalizations obtained using Think Aloud

TA allows collection of three types of verbalization (Ericsson & Simon, 1993; Ericsson, 2006; Greene, Robertson, & Costa, 2011). Type 1 refers to verbalization of cognitive processes related to verbal information, such as verbalization of the processing of a written text. Type 2 refers to verbalization of cognitive processes related to information without an inherent verbal component, such as verbalization about a musical task. Type 3 refers to verbalization of reflections on the participant's own cognitive processes (not the verbalization of *content* present in WM), such as verbalization of selected information about a task—for instance, traffic dangers while a person is driving (Ericsson & Simon, 1993).

Verbalization Types 1 and 2 are considered reliable because by verbalizing everything that happens in the moment, the person does not change the sequence of the cognitive processes normally used during the resolution of a task; and consequently, the performance is the same as if the person did not verbalize. However, Type 3 is not considered reliable because the person changes the normal sequence of the cognitive processes used in solving a problem and, therefore, its performance. Methodological choices can avoid collecting this kind of verbalization, especially as it is closely related to the type of instruction that is given by the researcher or teacher (see the section Methodological aspects to consider in applying Think Aloud).

The use of the Think Aloud approach

Van Someren, Barnard, and Sandberg (1994) reported on two main areas of scientific expertise that used the TA approach in research protocols to access the private thinking of their subjects: psychology and computer science. Since then, many other related domains have used TA, such as for text comprehension using computer based tools (Muñoz Magliano, Sheridan, & McNamara, 2006; Van Hooijdonk & Ummelen, 2006; Wang, 2016); software engineering (Hughes & Parkes, 2003); cognitive psychology (Fleck & Weisberg, 2004; Hölscher Meilinger, Vrachliotis, Brösamle, & Knauff, 2006; Malek, Berna, & D'Argembeau, 2017); clinical psychology (Meichenbaum, 1980; DeRubeis, Evans, Hollon, Garvey, Grove, & Tuason, 1990); psychology and law (Santtila, Korpela, & Häkkänen, 2004); sports psychology (Samson, Simpson, Kamphoff, & Langlier, 2017); education (Bannert, 2003; Cummings et al., 1989; van den Bergh & Rijlaarsdam, 2001; Kesler, Tinio, & Nolan, 2016); discourse processing (Long & Bourg, 1996); and business management (Hoc, 1991; Isenberg, 1986; Premkumar, 1989). That TA is useful in so many different domains shows the relevance and applicability of the method (Guss, 2018).

For this thesis, we will limit our explanations to the field of psychology, because it is closest to our concerns. Thus, in psychology and related domains, TA is used to study participants' cognition where verbal protocols aim to obtain raw data about their cognitive processes. Notably, it is used in fields searching for a better understanding of the psychological aspects of cognitive processes, especially those dealing with problem solving. TA can be a relevant approach to better understand how certain populations solve problems and perform certain tasks. It is also useful to measure the effect of certain educational factors that may influence improvement. TA allows investigating in detail many aspects involved in problem solving and, specifically, the steps taken by a person to solve a task (Van Someren, Barnard, & Sandberg, 1994).

Example of the utilization of Think Aloud in Music Education

Richardson and Whitaker (1996) conducted two studies in music education using TA to collect their data. Their 1996 article summarizes two studies using TA: the first by Richardson and the second by Whitaker. Although they are scientific studies, they nevertheless contain methodological weaknesses which are discussed below.

The first study (by Richardson) presents research results from 31 children taking music lessons on a weekly basis in primary school, while attending private instrument lessons outside their school. This study sought to understand the cognitive processes used by children during musical listening and to compare them with those identified in a study carried out with a music critic: expectation, comparison, prediction, and evaluation (Richardson, 1988). The researchers used TA and collected their data through one-on-one meetings. The children heard 10 short musical examples of works from different periods and styles (e.g., Varèse, *Hyperprism*, the Finale of Beethoven's *Ninth Symphony*, etc.). The instructions given to the children to carry out the task were based on the following three considerations: a) the purpose of the activity—"we are interested in what you think about music while listening to it"; b) what the child should do to achieve that goal—"I want you to tell me everything you think about music from the beginning to the end"; and c) the importance of continuing to talk—"the most important thing is to keep talking".

Richardson therefore made sure the children understood the task. However, according to Van Someren, Barnard, and Sandberg (1994), TA cannot be used with children because they have great difficulty in verbalizing and solving a task simultaneously. Training to use TA can be effective for adults, as their verbalizations do not use all their WM capacities; but it is not the same for children. TA training makes children uncomfortable with the act of verbalizing aloud their cognitive processes during the performance of a task. Thus, the "tell me everything you think about music from the beginning to the end" instruction contradicts, for children, the very aspects to be respected in order to collect reliable and valid information. According to Ericsson and Simon (1993), instructions to verbalize aloud must be formulated in a general way to avoid interpretations that move away from the cognitive processes. Indeed, this sentence (the instruction "tell me everything you think about the music", as Richardson puts it) suggests the type of instruction criticized by Van Someren, Barnard, and Sandberg (1994) because it could lead the participants to provide their *opinion* or an *evaluation of their own thoughts*, rather than uncovering their cognitive processes. In fact, this type of information is more a matter of introspection.

Richardson (1996) collected verbalizations of Type 2. The results obtained are very similar to those he had already obtained in a previous study (Richardson, 1988). His 1996 work identified the same seven categories of cognitive processes: knowledge/education; the use of imaginative language; sensitivity/feeling; expectation; comparison; anticipation; and evaluation. From the children's verbalizations, three new categories of cognitive processes emerged: satellite declarations; metacognition; and recognition/memory. These categories also have problems. Overall, several of Richardson's categories do not meet the criterion for cognitive processes defined by Van Someren, Barnard, and Sandberg (1994): namely, a cognitive process is a successive information set processed by working memory. According to this definition, among the seven categories listed by Richardson, only expecting, comparing, anticipating, and evaluating seem to fit the definition of cognitive processes.

Knowledge is not a cognitive process in itself, nor are the use of language imaginatively and sensitivity/feeling, which seem to be imaging processes.

The goal of the second study in Richardson and Whitaker (1996), this one by Whitaker, was to investigate *reflective thinking* in expert musicians engaged in a specific musical activity (interpretation, composition, or arrangement). The participants enrolled in this study were pianists, conductors, composers, and arrangers. Unfortunately, the author does not tell us the exact number of participants. Whitaker used TA to collect data and to identify participants' cognitive processes around tasks focused on "music selection, pre-rehearsal or practice session study, a practice session, simulated performance, and post-performance reflection". Printed instructions were provided to the participants as well as cassettes and a portable tape recorder to record their verbalizations. They had to say and record aloud whatever came to their minds while they were working on the tasks requested. The verbalizations collected were divided into three categories: "problem statements without any associated statements"; "funding statements"; and "intact problem statement groups" (p. 45). Then, the verbalizations were divided into pre-established categories: pre-reflection, suggestion, intellectualization of the problem, creation of a hypothesis, reasoning, hypothesis testing, and post reflection.

Like the Richardson study (1996), this study has a major methodological problem. According to Ericsson and Simon (1993), participants who read the instructions of a task, as in this study, may verbalize incompletely, because each individual can interpret the instructions in his or her own way. In other words, the interpretation of the purpose of the task may change from one individual to another if instructions are read.

These studies by Richardson and Whitaker (1996) examined the thought processes of musicians, using the TA methodology, and yielded results consistent with results from other fields. In particular, participant descriptions show a nonlinear process subject to reasoning. These studies suggest that TA may be relevant for accessing the private thoughts of musicians, as it is for other non-musical domains. Above all, Whitaker's study of listening to music gives us clues about the categories of cognitive processes involved in musical tasks closer to what an ET teacher might find in tasks performed during ET courses. In the area of ET teaching, TA can be used as an evaluation tool to inform the teacher about the knowledge and cognitive processes students use to solve dictations.

Methodological aspects to consider in applying Think Aloud

In applying TA, researchers and/or teachers must pay particular attention to their *methodological choices* in order to collect reliable and valid verbalizations (Van Someren, Barnard, & Sandberg, 1994).

First, the researcher must *give general instructions* on how to make the verbalizations (Ericsson & Simon, 1993; Van Someren, Barnard, & Sandberg, 1994). As an example: *Tell me everything that passes through your head* *during your work searching for the solution to the problem* (Ericsson & Simon, 1993, p. 80; Claparède, 1934). One must also avoid all instructions that censor verbalization or that specify how to verbalize the nature of the problem, (e.g., *Don't plan what to say […],* Ericsson & Simon, 1993, p. 81; Silveira, 1972). On the other hand, if verbalization stops the researcher can remind the person to continue verbalizing during the task (e.g., *Keep talking*, Ericsson & Simon, 1993, p. 83).

Secondly, researchers must *choose a suitable task* for the group of individuals. They must assure that the problem to be solved is neither too long nor too complex for participants' skill levels (Ericsson & Simon, 1993). If a task is too long or hard, solving the problem will occupy too much space in the individual's WM, and the act of verbalizing will then become a cognitive process in itself, which will result in less rich or even incomplete verbalizations.

Third, it is important to *provide sufficient training* on how to verbalize aloud during problem solving (Van Someren, Barnard, & Sandberg, 1994). This should make participants comfortable with verbalization (Ericsson & Simon, 1993; Van Someren, Barnard, & Sandberg, 1994). Obviously, the verbalizations collected are done individually and recorded in audio or video format in order to be able to transcribe them verbatim and analyze them adequately. The data collected permits the researcher to code and categorize systematically to produce a model of cognitive processes used by the students to solve the task. This exercise will also enable the researcher to discover the cognitive processes that are the basis for *success* in the demanded task as well as to hypothesize explanations about sources of *difficulty* in solving the task (Ericsson & Simon, 1993; Van Someren, Barnard, & Sandberg, 1994).

Think Aloud: Limitations and adaptation

Although TA is very relevant for accessing the private thoughts of individuals, it also has some limitations for purposes of the present study.

The researcher normally collects TA verbalizations aloud by recording them separately in *individual* sessions. This separate collection of data from each subject and the processing of such data (including transcription of audio-video reports verbatim and coding) are very lengthy. As a result, research that uses TA is usually done with small numbers of participants.

However, to study ET cognitive strategies in the ecological environment in which they are most often performed, the task must be carried out in *groups*, since the results obtained will more accurately reflect the pedagogical reality in which such exercises are normally done (Cruz de Menezes & Moreno Sala, 2016). It is clear that if research is conducted with groups, the researcher cannot have everyone all talking aloud at once during the task.

Accordingly, an *adaptation* of the TA method proved to be necessary to collect verbalizations of a larger sample at the same time. It was hypothesized that a viable method would be to *write* thoughts while taking a dictation instead of talking. In medical research, they call this written approach the "Written think aloud" (WTA) (Munshi, AlJarallah, & Harasym, 2013). We will keep this same name in this study.

In order to compare whether both approaches, regular TA (talking aloud) and "Writing think aloud" (WTA), allow collecting similar data about use of strategies, we conducted a pilot study using figured bass dictations to compare the relationship between verbalizations versus writing of the cognitive strategies and results in dictation. In fact, WTA had been tested previously and proved relevant because it allowed the researchers to catalogue and analyze many strategies used in solving a melodic dictation (Cruz de Menezes et al., 2008; Cruz de Menezes, 2010; Moreno Sala et al., 2008; Moreno Sala & Brauer, 2007). However, it was thought important to run the pilot study regardless, to ensure that WTA was as valid and reliable as TA concerning the amount of data and equally robust for figured bass dictation, as it had proved to be for melodic dictation (see Chapter 2).

To sum up, WTA was thus adopted for the current study in place of regular verbal TA. However, the researcher has respected and kept unchanged all the other methodological aspects discussed above as necessary for the collection of reliable and valid "verbalizations", i.e., *give general instructions* on how to make verbalizations; *choose a suitable task* for the group of individuals; and *provide training* on how to "verbalize", in this study by means of WTA.

In summing up this general section, it can be seen that studies that have examined the strategies used to solve melodic musical dictations have mainly used certain methodological approaches: retrospection (Buonviri, 2014); behavioral observation when performing the task through video or audio recordings (Hoppe, 1991; Potter, 1990); or the obligation to use a certain pre-established strategy by the researcher for each test situation (Beckett, 1997; Paney, 2016; Pembrook, 1986). The use of retrospection to study the cognitive strategies used to solve a musical dictation has the disadvantage of providing very general and inaccurate results to describe how to solve each note, as it focuses on participants' memories, not their thoughts during the task. Moreover, this approach does not permit the study of a large number of individuals at the same time, making the results difficult to generalize. As for the approach of behavioral observation when performing the task using video or audio recordings and taking notes, it provides only observable facts, such as the order of writing, the time to solve a dictation, or the changes individuals make (Hoppe, 1991; Potter, 1990). Therefore, these studies do not provide explanations of why subjects use specific strategies or how they articulate their thinking to solve the task. As for the approach requiring the use of a pre-determined strategy, it does not allow seeing all the strategies that subjects can use or determining which are the most effective.

Summary of Literature Review and Statement of the Main Research Objectives

Previous studies report that it is essential to study cognitive processes such as the memory capacity of and the strategies used by music students to better understand the mechanisms underlying their resolution of musical tasks (Barrouillet & Camos, 2007; Beckett, 1997; Cruz de Menezes, 2010; Cruz de Menezes et al. 2009, 2008; Cruz de Menezes & Moreno Sala, 2016; Trehub, Schellenberg, & Kamenetsky, 1999; Unsworth & Engle, 2007).

On the one hand, the literature review reported that understanding the perception of chord tension levels and resolutions in music is essential for musical understanding and the realization of figured bass dictations (Bigand, et al. 1996; Krumhansl et al, 1982). This understanding of tension and resolution is one of the objectives of ET to help students better solve the required tasks. Results of those studies may guide teachers in choosing which chord sequences to use, depending on the level of the ET.

On the other hand, previous studies on harmonic (and melodic) dictations have informed us about the order in which writing strategies were used and their effectiveness (Beckett, 1997; Murphy, 1989). Nevertheless, they did not study exhaustively other types of cognitive strategies used by students in solving harmonic tasks, nor were they able to explain the underlying reasons for success or failure in this type of task.

Concerning single-line melodic dictation, participants who use scale degrees as a strategy for identifying musical notes seem to perform better than those who use intervals (Potter, 1990). In addition, Hoppe (1991) describes some general strategies such as writing in a continuous manner and separating writing of rhythm from notes, and takes into account the impact of the time needed to finish taking the dictations. Dowling (1986) presents results on how to store a melody to identify the type of coding that the subject uses, either by intervals or by degrees. These early studies do not give statistical analyses, but only descriptive analyses, as in the case of Hoppe (who simply presents percentages on the use of strategies), thus limiting the scope and extent of their conclusions. In addition, the samples are sometimes very small and composed only of subjects having a facility for the task performed (Buonviri, 2014; Potter, 1990), limiting the transfer of their results for other populations, and especially populations of students demonstrating difficulty with music transcription. Finally, although Dowling's study presents statistics, he studies isolated elements, not a complete dictation.

In our recent studies on melodic dictation, detailed strategy categorization and explanation were done, as well as analysis of strategy effectiveness. A relation with WM was reported (Cruz de Menezes, 2010; Cruz de Menezes & Moreno Sala, 2016; Cruz, Bissonnette, Guiton, & Moreno Sala, 2009; Moreno Sala et al., 2016). However, little to no research information is available about strategies used in figured bass dictation, as it is a more complex task. As the strategies are unknown, their relationship with WM is also unknown.

In order to fill the data gap in the field of understanding how to do figured bass dictation, the current study proposes to examine in depth the cognitive processes involved, specifically all the strategies in use and their link to WM.

First, to better study strategies, the researcher proposes a *specific definition of strategy* appropriate to the field of musical dictation. Although previous studies have already started to investigate strategies used in musical dictations, there is a gap concerning the term's definition. Thus, a strategy in musical dictation is here defined as *a category of mental procedures selected through specific actions, comparing the stimulus heard with the knowledge of the individual, in order to solve a dictation task.* (See also Chapter 3.)

To study strategies within the framework of the present thesis, the researcher adapted the normal TA procedure, which aims to collect verbalizations about the strategies used aloud. Instead, she asked participants to verbalize in writing, in order to collect many verbalizations at once in a large group situation. A written procedure has already been used in other fields, such as medicine, and has been called Writing-Think-Aloud or WTA (Munshi, AlJarallah, & Harasym, 2013). Ericsson and Simon (1993) indicate that verbalizations collected by TA can reveal *information* dealt with in working memory by participants performing a task (the *what*) as well as the cognitive *processes* involved (the *how*). TA verbalizations and WTA provide a chronologically ordered image of the exact path a participant takes to accomplish a task. TA/WTA also can give information about the structure of working memory, an essential cognitive component in problem solving (Jonassen, 2000), since the verbalized information is the same information processed in WM. There is a general belief that some people are better problem solvers than others because they use more effective problem-solving strategies (Jonassen, 2000). That is why it is important to categorize the strategies used and understand their use in terms of frequency and efficacy. Some research has shown that less experienced solvers can also learn to use them (Mayer & Wittrock, 1996). Our research in repeated measurements will enable us to know if this is possible in Ear Training classes.

To study WM, two memory tests were developed for the current research, an auditory non-musical test and an auditory musical memory test. Measuring these two types of memory might enable us to verify if success in figured bass dictation is related to the capacity of non-musical memory or to that of musical memory, which is influenced by musical knowledge and the familiarity of the subjects with the tonal system. A questionnaire will allow us to evaluate participants' experience and familiarity by documenting their starting age of informal and formal musical studies as well as the number of years of their musical studies.

Thus, to understand the underlying reasons for success or failure in the figured bass dictations task, a study was conducted with six research objectives:

1. List all cognitive strategies used by music students while transcribing tonal figured bass dictations (the students are at the start of the first term of undergraduate degree programs in music);

2. Categorize the cognitive strategies listed in the previous step;

3. Identify the strategies most used and the strategies that seem to be most effective for tonal harmonic dictation transcription;

4. Analyze other cognitive factors that may influence use of strategies and learning, such as auditory musical and non-musical working memory capacity;

5. Analyze the relationship between strategy use, dictation success, and: gender, number of years of musical studies, age at beginning of musical studies, studied musical genre (e.g., classical versus jazz), main type of instrument, and memory capacity both musical and non-musical; and,

6. Check if the acquisition of new strategies is possibly due to the intervention of ET courses (*post hoc* work done at the end of participants' first term in undergraduate degree programs in music).

Despite the importance and complexity of the task of figured bass dictation and music dictation in general, a major effort has yet to be made to understand the cognitive processes involved in the transcription of musical dictations for pedagogical purposes. Should the current study reach its objectives, it is hoped that the results might better inform researchers and teachers about processes such as memory and the strategies involved in successfully solving figured bass dictations. It is also hoped that increased understanding of taking figured bass dictation will allow future researchers to determine the most effective strategies to help weaker students overcome their difficulties.

Chapter 2 - Methods

Research Questions

In this chapter, we describe our research questions, the tools and methodology developed to respond to them, and provide some important definitions. To match the objectives listed in Chapter 1, we tried to answer the following six research questions:

1. What are the *cognitive strategies* used by new university students during transcription of tonal figured bass dictations?

2. Considering the potentially wide range of similarities and differences of strategies, is it possible to create *categories* and groups of cognitive strategies?

3. If strategies are listed in response to the first objective (finding strategies), which ones are the *most used* and which ones are the *most effective* in solving the transcription of tonal harmonic dictations?

4. For both pre- and post-tests, is acquisition/utilization of strategies influenced by mnemonic factors and/or other variables?

5. For pre- and post- tests, to what extent do gender, number of years of musical studies, age of beginning musical studies, musical genre (e.g., classical versus jazz), type of instrument, type of strategy, and memory capacity contribute to the prediction of performance in figured bass dictation?

6. Can cognitive strategies and performance in figured bass dictations be improved by participating in ET courses?

Definitions

To understand the methodology and data of this study, it is necessary first to understand the definition of two main concepts that will be used: *short-term memory* and *strategies,* as situated within the domain of musical dictation.

Strategy: In non-musical areas, strategy has already been defined. In the field of music dictation, no definition has been proposed so far. It is therefore necessary to analyze the definition of strategies in other areas to be able to propose a definition for music dictation. Fayol and Montreuil (1994) defined *strategy* as an integrated cognitive sequence, more or less long and complex, of mental procedures selected for a goal, in order to optimize performance. In the field of elementary education, Bégin (2008) defined a *learning strategy* as a category of metacognitive or cognitive actions used in a learning situation for the purpose of carrying out a task and used to carry out operations on knowledge according to specific objectives. Finally, in music, in the field of improvisation, Després et al. (2017) defined *strategy* as "a sequence of cognitive processes undertaken by the musician to ideate, evaluate, select or realize one or several musical aspects (form, harmony, notes, rhythm, timbre, etc.) of his improvisation". Inspired by these definitions and based on the data of this research, we propose the following definition of cognitive strategies for the field of musical dictation:

A category of mental procedures selected through specific actions, comparing the stimulus heard with the knowledge of the individual, in order to solve a dictation task.

For example, a participant compares the stimuli to be identified (a cadence) with previous mental knowledge (types of cadences learned) in order to identify specific notes or groups of notes (label and write the cadence).

Short-term memory: This is a form of transitional, short-lived (on the order of seconds) memory with limited capacity, accessible for further operation or manipulation, and which has not undergone a consolidation process (Dudai, 2002).

Working Memory: This is also a transitional memory with the same information retention capacity and mechanism as short-term memory, with the addition of an information processing mechanism (Alloway et al., 2006; Baddeley, 1986; Barrouillet & Camos, 2007). Thus, these terms are often used in an interchangeable way (Colom et al., 2006; Unsworth & Engle, 2007).

Understanding these three concepts will support the reader's understanding of the methodology and the tests and results presented in this thesis, above all because the two central themes of the research questions are strategies and auditory memory span. Furthermore, when reporting the results of auditory memory tests only, we will refer to short-term memory, whereas when the use of auditory memory is in the context of musical dictation, we will refer to auditory working memory, because the information processing mechanism is also engaged in the task.

Participants

Freshmen students from Laval University and Concordia University were invited to participate in the study. A recruitment announcement was presented and distributed during the ET courses one week prior to the beginning of the study (Appendix A). This was done to inform students of the importance of their participation, as well as to give them a week to decide about their voluntary participation. Ultimately, our experimental sample came from three groups at Laval University and one group at Concordia University, with a total of 66 individuals enrolled in the first term of university courses. A crucial objective was to do the pre-test measures while participants were in the earliest days of their university ear-training courses in order to avoid influence of extensive university teaching on the pre-test results. The courses concerned were closely equivalent courses, i.e., "Formation auditive 1" at Laval, and "Aural Perception I" at Concordia.

Written consent was obtained from each participant in this study (Appendix B). Among the information specified in the consent form was that data would be anonymized and used only for research purposes without influencing their academic life. The name of each participant was replaced by a unique code. All procedures were submitted to and approved by the Université Laval and Concordia University ethics committees (see acceptances in Appendix C).

Procedures

A pre-experimental, repeated measures, pre-post-test design was used, allowing us to evaluate the same students at the beginning and the end of their first university semester. Tests administered at the beginning of the "Formation Auditive 1" course (Laval) and "Aural Perception I" (Concordia) are referred to as the pre-test session, while those done at the end of the same term are called the post-test session.

Three harmonic dictations and two tests of auditory memory (musical and non-musical), as well as a small questionnaire, were developed for this research. They will be detailed in the Materials section. Also, a relatively new instrument, the "Written Think Aloud" (WTA) procedure, was used to collect participants' strategies while doing dictation (see below). Data were collected to evaluate whether the subjects changed their harmonic dictation results, strategy use, and memory span *after* the first term of ear-training courses.

As participants came from different universities, Laval being francophone and Concordia anglophone, all tests, announcements, consent forms and communications were done in both languages, corresponding to each university. Not only is the language different in each university; the final objectives of the two institutions are not the same. Laval University participants were enrolled in Bachelor of Music degrees in performance or music education, whereas Concordia participants were in a Bachelor in Fine Arts (BFA) program with a major in music. Despite these differences, we wanted to evaluate whether the mere fact of participating in undergraduate ET courses would help improve results in harmonic dictation in terms of use of strategies and memory span, independently of the teaching peculiarities of different professors.

The pre-test session took place at Laval University on September 10^{th}, 2013, and at Concordia University on September 20^{th}. The post-test session took place at Laval University on November 28^{th}, 2013, and at Concordia University on November 27^{th} The ensuing university terms consisted of 13 weeks of normal ear-training instruction including harmonic dictations, with two 50-minute-long sessions per week in both institutions for a total of 26 sessions. Harmonic exercises in the form of study of individual chords, as well as taking written dictation of harmonic progressions, took place at least once a week, and the students were expected to do homework as well.

A newly-devised "Written Think Aloud" (WTA) approach was employed to collect descriptions about the strategies the participants used during dictation solving. The method had been previously developed and used (Cruz de Menezes, 2010; Cruz de Menezes et al. 2009; Moreno Sala et al., 2008; Moreno Sala & Brauer, 2007) and was improved in this project. A pilot study was conducted to verify if WTA verbalizations were as rich and complete as Think Aloud (TA) verbalizations (Ericsson & Simon, 1993) for harmonic dictation. This pilot was conducted with three participants who performed two harmonic dictations of equivalent level. First, they verbalized their thoughts out loud using the TA approach; the verbalizations were video recorded. They had to notate their dictations on paper. Second, the same subjects had to report their thoughts in writing. For both conditions, the dictations were repeated 4 times automatically using the computer, and the interval between repetitions was of the same duration. At the end of the musical test, we asked questions about which approach they preferred for dictation and the interval between repetitions. Participant 1 has a Master's in performance (flute); Participant 2 has a Ph.D. in performance (classical guitar); Participant 3 was a Ph.D. candidate in performance (classical piano). Since Participant 3 said he had made a mistake in his reading of the instructions, we made two tables with averages: the first for Participants 1 and 2 and the second for Participants 1, 2, and 3. Two *number of strategies* measurements were done: number of *different* strategies (counted once each strategy to determine variety) and *number of utilizations* of strategies (counted the number of times participants used each strategy to determine frequency).

The results showed that the average number of *different* strategies used by the two participants was 6 for TA and 5.5 for WTA, and the average number of *utilizations* of strategies was 7.5 for TA and 7.5 for WTA. The averaged results were 5.25 for TA and 6 for WTA.

2 participants average	**TA**	**Written TA**
Number of *different* strategies	6	5.5
Number of utilizations of strategies	7.5	7.5
Result on dictation on 6	5.25	6

Table 2.1. Results of pilot study to compare TA with WTA (2 PT average)

Results indicated that the average number of *different* strategies used by all three participants was 7 for TA and 6.6 for WTA, and the average number of *utilizations* of strategies was 8.6 for TA and 8 for WTA. The averaged results were 5.5 for TA and 5.63 for WTA.

3 participants average	TA	Written TA
Number of *different* strategies	7	6.6
Number of *utilizations* of strategy	8.6	8
Result on dictation on 6	5.5	5.63

Table 2.2. Results of pilot study to compare TA with WTA (3 PT average)

Table 2.1 (Participants 1 and 2) suggests that the use of strategies was similar for Participants 1 and 2 in both approaches (TA and WTA). However, the results were higher for the written approach. Table 2.2 (Participants 1, 2 and 3) suggests a similar use of the strategies; but for the written approach, there was a slight decrease in the number of strategies used and the number of uses of the strategies. However, the average score remained slightly higher for the written approach.

Both approaches seemed to yield similar results, with a tendency to favor the written: participants generally seemed to perform better when using WTA. In addition, there was no significant difference between the two approaches in the use of strategies. Finally, all three subjects preferred WTA, if only one approach were to be chosen.

These results would justify the use of the paper-based approach for data collection in this study, thereby permitting many more subjects to be involved at once, in groups, in the research. Note that the WTA approach had already been used successfully in previous studies on melodic dictation (Cruz de Menezes, 2010; Cruz de Menezes et al., 2009; Moreno Sala et al., 2008; Moreno Sala & Brauer, 2007), which further confirms its usefulness for collecting data on harmonic progression dictation strategies. A review of literature concerning the Think Aloud approach allowed us to improve the instructions to be used in the musical test (the most general possible), as well as the shape of the test, for example, adding a training part to make participants comfortable with written verbalizations, before collecting the data itself.

Materials

Questionnaire

At the beginning of the first test session (pre-test), students completed a short questionnaire concerning: gender; possession of absolute pitch; main musical instrument(s); musical genre; number of years of musical studies; and starting ages of informal and formal musical studies (See Appendix D.a). After finishing the questionnaires, they proceeded to do the musical tests as a group.

Musical tests

Stimuli

As musical tests, we used three different figured bass dictations specially composed for this study (see also next page). The same three dictations were played pre- and post-test to ensure that the results obtained were comparable. All dictations were in G Major, so that dictation accuracy and description of strategies would be unaffected by tonality changes. The tonic was not given. Neither was the first note of the dictation identified as tonic. Students had to find the tonality by themselves, as is done in ear training courses at Laval University. As mentioned before, keeping the task as normal as possible was important in order to fully reveal the most strategies from the most participants. Concordia participants did not have difficulty identifying the tonality. Complexity of the stimuli overall was determined by chord quality, inversion, and dictation length.

The complete testing session was recorded on the computer using a piano sound in "Wave" format offered by *Finale* software. The complete harmonic dictation session (identical pre-test and post-test, as mentioned) was recorded together to ensure that the test was done in the same way and took the same length of time in all testing situations. All dictations were tonal and played in an adagio tempo (quarter note = 75) with balanced voices. Before playing a new dictation, 4 beats were played to indicate the change. At all levels, the harmonic dictations were played completely through without stopping for every repetition of the example. The number of repetitions was chosen according to the difficulty of each dictation. Specifically, the easy-level dictation was played four times, the moderate-level dictation six times, and the difficult-level dictation eight times. The time elapsed between each repetition at one level was 55 seconds, and the time between two different levels of dictation was the same, plus 4 more beats to indicate that a new dictation was starting, making 60 seconds between dictation levels.

The total time for the full test, all dictation levels and repetitions, was 20'45", excluding initial instructions. Musical tests were administered in Laval and Concordia University music classrooms. At Laval, the sound system was *Denon DN A300M* and loudspeakers were both *JBL control 30*. At Concordia, the sound system was an *Ashley mx508* mixer-based sound system and loudspeakers were both *Mackie HR824MK2*.

The first dictation, called “easy-level”, consisted of 6 chords based on typical content in the beginning university ear training courses. It was a review of the harmonic knowledge the students are supposed to possess when they start university. The 6 chords presented I, IV, and V in root position.

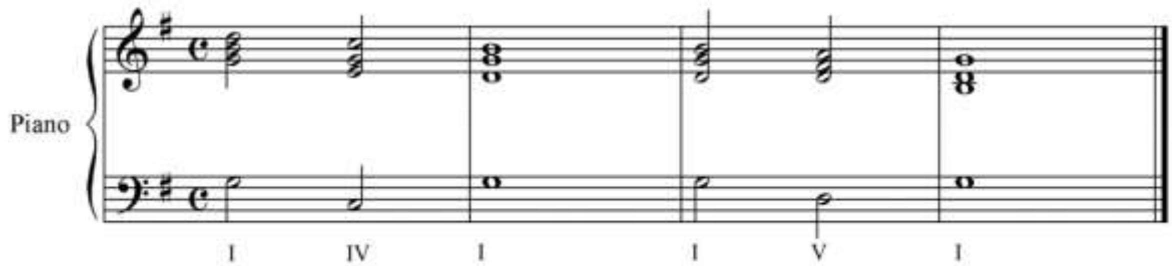


Figure 2.1. Musical Test – Easy-level dictation

The second dictation, called "moderate-level", consisted of 7 chords and was based on course content that would be worked on in the middle of term. In addition to easy-level chords, it presented ii, vii^{o}, and V7, with some chords in first inversion.

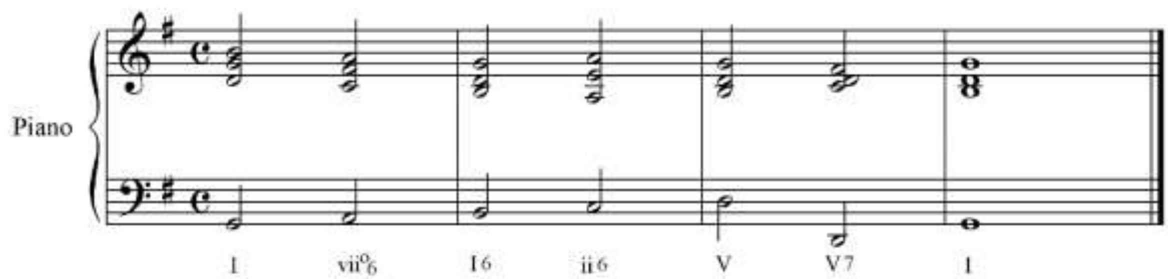


Figure 2.2. Musical test – Moderate-level dictation

The third dictation, called "difficult-level", consisted of 8 chords and was based on content expected at the end of term. It included, besides the minor and major chords of the easy and moderate levels, the secondary dominant V^{7}/V. By administering three levels of dictation at pre-test, we expected subjects to have difficulty performing at least in moderate and difficult dictations. At post-test we would be able to evaluate whether, after a term of ear-training courses, the participants' performance in dictation and strategy use had improved.

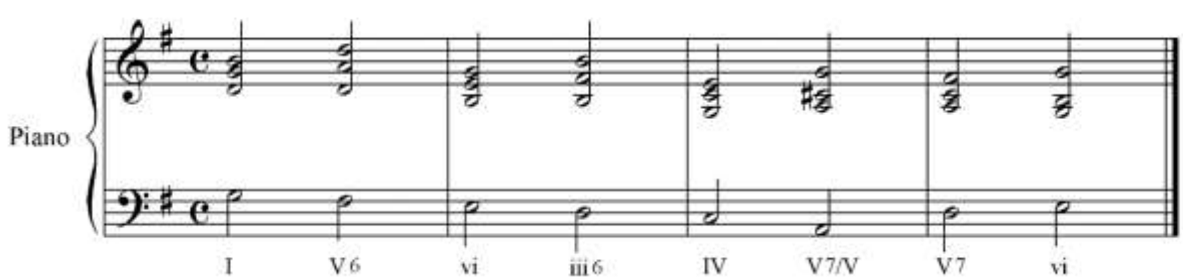


Figure 2.3. Musical Test – Difficult-level dictation

In summing up this presentation of stimuli, it is important to note that the choice of task was based on parameters indicated by Ericsson and Simon (1993) and Ericsson (2006). These authors explain that a task must be representative with regard to the cognitive processes involved for participants, that is, it must be a common problem, not too easy and not too difficult. The moderate-level dictation therefore was at a level of difficulty adapted to those ET courses the participants were about to enter, presenting at the same time the same challenge. Ericsson and Simon (1993) and Ericsson (2006) explain further that a representative task must be difficult enough to prevent subjects from automatically solving the problem; when a process becomes automatic, information about that process becomes less accessible. At the same time, since high-level tasks such as writing and reading already consist of many sub-processes that working memory uses for input and output, the task should not be overly difficult. Too hard a task means that verbalization (TA or WTA) risks becoming a cognitive process in itself, leading to an overload of working memory. We therefore chose an easy-level dictation; a moderate-level dictation, as a representative baseline with regard to the cognitive processes involved, presenting same challenge; and a difficult-level dictation. Moderate-level and difficult-level dictations should allow evaluating participants' progress in time (pre- and post-tests).

Instructions

Instructions were read at Laval University by a francophone and at Concordia University by an anglophone. After instructions, the participants were allowed to ask questions to ensure they understood the instructions.

Unlike the usual TA procedure, students from "Formation Auditive 1" (Laval University) and "Aural Perception I" (Concordia University) were asked to use WTA, i.e., to describe in writing, and in detail, what they were thinking while transcribing the dictations. This permitted observation of the mental processes used during the transcription of tonal figured bass dictations.

Instructions were given in a very general way (Ericsson and Simon, 1993) (see Appendix D.b), because the goal was to avoid interpretations that the subjects might make of their own thoughts. The only specification given was that the participants were to write first what they thought (strategies) to find chords, or notes, whatever element of the dictations they chose, and then write in full the results (i.e., the bass note names, such as "F" or "fa", and the chords in Roman numerals or jazz notation, for example "V_7/V". The order of what is given as figured bass dictation results was not pre-established. The only specification concerned the description of how they thought to find figured bass dictation results before the results themselves. Here are the Instructions that were verbally announced before the musical test:

"Tell me everything you think to find the chords while you transcribe the dictation. First write what you think. Then, write the name of the bass note, and the chord in Roman numeral *in the order of your choice*."

A writing procedure without staff was chosen on the basis of results of an earlier pilot study on melodic dictation. There it was found that, given a staff, students wrote first musical information and notes on the staff, and then described the strategy used, often using signs such as arrows and drawings (Cruz de Menezes et al., 2008). This made it difficult to identify certain strategies and to observe the order and quantification of strategies. It was also found that subjects who wrote even just the names of the notes before describing the strategies, described less than participants who respected the indicated working order. Therefore, it seemed important to determine exactly the procedure to be used to obtain comparable results: first describe the strategy used, then write the name of the note of the bass or the chords in Roman numerals. Therefore, no staff was used; only a blank answer sheet was provided to participants, containing some questions about personal identification on the first page (see Appendix D.a).

Moreover, during the verbalization, a sentence of encouragement was always said when subjects seemed to decrease the frequency of their verbalizations, something along the lines of "continue to verbalize" or “keep writing your thoughts”. This was said, at most, at each repetition of the dictation.

Pre-test training session in Written Think Aloud (WTA)

A training session in WTA was given to reduce the chance that verbalization might interfere negatively with the results on performance of the task (Ericsson & Simon, 1993; Van Someren, Barnard, & Sandberg, 1994). Verbalization using WTA was a way to avoid memory becoming overloaded with verbalization itself. The training was designed to make participants feel comfortable with doing written verbalization, and to become able to verbalize automatically. To do this, a simple chord sequence (same easy-level as the actual easy-level musical test) was used to train participants on the type of written verbalizations desired. The chords of the sequence I-IV-V-I were played automatically in the form of a “Wave” sound track using piano sound from *Finale*. This training was done just before the musical test. After the training session, the three harmonic dictations, unknown to the students and specially composed for this project, were played during a test session of approximately 30 minutes.

Auditory Memory Tests

After the harmonic dictations, a second independent test session, lasting about 30 minutes was dedicated to *auditory memory*. These tests allowed us to observe if a specific type of memory (musical versus non-musical memory) would have a greater influence on subjects’ performance in transcription of harmonic dictations. All the participants did two types of short-term memory tests (musical and non-musical) to measure if the type of memory, or its capacity, were related to the subjects' performance on harmonic dictation (see example in Appendix E). Specific memory tests, both *musical* and *non-musical,* were developed for this study, both adapted from a test used by Trehub, Schellenberg, and Kamenetsky (1999). Modifications permitted us to test the music student participants in groups. All tests were recorded to ensure similar conditions for all groups.

We kept some aspects of the test devised by Trehub, Schellenberg, and Kamenetsky (1999) and modified others. First, as in their study, the tests were composed of pairs of sound sequences. Each sound sequence was played twice; the participants responded to the same/different protocol. Second, we used the (currently standard) equal-tempered Western major scale to create the musical memory test sequences, i.e., with the octave divided into 12 identically-sized semitones. However, to generate the sequences of the *non-musical* auditory memory test, the octave was divided into 7 logarithmic intervals. This division of the octave into seven similar intervals was chosen because the resultant sounds were different from the notes that students are used to playing and working with. That allowed the evaluation of students' *non-musical auditory memory,* avoiding their usual musical knowledge which might influence the results of this test (Trehub, Schellenberg, & Kamenetsky, 1999). Rhythm was held constant for both tests, as we wanted to analyse strategies linked only to pitch identification.

Our previously studies concerning melodic dictation (Cruz de Menezes, 2010; Cruz de Menezes & Moreno Sala, 2016; Cruz de Menezes et al., 2009; Moreno Sala et al., 2016) already suggested a relation between auditory digit memory span and visual recognition memory span with results in melodic dictation. These findings led us to investigate if a task closer to musical dictation, using notes or non-musical sounds, for example, would report the same tendencies or even a stronger relation with figured bass dictation.

Since our study aimed to investigate the memory capacity of music students, instead of the students' psychology, we had to adapt some other aspects of Trehub, Schellenberg, and Kamenetsky's (1999) test, and we also made the test more difficult. The adaptations were as follows:

First, instead of listening to ascending and descending scales that are characterized by conjunct step-wise intervals as in Trehub at al.'s (1999) test, our sound sequences were composed of disjunct as well as step-wise intervals.

Second, the duration of each sound was shorter, 200 ms instead of 400 ms, and the silence between the two notes of the pair was 100 ms.

Third, we relied on 60 pairs of sequences in each condition (major scale and octave divided into 7 equal intervals scale) instead of 50 pairs per condition. There were in total 120 paired sequences, administered during 20 minutes in the second test session.

Fourth, the length of our sequences varied between 4 and 8 sounds and was exposed to the participants randomly (6 sounds, 4 sounds, 8 sounds), thus increasing the level of difficulty.

Fifth, unlike Trehub et al. (1999), who transposed the second sequence of the pair, we kept the same tonality for the two sequences of the pair. Only one note was changed in the second sequence if it differed from the first. For example, in the "different" trials the different note of the first sequence was placed at the 3rd note in the sequence of 4 sounds (see Figure 2.4). The notes were randomly drawn between C3 and C5 of C major using the program *Matlab.*

Sixth, timings were changed: the retention time between the two sequences of the pair was 2 seconds, while the response time, to respond the same or different in writing, was 2.5 seconds. An artificial voice was integrated automatically into the memory tests indicating the changing of sequence pairs just before the new one, for example "*one"*, a paired sequence played; "*two"*, next paired sequence played; "*three"*, and so on until the end of the tests.

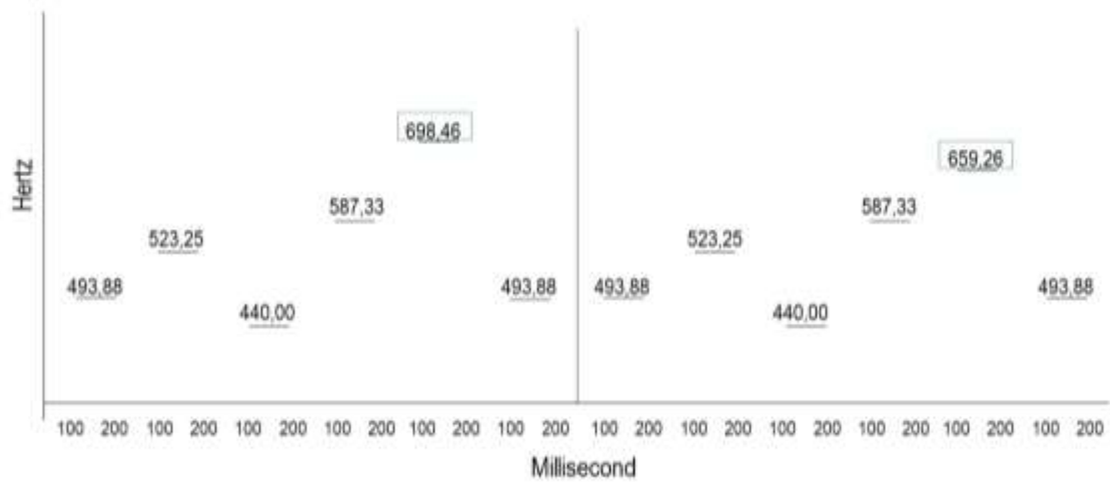


Figure 2.4. Example of a pair of 6-note sequences. The second sequence is different from the first because the penultimate sound has changed.

Finally, we had to adapt the tests to administer them in groups so that testing could be done during ET courses, maximizing the similarity to solving dictation tasks (which are usually done as group exercises during ET courses). This choice brought the test closer to actual tasks in ecological conditions (Furman, Dorfman, Hasson, Davachi, & Dudai, 2007; Hasson, Clarck, Dudai, Davachi, 2008; Sloboda, 1986). To do this, we made a single sound track with all pairs of sequences to be played via a sound system, so all the participants of the ear-training classes could do the test at the same time. We used synthetic and multi-harmonic sounds, not to favor students who were familiar with the timbre of a certain type of instrument, such as the piano.

We created a response sheet on which, after listening to each paired sequence, participants checked off if the second sequence of the pair was same or different (see Appendix E). To guide the participants, a synthetic voice was added between pairs of the sequences to tell them which paired sequence was being played (first, second, third, fourth, etc.); this also indicated on which numbered line of the response sheet they were to answer.

Post-test

After pre-test data collection (at the beginning of September), a post-test was conducted with the same participants at the end of the first term (in December). In the post-test session, we used exactly the same pre-test procedures and tests. Comparing the results of identical pre and post musical tests allowed us to analyze whether there were changes in strategy use (number, utilization, or efficacy) and/or any changes in performance on written dictations. In addition, we were able to check whether there were changes in the performance of auditory memory tests.

There were no controlled treatments provided to students between the pre- and post-tests. Participants simply attended their normal ET classes at their respective institutions. Students enrolled in an academic ET courses are expected to make progress during the semester. During the autumn semester, students attended ET courses twice a week. The professors did harmonic chord recognition and figured bass (harmonic progression) dictations at least once a week.

Data Analysis

This section reports the stages of data analysis as applied to the original 6 research questions. Qualitative and quantitative methodologies were used. All the results are reported in Chapter 3. Questions 1 and 2 involved listing, coding, and categorizing. It was possible to start data analysis on these questions as soon as we had pre-test data, whereas for Questions 3 and following, we had to wait for post-test data as well.

Question 1: What are the *cognitive strategies* used by new university students during transcription of tonal figured bass dictations?

Data analysis: All the participants' WTA reports were transcribed using *Microsoft Word* text editing software and evaluated qualitatively. They were then subjected to a content analysis using *QDA Miner* software in order to list and code all identified strategies.

Question 2: Considering the potentially wide range of similarities and differences of strategies, is it possible to create *categories* and groups of cognitive strategies?

Data analysis: An analysis of the coding done in Stage 1 was done to categorize the cognitive strategies. Categories were re-checked by a co-coder to ascertain the reliability and validity of the coding.

Question 3 developed emergent sub-questions which involved analysis over time, i.e., the comparison between pre- and post-tests. Post-test data were put through data analysis Stages 1 and 2 before work proceeded to Question 3.

Question 3: If strategies are listed in response to the first objective (finding strategies), which ones are the *most used* and which ones are the *most effective* in solving the transcription of tonal harmonic dictations?

Data analysis: Strategy frequencies were calculated using *Excel* software to get a first quantitative overview of the data, i.e., the most used and least used strategies.

Accuracy results from pre- and post-test harmonic dictations were evaluated quantitatively as follows: 1 point per correct chord (0.2 for the bass; 0.2 for the inversion; 0.2 for the Roman numeral chord symbol; 0.2 chord for chord quality, 0.2 for chord function). In the case of writing V instead of V^7 we counted as 0.8. ii_6 instead of IV was 0.3, as was ii or $V^6{}_4$ instead of $V^o{}_6$. Points were not allocated for the soprano or any other voices because those lines were not required in the experimental task. The bass was chosen because for the majority of the participants (Laval), the task is called dictation of figured bass, and the bass notes are integral part of the work. It was thought that changing their normal task would not reveal their normal strategies. For participants from Concordia, inclusion of the bass notes was also a regular enough part of their normal dictation work for it to make sense to include bass notes names in the experimental task.

A *Repeated Measures ANOVA* in *SPSS* software was run, using a Mixed Model Analysis, to calculate which types of strategies were linked to the best results obtained, and which were linked to the worst results, on both conditions. One-Way ANOVA was run to analyse procedural strategies. During the analysis of Question 3, two other important questions emerged:

Question 3.1: Is there any combination of strategy that is more efficient?

Another *Repeated Measures ANOVA* was run so that the most efficient combination of strategies could be calculated.

Question 3.2: On the post-test, are the efficacy of strategy and/or combination of strategies improved?

All of the above analyses were done for the pre- and post-tests separately, and the results were compared.

During quantitative analysis of research questions 4, 5, and 6, data was always retained for the largest possible number of participants who participated in the tests relevant to the analyses.

Question 4: For both the pre- and post-tests, is acquisition/utilization of strategies influenced by *auditory memory span* and/or other variables?

Data analysis: Before answering the main question, the two types of memory tests were analysed to answer two preliminary questions:

Question 4.1: Is there any difference between *musical* and *non-musical* memory tests?

Question 4.2: Is there any difference *in time* (pre- and post-tests) between the memory types or the same memory type?

Paired Sample T-Tests were performed on the data from the memory tests. *Spearman correlations* were run to verify any relation between the two types of auditory memory, performance in dictation, and the frequencies and types of strategies.

The *General Linear Model* was used to verify the relations indicated by Spearman correlations and other variables from the questionnaire in predicting the utilization of strategies. Specifically, this model was used to determine the variables that predicted the number of strategies used in pre- and post-tests.

The final analyses of Stage 4 were *linear regressions*, and *two-way Ancova*, depending on which variables were significant. All statistical analyses were done using *SPSS* software.

Question 5: For the pre- and post-tests, to what extent did the number of years of musical studies, age of beginning of musical studies, gender, musical genre (e.g. classical versus jazz), the type of instrument, the type of strategy, and memory capacity contribute to the prediction of performance in harmonic dictation?

Data analysis: The questionnaire has been described above. See also Appendix D.a. A theoretical model was created, based on initial indices emerging from qualitative analysis, frequencies, and correlations as reported above to guide us in choosing variables that should be included in further analyses of variance. This model took into account: the several independent variables listed above; the types of strategies used during the transcription of dictations; results of the memory tests; and the main dependent variable, average dictation results on the 3 harmonic progressions. The aim of creating this theoretical model was to statistically verify any relationships between all the independent variables mentioned above with the subjects' performance in dictation (dependent variable) and to discover which, if any, of these variables strongly predict the results in figured bass dictation and in what order of importance. In other words, answering this question enabled us to find out how much the type of instrument played, for example, contributed to the prediction of performance in dictation, and so on.

To verify the theoretical model, the *General Linear Model* was conducted once again using *SPSS* software. The final models were *ANCOVA* and *linear regression*, depending on which variables were significant. These analyses are the most important of this research, as they relate all the variables used in the previous steps.

Question 6: Can cognitive strategies and performance in harmonic dictations be improved by participating in ET?

Data analysis: *Paired sample T-tests* were conducted to verify significant changes in dictation accuracy and number of strategies used between the pre- and post-tests. When data were not normally distributed, the *Wilcoxon Signed Rank Test* was used. These tests allowed us to check whether participation in ET courses might have improved participants' performance on the musical tests; new strategies emerged from the descriptions; and the number of strategies increased compared to the pre-test.

Goals of the study: hoped-for contributions to the advancement of knowledge

This study focused on solving the concrete problems that all students face in resolving figured bass dictations (Cruz de Menezes, 2010; Hedges, 1999; Hoppe, 1991; Frkovich, 1984). Such a study has not, to the best of our knowledge, been done before on figured bass dictation tasks. A number of main points to be made about the study include:

First, few studies have even considered strategies used by students during harmonic dictation. The analysis and categorization of strategies used by students in a learning situation will allow us to learn the diversity of strategies involved in the transcription of figured bass dictations. Such strategies have certainly not been analysed in detail and reported before.

Second, the data obtained will complement previously achieved results in the field of melodic dictation transcription (Buonviri, 2014; Cruz de Menezes, 2010; Cruz de Menezes et al., 2009; Moreno Sala et al., 2008; Moreno Sala & Brauer 2007; Potter, 1990) and will promote better understanding of the cognitive processes in action during the transcription of a wider variety of musical dictations than have been previously studied.

Third, knowing which strategies prove to be most effective when transcribing harmonic dictations can provide teachers with information on strategies to encourage them when teaching ET. Thus, we hope to offer tools both to teachers and to students looking for effective solutions for their difficulties in this task.

Fourth, comparing strategies that yielded higher or lower performance to students' varying memory capacities (both musical and non-musical) will allow us to better understand some underlying processes involved in music transcription and to discover whether other cognitive factors may be involved as the source of the difficulties in figured bass dictation. The various tests proposed in this project may allow us to grasp whether success in this task is related to general (non-musical) auditory memory, since this task is accomplished by the perception of sounds, or whether it is related to musical memory, since tonal context plays an important role in harmonic perception (Bigand et al., 1996, Krumhansl et al., 1982).

Fifth, the research may allow us to know to what extent genre, type of instrument, type of strategy, and auditory memory contribute to the prediction of performance in figured bass dictation. In other words, if our model is conclusive, we will be able to know, for example, which variable best explains the variance in the performance. Would it be the type of strategy? Would it be the type of instrument? Would it be the capacity of auditory memory? This type of information will help us understand both what is truly important about the *cognitive processes* involved in the transcription of musical dictations and what is important from a *pedagogical* point of view. These are questions that have not yet been addressed in the research literature.

Sixth, it is hoped that this research will enable us to discover to what extent it is possible to influence the acquisition and implementation of more effective cognitive strategies during ET courses. The data obtained, while meeting research objectives, will contribute to the improvement and updating of teaching methods in ET in order to increase the listening efficiency of future musicians, especially for harmonic progressions.

Chapter 3 - Results

Due to the large amount of information concerning the results of this thesis, and to better understand them, this chapter is divided into three sections. The first section reports analyses which confirmed that the two participant groups, from Laval and Concordia, did not differ significantly. These groups have accordingly been collapsed into a single group for all further analyses. This section also explains the decision to exclude or retain participants on the basis of how complete their testing was, concerning pre- and post-tests, in order to keep as many participants as possible in the analyses.

The second section presents results concerning qualitative analyses. This study presents a substantial amount of data analyzed for qualitative research, with fine-grain descriptions of strategies from all 66 participants, much of the information in the participants' own words. This section also presents a definition of each strategy categorized, with examples to illustrate each one, and how the many strategies were categorized into sub-categories to arrive at four main categories.

The third section reports the results of the quantitative analyses that were run to examine relationships between the types of strategies used on pre-and post-tests, dictation accuracy pre- and post-, memory span pre- and post-, and the answers from the questionnaire. This section also presents other aspects of the work, such as unforeseen results emerging from the analyses. We looked at the entire group (N = 66 at pre-test), then at the different samples (Laval and Concordia) by dictation difficulty levels.

Section One: Collapsing the Laval and Concordia Groups

While qualitative analysis of the strategies was done for all 66 participants, including the frequency of utilization of strategies, further quantitative analyses concerning dictation results, after the end of term, required that participants attended all sessions, in order to compare pre- and post-tests. There was therefore, later, a reduction from 66 to 56 participants because 10 people did not participate in both the pre- and post- musical tests. For other analyses, we kept as may participants as possible, indicating the number of PTs by analysis. The decision to use the data of all 66 participants in the qualitative research was determined by the intention to list and categorize as many strategies as possible in order to report the potential variety of strategies used in figured bass dictation.

Dictation results were scored on a scale from 0 to 10 for every dictation. For the pre-test, overall, the dictation mean of all 66 participants was M = 5.837 out of 10 (SD = 2.183), with the raw score distribution seen in Figure 3.1 (scores have been rounded to the nearest integer).

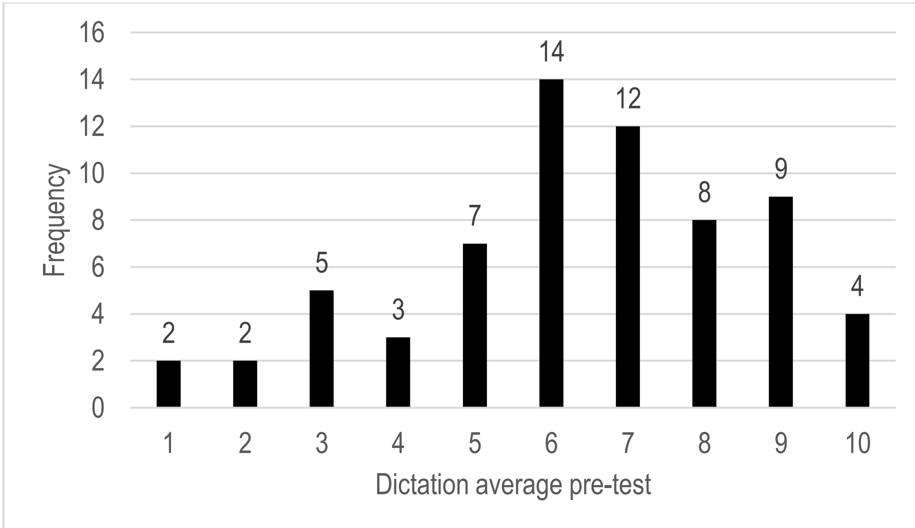


Figure 3.1. Raw score distributions of all participants on pre-test (*N* = 66)

Figure 3.1 shows a normal distribution (Shapiro-Wilk = .102). At the dictation mean, *M* = 5.8, one sees the largest group of participants, 14; from score 0 to the mean, there are 33 participants (including the group of 14 at precisely the mean); above the mean, between scores 6 and 10, there are also 33 participants. The pre-test mean thus divides the group into two groups with the same number of participants.

Before proceeding to any main statistical analyses, we had to determine whether our participant pool, from two quite different universities, constituted one group or two. First, there was no specific treatment between pre- and post-tests. Each university was using its own program, but they were similar in the number of times they practiced figured bass dictation per week, and in time, as both had the same number of ET courses. Then, the difference in the size of both groups could affect results (Laval *N* = 43, Concordia *N* =13). Furthermore, in this research, it was essential to note any possible changes over time, i.e., between pre- and post-tests. Accordingly, only participants who took both test sessions, pre- and post-, were retained for analyses concerning dictation results at pre- and post-tests (*N* = 56). So, we wanted to verify if the progression in dictation results on the three difficulty levels separately, between pre- and post-tests, were similar in both groups and for them together, in order to verify if collapsing the two groups into one was appropriate for overall analysis. Looking first at all the retained participants (*N* = 56) from both institutions, we analyzed dictation difference scores between pre-and post-tests. Then, we analyzed each university separately. The Shapiro-Wilk test indicated that the dictation results were normally distributed for both groups (Concordia, *p* = .688, and Laval, *p* = .166), which permitted us to proceed to the Paired T-tests. A Paired-Sample T-test was run on participants from Laval University (*N* = 43), then on participants from Concordia (*N* = 13), to see if the difference in dictation results on pre- and post-tests followed the same direction in both groups separately, and compared to the two together, for all dictation levels. These results will be presented on the next paragraphs.

We will now look at the results reported by dictation level, first for the whole group together, then for the two universities separately (and compare them to the whole group). For all the retained participants (*N* = 56), the easy-level (Dictation 1) pre-test mean was *M* = 7.55 (*SD* = 2.71); post-test was *M* = 7.71 (*SD* = 2.61). There was no significant difference observed between the pre- and post-tests ($t(56) = -352$, $p < .726$). However, at the moderate level, the pre- and post-test difference was significant ($t(56) = -4.10$, $\boldsymbol{p < .001}$). The mean of the moderate-level dictation on the pre-test was *M* = 5.46 (*SD* = 2.26), while on the post-test it was *M* = 6.61 (*SD* = 1.85). Similarly, there was a significant difference reported at the difficult-level, Dictation 3, between pre- and post-tests ($t(56) = -385$, $\boldsymbol{p < .001}$). The mean on the pre-test was *M* = 4.33 (*SD* =2.89) and on the post-test *M* = 5.44 (*SD* = 2.91).

The lack of significant difference in scores on the easy-level dictation was expected. This level was supposed to create a ceiling effect, as it was easy. The significant increase of raw scores between pre-test and post-test on the moderate and difficult levels was also supposed to happen. At pre-test, these levels were meant to be challenging; then, it was thought, participants would learn and increase their competence in performing harmonic dictation during their ET courses and show higher scores on the post-test. All significant differences are indicated by different letters in the figure below.

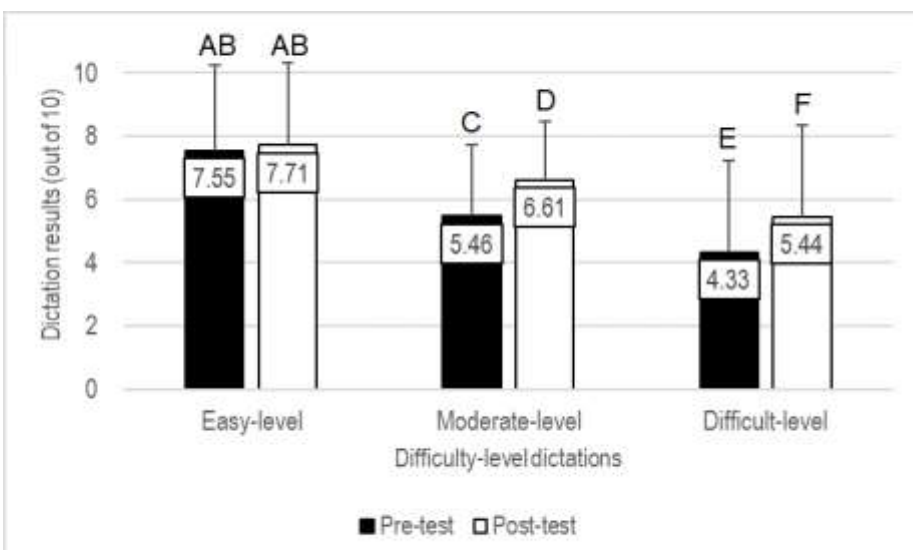


Figure 3.2. Dictation results by difficulty level for Laval and Concordia participants (collapsed)

For both groups separately, Concordia *(N* = 13) and Laval (*N* = 43), there was no significant difference observed in scores for the easy-level dictation pre- and post-test, as we reported for the whole group together (probably again due to the ceiling effect mentioned before). For Concordia, there was a little decrease in easy-level dictation results, but not significant; they had *M* = 8.15 (*SD*= 2.90) on the pre-test and *M* = 7.12 (*SD* = 3.44) on the post-test (*t* (13) = .140, *p* = *.649*). For Laval, there was no significant increase on the easy-level scores, with M = 7.36 (*SD* = 2.66) on the pre-test and *M* = 8.19 (*SD* = 2.12) on the post-test (*t* (43) = .290, *p* = .060). Note that in both groups and in both conditions (pre- and post-test), the scores on the easy-level dictation are situated between 7.12 for the lower and 8.19 for the higher, out of 10. This reveals that the participants obtained the highest scores on the easy-level dictation, compared to the results obtained on the moderate and difficult levels, thus suggesting a ceiling effect.

Concerning the moderate-level dictation, both separate groups increased their scores: Concordia, with *M* = 4.41 (*SD* = 2.12) on the pre-test and *M* = 5.23 (*SD* = 2.33) on the post-test (*t*(13) = -1.36, *p* = .196); and Laval, with *M* = 5.78 (*SD* = 2.22) on the pre-test and *M* = 7.03 (*SD* = 1.47) on the post-test (*t*(43) = -391, ***p* = .000).** As reported above, the difference in scores between pre- and post-tests was normally distributed for both groups: Laval (Shapiro-Wilk = .166) and Concordia (Shapiro-Wilk = .688). However, only in Laval was the difference significant in the moderate-level dictation results, perhaps because of a size effect (the Laval group was three times bigger than the Concordia group). As for the difficult-level dictation, the increase in results was significant for both groups: Concordia, *M* = 3.17 (*SD* = 2.52) on the pre-test, *M* = 4.89 (*SD* = 2.46) on the post-test (*t*(13) = -3.18, ***p* = .008**); Laval, *M* = 4.58 (*SD*=2.92) on the pre-test, *M* = 5.61, (*SD*=3.04) on the post-test (*t*(43) = -2.75, ***p* = 009)**. All significant differences are indicated by different letters in the figures below.

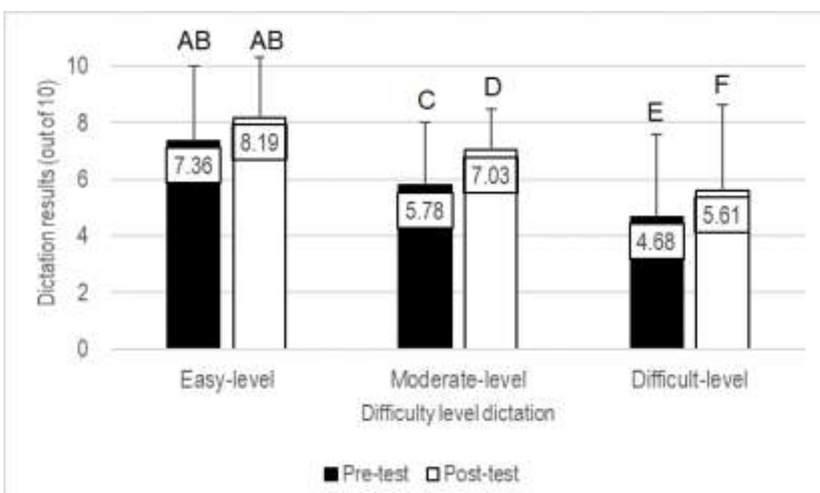


Figure 3.3. Dictation results by difficulty level for participants from Laval

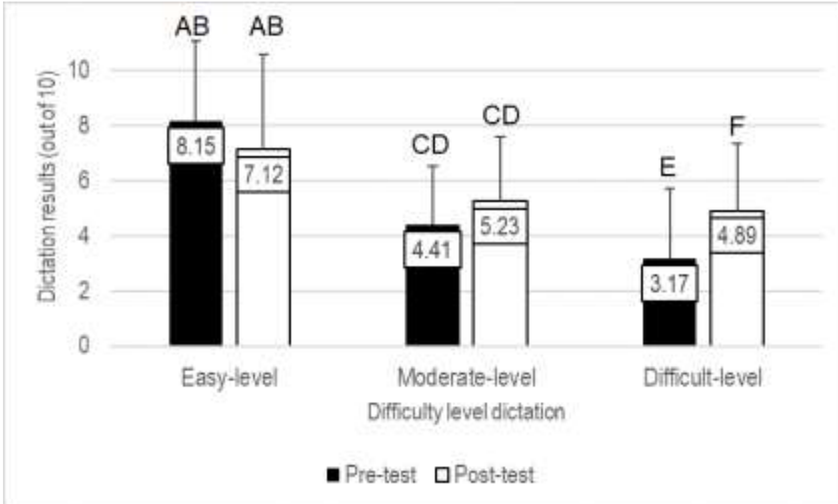


Figure 3.4. Dictation results by difficulty level for participants from Concordia

We thus observed the same general trends for results—increased dictation results only at the more challenging difficulty levels (moderate level and difficult level) for all participants together as well as for the two separated groups. Hardly any significant difference was observed for all the participants together, or for the two separated groups. It therefore appeared reasonable to collapse the two groups for all the remaining analyses. From this point forward, all reported analyses will concern the complete group, Laval and Concordia together, $N = 66$, for section two of this chapter (qualitative analyses of strategies) and part of section three (frequency of utilization of strategies). For the third (and last) section of Chapter 3, from efficacy of strategies to the end of the chapter, the number of participants was reduced ($N = 56$) for most of the analyses concerning dictation results' progression in time (pre- and post-tests). For other analyses, we kept as many subjects as possible, indicating the number of participants by analysis.

Section Two: Qualitative Analyses of Strategies

This section answers the first two research questions presented in Chapter 2 Methodology:

1. **What are the cognitive strategies used by new university students during transcription of tonal figured bass dictations?**

2. **Considering the potentially wide range of similarities and differences of strategies, is it possible to create *categories* and groups of cognitive strategies?**

A very large number of cognitive strategies emerged from qualitative analysis of participants' (PTs') descriptions collected during the three harmonic dictations. A detailed description of these numerous strategies is followed here by categorization according to their common or different characteristics. Categorization permitted the reduction of a large number of individual strategies into just four main strategy groups.

Qualitative content analysis (L'Écuyer, 1990) was applied to all data. An open model was used rather than a closed or a mixed model because the analysis follows an inductive approach without pre-established codes or categories (Paillé & Mucchielli, 2012; L'Écuyer, 1990). This approach was also chosen because the open model permits the observation of *emergent* strategies (as this is, to the best of my knowledge, the first time descriptions of harmonic dictation strategies have been analyzed).

The first step was to transcribe all descriptions using *Microsoft Word*. Second, coding of texts and categorization of strategies was done using a qualitative analysis program, *QDA Miner – Provalis Research.* The objective was to build a synthetic representation of the strategies found by grouping them into categories. To do so, we had to identify their highest similarities by using QDA Miner's *thematic content analysis* method. Finally, all categories were verified by an independent co-coder (inter-judge reliability = 92%).

A number of additional analyses will be presented concerning the variety and frequency of use of the strategies as well as their efficacy, when answering question 3 (see question 3 in Chapter 2).

Categorization and description of cognitive strategies

Observed strategies were first coded in fine-grain detail, then reorganized into more inclusive categories. Four levels of categories emerged. The categories, ordered from largest to smallest frequency of use, are: *Tonal, Procedural, Non-tonal, and Implemental strategies*.

Each main category groups various actions at three levels: *Level 1* presents a global action characterized by a verb; *Level 2* presents a specific action about level 1, also characterized by a verb, and *Level 3* adds details about level 2, characterized by a verb, an adjective, or a noun.

It is important to define terms. Looking at strategy definitions in cognitive psychology, we see that Bégin (2008) defines strategy as: a category of cognitive or metacognitive action used in a learning situation to solve a task and serves to perform operations on knowledge as functions of specific objectives. He considers there to be two types of strategies: a) processing strategies, such as selecting, organizing, decomposing, elaborating, and spotting, and b) implemental strategies, such as evaluating, verifying, translating, and producing.

For purposes of this thesis, strategy has been defined as: *a category of mental procedure selected through specific actions, comparing the stimulus with the knowledge of the individual, to perform a dictation task.*

This proposed definition of strategy guides the categorization levels of our analyses: *category of mental procedure* refers to the main categories—*Tonal, Procedural, Non-tonal, and Implemental*; *selected through specific actions* refers to the next *2 levels*, where we see the emergence of verbs such as evaluate, compare, concentrate, and identify; *comparing the stimulus with the knowledge of the individual* is observed in participants' written descriptions of how they worked (all strategy has a knowledge component recovered in memory (Bégin, 2008; Buonviri, 2014; Sisley, 2008); and *to perform a dictation task* refers to the end goal of participants' activities during the three harmonic dictation tasks.

The next section presents all the strategies grouped into the four main categories that emerged. Levels 1, 2, and 3 are presented as subsidiary to each main category section. Table 3.1 summarizes all categories and levels of strategies and gives the readers an overview to guide their reading of the ensuing sections.

Main Categories	Level 1 (global action)	Level 2 (specific action)	Level 3 (complementary)
Tonal strategies	Focusing on functional degrees of notes	Identifying scale degrees/pillars	"No finer-grain descriptors"
		Using tonal references	
		Identifying scalar patterns	
		Singing scale or degrees (mentally or not)	
		Using Moveable do/Transposing	
		Identifying passing notes	
	Focusing on harmonic function of chords	Identifying chord quality (M/m)	
		Identifying chord position	Without specifying how
			Using bass movement
			Using soprano
			Using arpeggio
		Calculate tonality and/or mode or 1st note	Identifying tonic
			Using previous dictation
		Identifying cadences	
		Analyzing notes from different voices	
		Identifying 7th chords	
		Identifying chord function	Using one voice
			Using the scale and other chords
			Using memorized musical extracts
		Memorizing/Singing harmony internally	
		Identifying arpeggio	
		Anticipating next chord	
		Identifying consonant or dissonant chords	
		Building the triad from the bass notes/scale	
Procedural strategies	Focusing on a specific element	Writing Bass	Bass 1st
			Bass 2nd
			Bass 3rd
		Writing Soprano	Soprano 1st
			Soprano 2nd
			Soprano 3rd
		Writing Chord	Chord 1st
			Chord 2nd
			Chord 3rd
		Writing inner voices	
		Dissociating voices	
		Writing voices on the staff	
		Writing bass and chords at the same time	
		Writing rhythm 1st	
	Focusing on the structure	Listen to the whole dictation a 1st time	
		Counting number of chords	
		Writing from the end	
		Naming the steps to perform figured bass dictation	
Non-tonal strategies	Focusing on a specific element	Identifying intervals	Without specifying how
			By reference to a song
			By gap-filling
		Using a sound reference	
		Identifying a note/context using memorized piece	
	Focusing on the structure	Focusing on ascending/descending motion	General
			Separated
			By drawing
		Focusing on conjunct/disjunct motion	
Implemental strategies	Evaluating	Evaluating difficulty level of the test	
		Comparing several possible answers (T and N-T)	
		Making a negative judgment on answers	
		Evaluating time to solve dictation	
	Verifying	Verifying the answers	
	Using kinesthetic strategy	Playing an instrument mentally	

Table 3.1. Overview of all strategy category levels

Tonal strategies

In this main category are all strategies that fit the description of "tonal", i.e., those which identify notes or chords by comparing or associating them with the tonal context of the dictation. Various strategies found in PTs' descriptions coincide with the same tonal strategies found in previous studies, such as the use of the pillars (tonic, subdominant, dominant, leading tone) or scale degrees (Cruz de Menezes, 2010; Cruz de Menezes et al. 2008; Dowling, 1986; Moreno Sala et al., 2008; Moreno Sala & Brauer, 2007; Potter, 1990). However, other subcategories have emerged in this present study and are categorized a little differently. This is to be expected, as the type of dictation is different; and it is also gratifying as these new subcategories enrich our understanding of tonal strategies. Compared with Bégin's (2008) categorization of strategies, tonal strategy would be a *processing strategy* that includes, for example, selecting, identifying, and comparing.

Within level 1, which presents a *global action*, there are two subcategories: a) *Focusing on functional degrees,* in which participants say they focus on one or more notes in relation to their function in the tonal context to solve the harmonic dictation; b) *Focusing on harmonic function,* in which participants say they focus on the harmony and analyze the voices and the chords to figure out cadences and harmonic progression in the dictation. Level 2 presents a specific action on level 1, for example *identifying chord functions*. Finally, level 3 completes level 2 for some strategies, for example, identifying chord functions *using a memorized music extract*, i.e., comparing it with a past exercise or a known harmonic progression that participants have in memory. Not all strategies in level 2 need a level 3.

All examples cited in the following explanations are followed by the participant's code in parentheses. The English version is presented first, then the original version when the example comes from a francophone participant. When there is no French version following, the English is the original from an anglophone participant. The strategies explained below start with the number of the corresponding level of strategy: *1. Focusing on functional scale degrees* means that this strategy belongs to level 1 of the strategies; *2. Tonal reference* means that this strategy belongs to level 2 of the strategies, and so on.

Main Category	Level 1 (global action)	Level 2 (specific action)	Level 3 (complementary)
Tonal strategies	Focusing on functional degrees	Identifying scale degrees/pillars	
		Using tonal reference	
		Identifying scalar patterns	
		Singing scale or degrees (mentally or not)	
		Using moveable do/Transposing	
		Identifying passing note	
	Focusing on harmonic function	Identifying chord quality (M/m)	
		Identifying chord position	Without specifying how
			Using bass movement
			Using soprano
			Using arpeggio
		Identifying tonality and/or mode	Identifying tonic
			Using previous dictation
		Identifying cadences	
		Analyzing notes from different voices	
		Identifying 7th chords	
		Identifying chord function	Using one voice
			Using the scale and other chords
			Using memorized musical extracts
		Memorizing/Singing harmony internally (Mental rehearsal)	
		Identifying arpeggio	
		Anticipating next chord	
		Identifying consonant or dissonant chords	
		Building the triad from the bass notes/scale	

Table 3.2. Tonal strategies with all levels of categories

1. Focusing on functional scale degrees

In this level 1 of tonal main category, participants describe tonal strategies relying to the position and function each note has in the scale.

2. Identifying scale degrees/pillars

In this level 2 of tonal strategy subcategory, participants *identify scale degrees*, such as 1^{st} degree and 5^{th} degrees or tonal *pillars* by their names, i.e., the tonic, the subdominant, the dominant, and the leading tone. A total of 27 participants reported using pillars and/or other scale degrees to solve at least one of three dictations on the pre-test. To cite one PT:

"The bass progresses slowly towards the 5th degree" (40).

« La basse progresse doucement vers le 5^{e} degré » (40).

2. Using tonal reference

In this level 2 of tonal strategy subcategory, participants memorize and *use a degree or a pillar as a reference to compare* and find other notes or chords in the dictation. Seven participants reported using this strategy for at least one of the three dictations on the pre-test. One of them reported singing the tonal reference.

"I think a fourth below the I (tonic)" (19).

Je pense une quarte en dessous du I (la tonique) (19).

"Same chord as the first one" (42).

« Même accord que le premier » (42).

2. Singing the scale or degrees

In this level 2 of tonal strategy subcategory, participants reported singing the scale in order to find the notes or chords of the dictation. They can mentally sing or actually sing in a soft voice. Five participants reported using this strategy for at least one of the three dictations on the pre-test.

"(I) Sing a scale" (41).

« (je) Chante une gamme » (41).

2. Using Moveable do/transposing

In this level 2 of tonal strategy subcategory, participants say that they find the notes "in Do" i.e., in C Major, first; then they transpose to the correct tonality. We considered this strategy translating, which is why it is also categorized among the implemental strategies (Bégin, 2008). Only one participant reported using this strategy in the pre-test.

"C D E F G G C   Bass: so, G A B C D D G" (61).

« C D E F G G C   Basse : donc, G A B C D D G » (61).

2. Identifying a passing note

In this level 2 of tonal strategy subcategory, participants identify a note filling the gap between two main notes that are normally at the distance of a third. Only one participant reported using this strategy in the post-test.

"It sounds like passing tones" (44)

2. Identifying scalar patterns

In this level 2 of tonal strategy subcategory, participants report *identifying scalar patterns* in the dictation when they hear conjunct motion in a voice. This strategy was reported only in the post-test.

"The bass is like a descending major scale at the beginning" (16).

« La basse fait comme une descente de gamme majeur au début » (16).

1. Focusing on harmonic function

In this level 1 of tonal main category, participants describe tonal strategies relating to the harmony, as chords, arpeggio, or harmonic progression.

2. Identifying chord quality (M/m)

In this level 2 of tonal strategy subcategory, participants said they identified the chord qualities as either major or minor. Twenty-nine participants reported using this strategy for at least one of the three dictations on the pre-test.

"The chords seem to be in a sequence of M, m, m, M, a, M, m" (59).

2. Identifying chord position

In this level 2 of tonal strategy subcategory, participants said they searched for the chord position. Often, they wrote about inversions, and a few times also about root position. Here we have four subcategories at level 3 to complete this action, i.e. without specifying how; by singing bass movement; by using soprano; and by using arpeggio.

3. Without specifying how

In this strategy, participants describe that they look for chord inversions in a general way without specifying how they find them. Twenty participants reported using this strategy for at least one of the three dictations on the pre-test.

"Finally, I notice whether the chord is in inversion" (11).

« Finalement, je prends connaissance si l'accord est renversé » (11).

3. Using bass movement

In this strategy, participants describe that they calculate the inversions using the bass notes. Only two participants reported using this strategy for at least one of the three dictations on the pre-test.

"I especially listen to the bass note to help me identify the position of the chord" (62).

« J'écoute particulièrement la note de basse pour m'aider à identifier la position de l'accord » (62).

3. Using soprano

In this strategy, participants describe that they calculate the inversions from the soprano notes. Only two participants reported using this strategy for at least one of the three dictations on the pre-test.

"Listen to the top note to help determine the nature of each chord (major, minor, inversion)" (16).

« Écoute de la note supérieure pour aider à déterminer la nature de chaque accord (majeur, mineur, renversement) » (16).

3. Using arpeggio

In this strategy, participants describe that they calculate the inversions using an arpeggio. Only 1 participant reported using this strategy to solve the intermediate-level dictation.

"I hear clearly the arpeggio on ii. The chord is inverted. I hear it in my head" (14).

« J'entends bien l'arpège sur le ii^{e}. L'accord est renversé. Je l'entends dans ma tête » (14).

2. Identifying tonality and/or mode

In this level 2 of tonal strategy subcategory, participants identify tonality and/or the mode, and the note that is the first scale degree (tonic). The identification of the tonality and mode by writing the accidentals in the results has been counted even if it was not verbalized in the descriptions. Sometimes participants do not explain how they get the tonality (*without specifying how* – level 3). Other times, they say they "calculate the first note" of the dictation, tonality, and/or mode on the basis of the previous dictation (*using previous dictation* – level 3). 20 participants reported using this strategy for at least one of the three dictations on the pre-test. Two of them reported using both identifying the tonality without specifying how in the first dictation and using the previous dictation in the third one.

3. Identifying 1st degree

Twelve participants reported using this strategy for at least one of the three dictations on the pre-test.

"Always G Major, even if we finish with the E minor chord" (6).

« Toujours sol majeur (même si ça fini sur un accord de mi mineur) » (6).

"Identification of the first degree to get into the tonality" (21).

« Repérage du 1er degré afin de s'impregner de la tonalité » (21).

"Sol: really the tonic" (25).

« Sol : vraiment la tonique » (25).

3. Using previous dictation
Eight participants reported using this strategy for at least one of the three dictations on the pre-test.

"Inner singing of the tonic from the previous dictation to find the starting note" (16).

« Chant intérieur de la tonique de la dictée précédente pour trouver la note de départ » (16).

2. Identifying cadences
Tonal strategy reported by participants who identify and name the types of cadences heard in the harmonic dictation. 14 participants reported using this strategy for at least one of the three dictations on the pre-test.

"AC (Authentic Cadence)" (47).

« CA cadence autentique » (47).

2. Analyzing notes from different voices
Tonal strategy reported by participants who analyze the notes from different voices of the dictation or analyze the relation between the chord quality and other voices to figure out the chords, or to fill in the chords using theory. A total of 13 participants reported using this strategy for at least one of the three dictations on the pre-test.

"Using theory to fill in the chords' possibilities" (48).

2. Identifying 7th chords
Tonal strategy reported by participants who identify the dissonance of the 7th in the V7 chord. A total of 11 participants reported using this strategy for at least one of the three dictations on the pre-test.

"I deduce that my penultimate chord is a V^7" (14).

« Je déduis que mon avant-dernier accord est un V^7 » (14).

2. Identifying chord function
This was a tonal strategy reported by participants who identify chord functions by comparing the chord heard with a variety of reference factors: the bass and/or soprano, the scale, other chords, and/or memorized past exercises, sounds, pieces, or common progressions.

3. Using one voice (bass or soprano)

In this level 3 of tonal strategies, participants compare the chords they want to find with intervals in the movement of the bass or soprano. One participant reported using the bass for at least one of the three dictations on the pre-test, and another one reported using the soprano.

"2nd listening. I pay more attention to the qualities of the chords and the higher notes" (4).

« 2e écoute. Je porte plus attention aux couleurs de l'accord et aux notes supérieures » (4).

"From there (intervals), I can judge the functions of the chords" (49).

3. Using memorized music extracts

In this level 3 of tonal strategies, participants recover in memory past exercises, sound memorization, common progressions, or memorized pieces to figure out the chords. Four participants reported using past exercises, sound memorization, or common progressions, while 7 participants reported using memorized pieces.

"Recollecting past practices and sound memorization to understand which chord is which" (52).

3. Using the scale and other chords

In this level 3 of tonal strategies, participants compare the heard chords with the scale to place them in relation with the degrees. Only 1 participant reported using this strategy with chords, for the easy-level dictation on the pre-test; and another 2 participants used this strategy with the scale, also for the easy-level dictation.

"Which chords were which in relation to the major scale" (58).

"Comparing chords with each other to find them on the scale" (44).

2. Memorizing/ singing harmony internally (mental rehearsal)

This level 2 of tonal strategies was reported by participants who sing or repeat the chord sequence in their head. The following examples show both situations. Eight participants reported using this strategy for at least one of the three dictations on the pre-test.

"Repeat the sequence heard in my head" (41).

« Répète la séquence entendue dans ma tête » (41)

"Sing the chord sequence" (41).

« Chante la séquence d'accords » (41).

2. Identifying arpeggio

This level 2 of tonal strategies was reported by participants who identify a melodically successive series of notes that would be a chord if played together. Two participants reported using this strategy for at least one of the three dictations on the pre-test.

"I can hear well the arpeggio on the ii" (14).

« I j'entends bien l'arpège sur le ii[e] » (14).

2. Anticipating the next chord

This level 2 of tonal strategies was reported by participants who anticipate the next chords in their head before they were played. Only 2 participants reported using this strategy, both to solve the second dictation of the pre-test, the one at the intermediate level.

"Making my ear want to hear a minor chord after the 3rd chord" (59).

2. Identifying consonant or dissonant chords

This level 2 of tonal strategies was reported by participants who identify if they hear a dissonant or consonant chord using those words, but without naming the chord quality (such as major or minor) or chord function, such as tonic or dominant. This strategy was reported for the post-test only. Likewise, when a participant identified if it was a chord of three or four sounds, without using the words consonant or dissonant, it was also coded in this category. The latter version of this strategy was reported once in the pre- and twice in the post-test.

"(We hear the dissonance)" (10).

« (On entend la dissonance) » (10).

"I hear only three sounds in the 5th chord". (14).

« Je n'entends que trois sons au 5e accord » (14).

2. Building the triad from the bass notes/scale

In this level 2 of tonal strategies, participants build the triads on top of the notes, probably to consult afterwards or to compare with what they are listening to and find the answers. Only one participant reported using this strategy on the pre-test, but in the training session.

"And then build a triad on top of the bass note" (55).

Procedural strategies

This main category includes all the strategies deemed procedural, that is, the strategies used to plan the dictation writing. In level 1, which presents a global action plan, there are two subcategories: (a) *Focusing on a specific element,* in which participants say they focus on one specific element of the dictation, such as the bass; and (b) *Focusing on the structure,* in which participants say they focus on elements of the dictation structure, such as the number of chords. Level 2 presents descriptions of specific actions in each subcategory, for example, *writing* the bass. Finally, level 3 completes level 2 for those subcategories for which the PTs wrote more specific explanatory details, such as writing the bass *first*.

The next table shows all procedural strategies put together with an overview of all subcategory levels. It is meant to guide the following explanation of all the categorizations. All examples presented in the following explanations give the participant code between parentheses. As before, the English version is presented first, then the original French version when the example comes from a francophone participant. When there is no French version following English, the example comes from an anglophone participant. The strategies explained below start with the number of the corresponding level of strategy: *1. Focusing on a specific element* means that this strategy belongs to level 1 of the strategies; *2. Writing bass*, means that this strategy belongs to level 2 of the strategies, and so on.

Main Category	**Level 1 (global action)**	**Level 2 (specific action)**	**Level 3 (complementary)**
Procedural strategies	Focusing on a specific element	Writing Bass	bass 1st
			bass 2nd
			bass 3rd
		Writing Soprano	soprano 1st
			soprano 2nd
			soprano 3rd
		Writing Chord	chord 1st
			chord 2nd
			chord 3rd
		Writing inner voices	
		Dissociating voices	
		Writing voices on the staff	
		Writing bass and chords at the same time	
		Writing rhythm first	
	Focusing on the structure	Listening to the whole dictation a first time	
		Counting number of chords	
		Writing from the end	
		Naming steps to perform figured bass dictation	

Table 3.3. Table of procedural strategies with all levels of categories

1. Focusing on a specific element
In this level 1 subcategory, participants focus on one specific element at a time. We found 7 specific actions or subcategories at level 2, i.e., Writing: *the bass*; *the soprano*; *the chords; voices on the staff; writing rhythm first; writing iinner voices; and focusing on the starting note*.

The three first strategies presented above (writing the bass, soprano, or chords) indicate the *order* each participant chose to write the voices (soprano or bass) or chords. To describe that order precisely, a subcategory of level 3 appears to be necessary: writing the bass (*first, second or third*), writing the soprano (*first, second or third*), and writing the chord (*first, second or third*). Examples of descriptions for each strategy are presented below.

2. Writing the bass
In this level 2 of procedural strategy subcategory, participants tell us at which moment of the dictation they wrote the bass.

3. Writing the bass first
In this level 3 of the procedural strategy subcategory, participants choose to start writing their dictation with the bass. 69.69% of the participants started with the bass for at least one of the three dictations.

“I focus more on the bass at first listening” (11)

« Je me concentre davantage sur la basse à la première écoute » (11).

3. Writing the bass second
In this level 3 of the procedural strategy subcategory, participants choose to start writing their dictation with another voice, such as the soprano, or by hearing chord qualities before writing the bass.

"I hear the chords and their quality first. Then I identify the bass" (20).

« J’entends les accords et leurs couleurs en 1er. Ensuite, j’identifie la basse » (20).

3. Writing the bass third
In this level 3 of the procedural strategy subcategory, participants choose to start writing their dictation with the soprano, then the chord qualities (or vice-versa), before writing the bass.

"Write the chord colors (…) I will try to concentrate on the soprano (…) write the bass note (easier step in this case)" (13).

« Écrire la couleur des accords (…) je vais essayer de me concentrer sur le soprano (…) écrire la note de basse (étape la plus facile dans ce cas-ci) » (13).

2. Writing the soprano

In this level 2 of the procedural strategy subcategory, participants tell us at which moment of the dictation they wrote the soprano, if applicable. Not all participants wrote the soprano. The majority of PTs (N=46) wrote just the bass and the chords.

3. Writing the soprano first

In this level 3 of the procedural strategy subcategory, participants choose to start writing their dictation with the soprano. 22.72% of participants started at least one of the three dictations with the soprano.

"I heard the soprano first" (11).

« J'ai entendu le soprano en premier » (11).

3.Writing the soprano second

In this level 3 of the procedural strategy subcategory, participants choose to start writing the dictation with another voice such as the bass, or by hearing chord qualities, before writing the soprano. In the following example, participant 16 wrote the bass first, then the soprano to help find the chords.

"Listening from first note comparing following notes to determine intervals separating the notes of the bass. Listening to the top note to help determine the nature of each chord. Then listening to the chords to confirm all" (16).

« Écoute de la note de départ et comparaison avec les notes suivantes pour déterminer les intervalles séparant les notes de basse. Écoute de la note supérieure pour aider à déterminer la nature de chaque accord. Puis, écoute des accords pour confirmer le tout » (16).

3. Writing the soprano third

In this level 3 of the procedural strategy subcategory, participants choose to start writing their dictation with the bass, then the chord qualities, or vice-versa, before writing the soprano.

"Towards the end I realized that I could follow the upper voice" (3).

« Vers la fin j'ai réalisé que je pouvais suivre la voix du haut » (3).

2. Writing the chords

In this level 2 of the procedural strategy subcategory, participants tell us at which moment of the dictation they *wrote the chords*, if applicable. Some participants did not finish writing the chords (N=11), mainly in the difficulty-level dictation (N=7), compared to the easy (N=3) and moderate levels (N=3). Participant 15 did not finish the moderate- and difficult-level dictations, and participant 32 did not finish the easy- and difficult-level dictations.

3. Writing the chords first

In this level 3 of the procedural strategy subcategory, participants choose to start writing their dictation with the chords, i.e., the Roman numeral chord symbols. 19.69% of the participants in the pre-test started the dictation by figuring out the chords for at least one of the three dictations.

"I find the function of each chord, and its color"(15).

« Je trouve la fonction de chaque accord, et sa couleur » (15).

3. Writing the chords second

In this level 3 of the procedural strategy subcategory, participants choose to start writing their dictation with a voice, such as the bass or the soprano, before writing the chords. In the following example, participant 11 wrote the bass first, then the chords.

"When I listen to the progression, I concentrate more on the bass at the first listening (...) Afterwards, I notice the chords and their chord degrees" (11).

« Lorsque j'écoute l'enchaînement, je me concentre davantage sur la basse à la première écoute (…) Par la suite, je prends connaissance des accords ainsi que le degré de l'accord » (11).

3. Writing the chords third

In this level 3 of the procedural strategy subcategory, participants choose to start writing their dictation with the bass, then the soprano, or vice-versa, before writing the chords.

" I listened especially to the note above (the melody). I identify the bass note of the chord, then the chord degrees " (62).

« J'ai écouté particulièrement la note du dessus (la mélodie). J'identifie la note de basse de l'accord, puis les degrés des accords » (62).

2. Writing inner voices

In this level 2 of the procedural strategy subcategory, participants *write the inner voices or notes* in addition to the bass and soprano. Only four participants reported using this strategy. They used it for at least one of the three dictations.

"So, the inner voices allow me to do: Bass: sol la ti do re re sol, I V43 I6 ii6 I64 V7 I" (6).

« Alors les notes intermédiaires permettent de faire : Basse : sol la si do ré ré sol, I V43 I6 ii6 I64 V7 I » (6).

2. Dissociating voices

In this strategy, participants try to hear separately, mentally, and horizontally, the four SATB (i.e., soprano, alto, tenor, bass) voices of the chords that are actually played together. Only 4 participants reported this strategy in the pre-test: 3 participants reported it for the moderate-level dictation and 1 participant for the difficult-level dictation.

"I Try to dissociate the notes" (50).

2. Writing voices on the staff

This level 2 of the procedural strategy subcategory was observed in three dictation descriptions. The participants wrote directly on the staff they drew for themselves, without specifying the strategies they used. However, in the test instructions the researcher asked them clearly to write the strategies and note names instead of writing the notes on the staff. Only four participants wrote directly on the staff (participants 23, 29, 37, and 42), and they did so for all three dictations, without mentioning it as a strategy. They also described using very few other strategies, characterizing a poor description, as observed in a previous pilot study (Cruz de Menezes et al., 2008).

2. Writing the bass and the chords at the same time

In this level 2 of the procedural strategy subcategory, participants write the dictations in a combined way, *writing the bass and the chords at the same time*. Only two participants reported this strategy: PT 14 when writing the third dictation (difficult level) and PT 49 when writing the second dictation (intermediate level).

"For this one I went with a mixture of function and bass" (49).

2. Writing rhythm first

Instructions were given by the researcher concerning not *writing the rhythm* of the dictations; however, one participant wrote the rhythm as part of his/her strategies. When it happened, it was the first strategy used, before writing the voices and the harmonic functions. Only one participant wrote the rhythm first to solve the easy-level dictation on the pre-test.

"Rhythm, listen to the bass, listen to the chord qualities" (17).

« Rythme, écouter la basse, écouter la qualité des accords » (17).

1. Focusing on the structure

In this level 1 subcategory of the procedural strategies, the participants *focus on the structure* of the dictations as a plan to write the dictation, instead of focusing on specific separate elements of the dictation (e.g., voices, chords, and rhythm).

2. Listen to the whole dictation a first time

In this level 2 of the procedural strategy subcategory, participants *listen to the complete dictation the first time* they hear it before writing anything. A total of 9 participants used this strategy on the pre-test for at least one of the three dictations.

"Listen the first time" (12).

« Écouter une première fois » (12).

2.Count the number of chords

In this level 2 of the procedural strategy subcategory, participants *count the number of chords* included in the dictation. A total of 6 participants used this strategy for at least one of the three dictations.

"Then I count the number of chords" (5).

« Ensuite je compte le nombre d'accords » (5).

2. Writing from the end

In this level 2 of the procedural strategy subcategory, participants *write from the end* instead of writing in a chronological way from the beginning to the end. In these cases, the participants start from the beginning, then at a certain point change the strategy to writing from the end. Only 3 participants used this strategy on the pre-test. Each participant used it for only one of the three dictations: PT 28 wrote from the end the last two chords in the easy dictation (score on dictation, 1/10); PT 42, the last three chords in the intermediate dictation (score on dictation, 6.14/10); and PT 49, the last three chords also in the intermediate dictation (score on dictation: 4.85/10).

"I start from the end" (42).

« Je pars de la fin » (42).

2.Naming the steps to perform figured bass dictation

In this strategy, participants *name the steps they are supposed to do to solve a harmonic dictation*. Only 2 participants used this strategy in at least one of the three dictations on the pre-test.

"For all dictations: We must look for the bass note (hear it) and whether there is an inversion, helping oneself by means of the harmony" (38).

« Pour toutes les dictées : Il faut chercher la note de basse (l'entendre) et s'il y a un renversement, en s'aidant de l'harmonie » (38).

Non-tonal strategies

Categorized in the main category, *non-tonal* strategies are those that participants use to find the notes or chords in a perceptual way, i.e., without relying on the tonal context of the dictation or the notes' functions. Table 3.4 summarizes this categorization and is presented to guide the reading and explanations that follow. All examples presented in the following explanations have the participant's code between parentheses, and the language parameters remain the same. The strategies explained below start with the number of the corresponding level of strategy: *1. Focusing on a specific element* means that this strategy belongs to level 1 of the strategies; *2. Identifying intervals*, means that this strategy belongs to level 2 of the strategies, and so on.

Main category	**Level 1 (global action)**	**Level 2 (specific action)**	**Level 3 (complementary)**
Non-tonal	Focusing on a specific element	Identifying intervals	Without specifying how
			By song
			By gap-filling
		Using a sound reference	
		Identifying a note/context using a memorized piece	
	Focusing on the structure	Focusing on ascending/descending motion	General
			Separated
			By drawing
		Focusing on conjunct/disjunct motion	

Table 3.4. Table of non-tonal strategies with all levels of categories

In level 1, which presents a global action, there are two subcategories: (a) *Focusing on a specific element,* in which participants say they focus on one or more items, such as the bass line, an interval, or a given note, and (b) *Focusing on the structure,* in which participants say they focus on a phrase's characteristics, such as ascending or descending motion. Level 2 presents the description of a specific action of each subcategory, for example, *identifying intervals*. Finally, level 3 completes level 2 for those categories needing more specific details: identifying an interval *by song*, i.e., comparing with a known song. In fact, only the category *identifying intervals* needs level 3 to complete the action: by song, by gap-filling, or without specifying how they found the interval. Compared with Bégin's (2008) categorization of strategies, non-tonal strategies, like tonal strategies, would be *treatment strategies*, which include, for example, selecting, identifying, and comparing.

1. Focusing on a specific element

In this subcategory (level 1) of the non-tonal main category, focusing on a specific element, we found 4 specific actions (level 2): memorizing/singing notes of bass internally; identifying intervals; using a sound reference (sometimes "la"); and identifying a note or context by using a memorized piece.

As mentioned above, only the strategy *Identifying intervals* needed a level 3 to add specifications about this action. In this case we found identifying by an interval by song, gap-filling, or without specifying how. Examples from the descriptions will now be presented for all the strategies.

2. Memorizing/singing bass internally (mental rehearsal)

In this level 2 of the non-tonal strategy subcategory, participants memorize and sing mentally the notes from the bass previously heard, to figure them out. Only two participants used this strategy in the pre-test.

"I Try to memorize the bass" (64).

« J'essaie de mémoriser la basse » (64).

2. Identifying intervals

In this level 2 of the non-tonal strategy subcategory, the participant tries to *identify the intervals* heard. Three subsidiary subcategories were observed (level 3). Sometimes participants simply name the interval (for example: it is a rising octave) without telling how they got the answer (*without specifying* how, level 3). Sometimes participants fill the gap between the two notes of the interval by means of scale steps (i.e., *by gap-filling*, level 3). Other times they compare the interval heard with a memorized interval from songs (*by a song*, level 3).

3. Without specifying how

Twenty-one (21) participants used this strategy for at least one of the three harmonic dictations on the pre-test.

"Major third" (10).

« Tierce majeur » (10).

3. By gap-filling

Only two participants reported this strategy on the pre-test for one of the three dictations.

"I sing the notes between each to arrive at the other note" (23).

« Je chante les notes entre chaque pour arriver à l'autre note » (23).

3. By a song

Only three participants used this strategy for at least one of the three harmonic dictations.

"Connecting intervals to common songs" (52).

2. Using a sound reference (sometimes "A")
In this level 2 of the non-tonal strategy subcategory, participants memorize one note from the dictation to figure out the other notes, either comparing it with other notes or identifying when it is repeated. Nine participants reported using this strategy in the pre-test.

"I remember "mi" from the first dictation" (35).

« Je me rappelle du « mi » de la 1re dictée » (35).

"Obviously repeated" (6).

« Évidement répété » (6).

Two participants in the pre-test reported comparing a note or a chord of the dictation with the memorized note "la". It seems to be a note memorized in another situation different from the musical test. This strategy has been merged into *Using a sound reference* because of its low occurrence and because of the similarity with this category.

2. Identifying notes or context using a memorized piece
An element of the dictation makes participants think of a known song. Sometimes, participants specified that it was a melody, from the soprano or from the bass; other times, participants did not specify what element of the music made them remember the familiar song and just reported in a general way. Both situations will be presented as examples. Two participants reported using this strategy in the pre-test.

"Upper note starts on 5th goes to 4th and 3rd like in 'Twinkle, Twinkle Little Star'" (53).

"It sounds like Pachelbel's Canon" (25).

« Ça ressemble au canon de Pachelbel » (25).

1. Focusing on the structure
In this subcategory (level 1) of the non-tonal main category, participants focus on the harmonic dictation's phrase structure. We found 2 subcategories of specific actions (level 2): *joint/disjoint motion,* and *ascending/descending motion*. Only the strategy *ascending/descending motion* needed a level 3 to add complementary specifications. In this case we found *general* motion direction and *separated* motion direction. Examples from participants' descriptions will be presented for the strategies as usual.

2. Focusing on conjunct/disjunct motion

In this strategy, participants identify if the sound sequence they hear contains conjunct or disjunct motion in a voice.

Sixteen (16) participants reported using this strategy during the pre-test; one identified disjunct motion; all the others, conjunct motion.

"Reasoning in relation to the conjunct motion of the bass" (21).

« Raisonnement par rapport au mouvement conjoint de la basse » (21).

2. Focusing on ascending/descending motion

In this strategy, participants identify whether a sound sequence or an interval is ascending or descending. Three types of description were identified in this category. For the first type, 29 participants reported using this strategy describing an ascending sequence in a global manner. Two other ways were observed. For the second type, 6 participants identified the direction note by note, in a separated way. Finally, for the third type of description, the participants drew a sketch of the melodic contour, showing the ascending/descending motion on a continuum line. Only two participants used this strategy in the pre-test.

"The bass is ascending" (14).

« La basse est ascendante » (14).

One participant in the pre-test reported identifying the register of part of the dictation as low-pitched. This strategy has been merged into *Focusing on the ascending/descending motion* because of its low occurrence and similarity with this strategy.

"Fairly low-pitched" (42).

«Assez grave » (42).

Implemental strategies

Cognitive psychologist Bégin (2008) proposed a taxonomy of strategies, which we have used to categorize any new strategies seen in this study, i.e., that have not been previously reported to be observed and analyzed in the music domain. Among other strategies, Bégin classifies "evaluate" and "verify" as implemental strategies. Based on Bégin's (2008) study, in this main category we grouped all the implementation strategies by which participants: evaluate whether or not their answers are accurate; compare several possible answers; evaluate the time to solve dictation and/or the difficult level of the dictation; and verify their final answer at the end of the task. As above, all the examples presented in the following explanations give the participant's code between parentheses, and the language parameters remain unchanged. The strategies explained below start with the number of the corresponding level of strategy: *1. Evaluating* means that this strategy belongs to level 1 of the strategies; *2. Evaluating difficulty level of the test*, means that this strategy belongs to level 2 of the strategies.

Mean Category	**Level 1 (global action)**	**Level 2 (specific action)**
Implemental	Evaluating	Evaluating difficulty level of the test
		Comparing several possible answers (tonal and non-tonal)
		Making a negative judgment on answers
		Evaluating time to solve dictation
	Verifying	Verifying the answers
	Kinesthetic strategies	Playing an instrument mentally

Table 3.5. Table of implemental strategies with all levels of categories

1. Evaluating

In this strategy, participants evaluate their answers, the time to solve the dictation, compare possible answers, evaluate the difficulty level of the test, and make judgments (usually negative) about their answers.

2. Comparing several possible answers (tonal and non-tonal)

In this strategy, participants try possible answers or attempt to remember the possibilities studied probably in ET or theory classes. Normally, they are expressed in the form of questions, for example, "*Sol*?" A total of 11 participants reported using this strategy for at least one of the three dictations on the pre-test.

"I try to remember the possibilities viewed in ear training for this kind of figured bass" (5).

« J'essaie de me souvenir des possibilités vues en formation auditive pour ce genre de basse chiffrée » (5).

2. Evaluating the time to solve the dictation

In this strategy participants, evaluate the time it takes to do a dictation: whether the time to write between the repetitions was too short or too long; whether they had enough time to solve the dictation. Only two participants used this strategy in the pre-test.

"Too late to hear dissonances" (25).

« Trop tard pour entendre les dissonances » (25).

2. Evaluating difficulty level of the test

In this strategy, participants make a judgement about the difficulty level of the dictation: whether it is too easy or too difficult. Twenty-five (25) participants reported this strategy in at least one of the three dictations of the pre-test.

"N.B. difficult test at the beginning of the session after 3 months without taking ET" (13).

« N.B. test difficile au début de la session après 3 mois sans faire de FA » (13).

2. Making negative judgments on answers

In this strategy, participants evaluate if they wrote right or wrong answers in order to try to correct them. A total of 6 participants reported this strategy for at least one of the three dictations on the pre-test.

"I'm not really sure of my answers" (5).

« Je ne suis pas vraiment sûr de mes réponses » (5).

1. Verifying

In this strategy, participants verify their answers to confirm that they wrote correct ones. A total of 6 participants reported using this strategy for at least one of the three dictations on the pre-test.

"Then, listen to individual chords to confirm everything" (16).

« Puis, écoute des accords individuels pour confirmer le tout » (16).

1. Kinesthetic strategies

In this strategy, participants mentally visualize themselves (or someone else) playing a musical instrument to find the notes and/or chords of the dictation. A total of 6 participants reported this strategy for at least one of the three dictations of the pre-test.

"Visualizing it being played on a piano" (52).

Summary of results to answer questions 1 and 2

In answer to our 1st and 2nd questions (What are the *cognitive strategies* used by new university students during transcription of tonal figured bass dictations? and Considering the potentially wide range of similarities and differences of strategies, is it possible to create *categories* and groups of cognitive strategies?), this long second section of this chapter has reported all the strategies used and described in writing by participants during transcription of figured bass dictations on the musical tests. A wide variety of strategies were reported (*N* = 43), analyzed and categorized. During data analysis, these strategies were grouped according to their similarities and differences. We found four main categories of strategies: tonal, procedural, non-tonal, and implemental strategies, each with three possible subcategories designated levels 1, 2, and 3. Level 3 did not apply to all level 2 subcategories because the actions were not always broken down into fine detail in the participants' reports. The categorization groups and levels have been explained and demonstrated with specific examples selected from the participants' descriptions.

Section Three: Quantitative analyses

Descriptive statistics: Utilization of strategies

For this descriptive statistical part of section 3, data from the same 66 participants reported in section 2 are employed to calculate the frequency of use of strategies. This section answers the following research question:

3. If strategies are listed in response to the first objective (finding strategies), which ones are the most used and which ones are the most effective in solving the transcription of tonal harmonic dictations?

To answer this question, we will present, first, the *utilization frequencies,* i.e., how many participants used each strategy (figure 3.2); and, second, *data regarding efficacy of the strategies*, i.e. which ones led to success and which to failure. For this last analysis, we also compare efficacy of the strategies in time (pre- and post-test).

Frequency of utilization of strategies: Tonal Strategies

The first few figures will present frequency counts for Tonal Strategies, after which we will proceed to the other main groups of strategies in the same order as in section 2. This frequency shows whether participants used each strategy for at least one of the three dictations. To contextualize the raw frequency counts, a reminder is given that the total number of participants was 66, the same PTs as for the qualitative analyses.

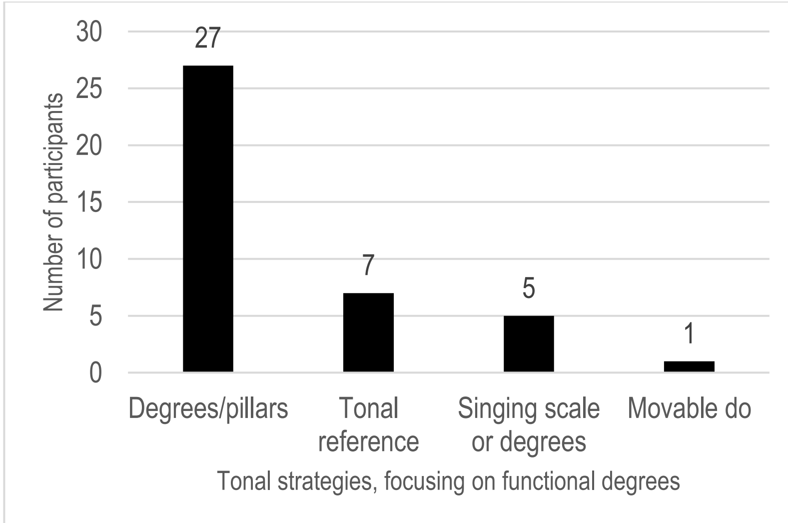


Figure 3.5. Frequency of Tonal Strategies, focusing on functional degrees

In Figure 3.5 above, we can see that identifying degrees or pillars (1 and 5) was the most-used tonal strategy based on functional degrees, followed by: a tonal reference; singing scale or degrees; and, last, using moveable do.

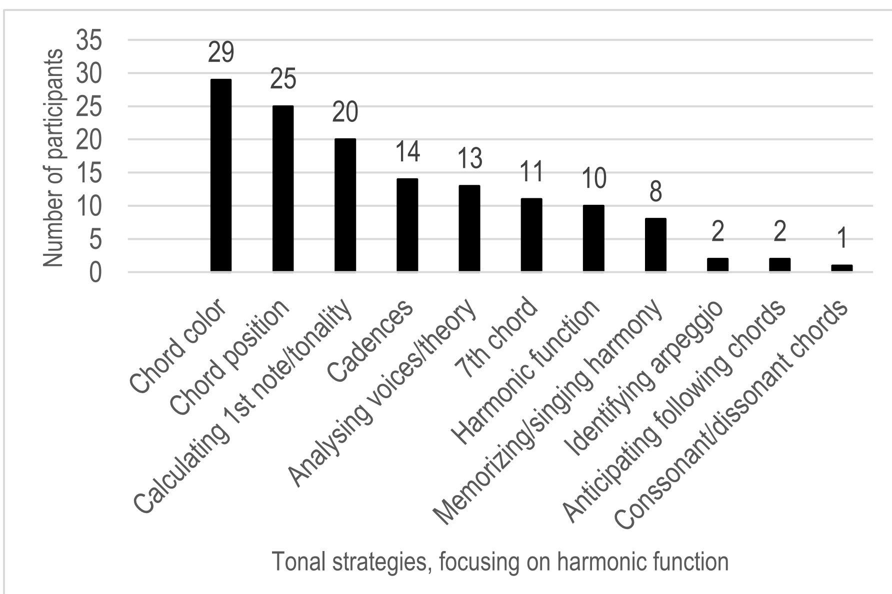


Figure 3.6. Frequency of Tonal Strategies, focusing on harmonic function

In the figure above, we can see that identifying chord quality (M/m) was the most-used tonal strategy in focusing on harmonic function strategy, followed by: identifying chord position; identifying cadences; analyzing the voices;

identifying 7th chords; identifying harmonic function; memorizing/singing harmony; identifying arpeggios; anticipating the next chord to come; and, last, identifying consonant/dissonant chords.

Frequency of utilization of strategies: Procedural Strategies

The next two figures present frequency counts for Procedural Strategies. This frequency shows whether participants used each strategy for at least one of the three dictations.

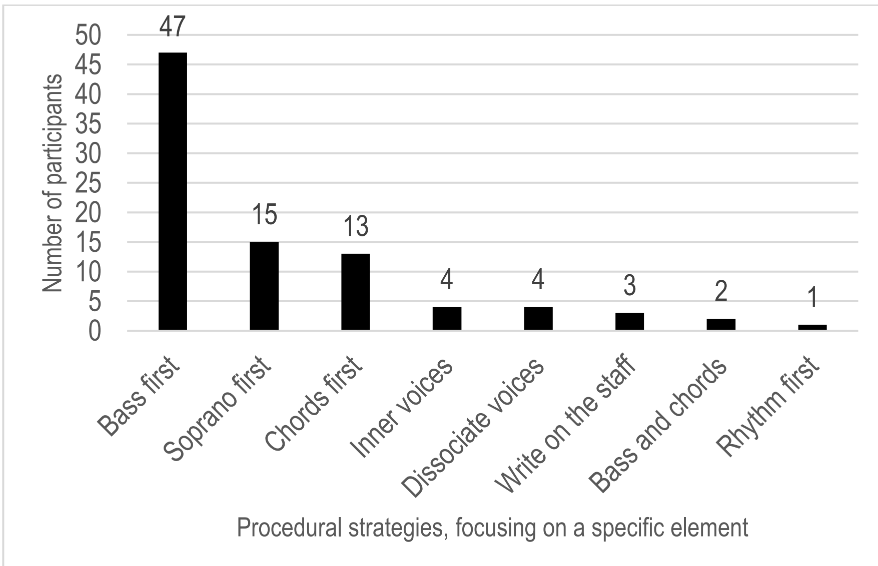


Figure 3.7. Frequency of Procedural Strategies, focusing on a specific element

In the figure above, we can see that writing the bass first was the most-used procedural strategy, followed by: writing the soprano first; writing the chords first; writing the inner voices and/or notes on the staff; writing the bass and the chords at the same time; and, last, writing the rhythm first.

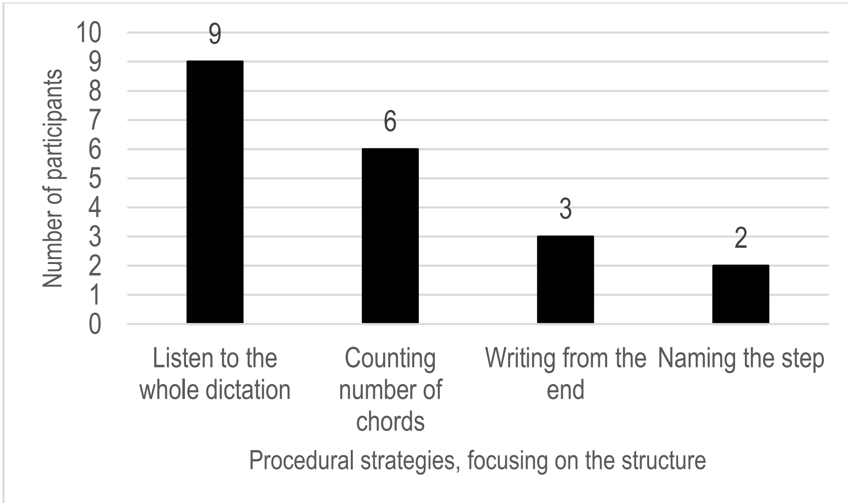


Figure 3.8. Frequency of Procedural Strategies, focusing on the structure

In the figure above, we can see that listening to the whole dictation the first time was the most-used procedural strategy focusing on structure, followed by: counting the number of chords; writing from the end; and, last, naming the steps to solve a dictation.

Frequency of utilization of strategies: Non-tonal Strategies

The next two figures present frequency counts for Non-tonal Strategies. This frequency shows whether participants used each strategy for at least one of the three dictations.

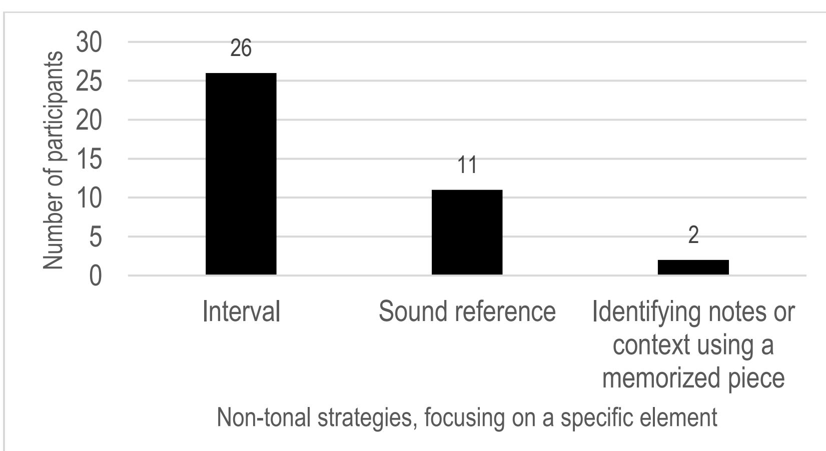


Figure 3.9. Frequency of Non-tonal Strategies, focusing on a specific element

On the figure above, we can see that identifying intervals was the most used non-tonal strategy focusing on a specific element, followed by using a sound reference, and identifying notes or context by using a memorized piece.

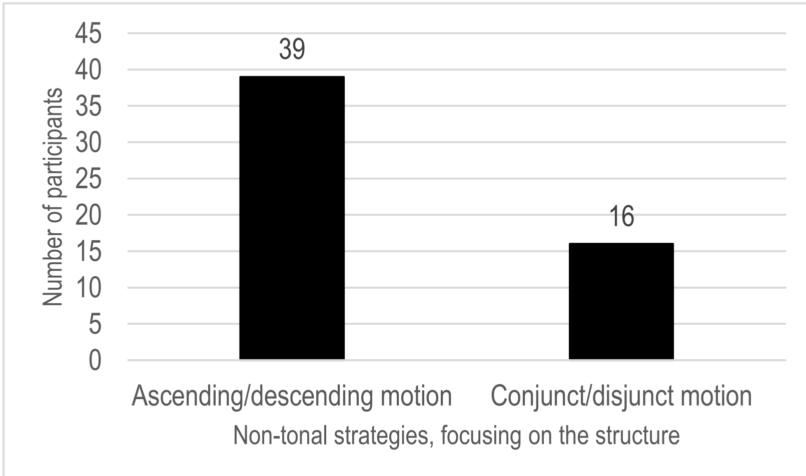


Figure 3.10. Frequency of Non-tonal Strategies, focusing on the structure

In the Figure above, we see that focusing on ascending/descending motion was the most used non-tonal strategy focusing on the structure, followed by focusing on the conjunct/disjunct motion.

Frequency of utilization of strategies: Implemental Strategies

The next two figures present frequency counts for Implemental Strategies. This frequency shows whether participants used each strategy for at least one of the three dictations.

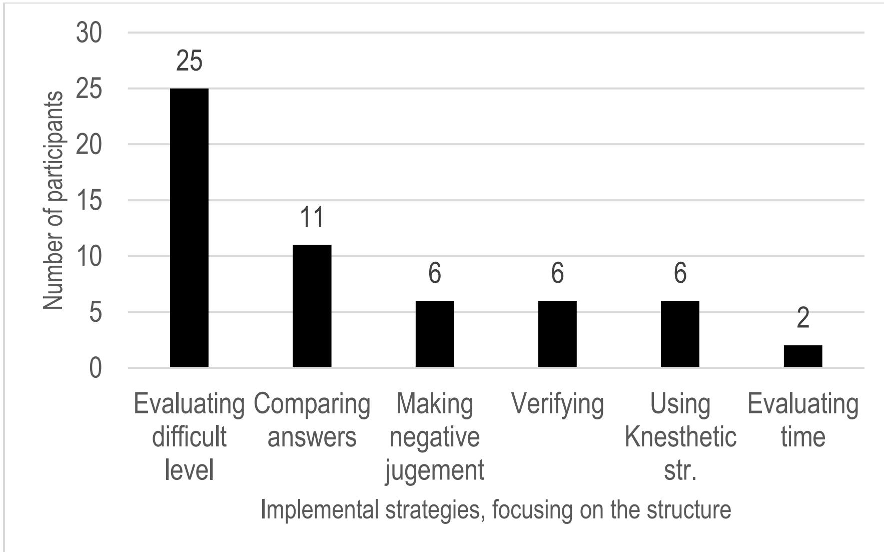


Figure 3.11. Frequency of the Implemental Strategies, focusing on the structure

In Figure 3.11 above, we see (in decreasing order) that evaluating difficulty level was the most-used implemental strategy, followed by: comparing possible answers; making negative judgments on answers; verifying; using a kinesthetic strategy; and evaluating the time it took to solve a dictation.

Analytical statistics

As quantitative analyses were run on pre- and post-test comparisons, it was essential, among other things, that the participants have both pre- and post-test data. Data from participants who were not present for both pre-testing and post-testing had to be excluded. As mentioned above at the beginning of this chapter, this means that qualitative analysis and descriptive statistics of the strategies (frequency of use) were done on all 66 participants' data, but quantitative analyses were done only on the largest number of possible participants. For the next section, *Efficacy of strategies*, only 56 participants' data were used (43 from Laval and 13 from Concordia). This sample represents all the PTs who did both the pre- and post- musical tests. The Shapiro-Wilk Normality test was applied, as well as a visual inspection of their histograms, normal Q-Q, and box plots to verify the distribution for all statistical analyses.

Efficacy of strategies

The efficacy of strategies was calculated to compare whether the impact of each type of strategy in the dictation results by chords was positive or negative. To calculate the efficacy of each type of strategy, a Repeated Measure ANOVA was done, using a Mixed Model Analysis, to explain dictation results per chords. Each chord result varies between 0 (total failure) and 1 (total success). For more details on dictation correction, see methodology. The fixed factors were the type of strategy (*Tonal, Non-Tonal, and Implemental*), counted one time, the time (pre- and post-test), and the interaction type of strategy * time; random factors were the interaction of participants with dictation difficulty levels, chords, time, and the interaction between dictation difficulty levels and time (dictation * time), chords and time (chords * time), and chords and dictation (chords * dictation). Random factors take into account the number of repeated measures for each participant and the possible correlations among observations of the same participants. Since each strategy was counted only once for this analysis, the counted strategies represent the first time the participants used each type of strategy during dictations.

Procedural strategies were excluded and analyzed separately, and will be presented after this analysis. This was because the use of a single procedural strategy was often the same for the entire dictation during a listening period, which means that the change of procedural strategy is less dynamic than for all the other strategies. The other types of strategies were more flexible and could change chord by chord. Since we count only once the use of each type of strategy in the next analysis to predict the results per chord, the same procedural strategies would appear in each chord and their real impact on performance would not be measured. The main interest in the analysis of procedural strategies is to see which subcategory was most efficient among those most used: bass first, soprano first, or chord first. For that reason, we did separate analyses of the efficacy of *procedural strategies*. The results will be presented later in this chapter.

The actual analysis considers 3 main categories (*Tonal, Non-Tonal, and Implemental*), counted one time, whether used or not, for each category to solve each chord. The fixed effects results indicate that *Tonal* (F = 21.608, df = 1, 857.658, ***p* = .000**), and *Implemental* (F = 6.169, df = 1, 452.707, ***p* = .013**) strategies impacted the results, while *Non-Tonal* did not (F = .073, df = 1, 832.402, p = *.787*). To understand the direction of this impact on dictation results, either positive or negative, we will present in the next sections the significant factors found and explain the efficacy of each type of strategy. Also, the *timeline* (pre-test as compared to post-test) had an impact on the results (F = 5.800, df = 1, 89.460, ***p* = .018)**, but there was no interaction between time and strategy type, i.e., strategies were equally efficient or inefficient at both time conditions, pre- and post-test.

Type III Tests of Fixed Effects[a]

Source	Numerator df	Denominator df	F	Sig.
Intercept	1	82.394	655.877	.000
Time (pre-post-tests)	1	89.460	5.800	**.018**
Non-Tonal	1	832.402	.073	.787
Tonal	1	857.658	21.608	**.000**
Implemental	1	452.707	6.169	**.013**
Time * Non-tonal	1	685.411	.445	.505
Time * Tonal	1	1116.179	.555	.457
Time * Implemental	1	335.394	.051	.821

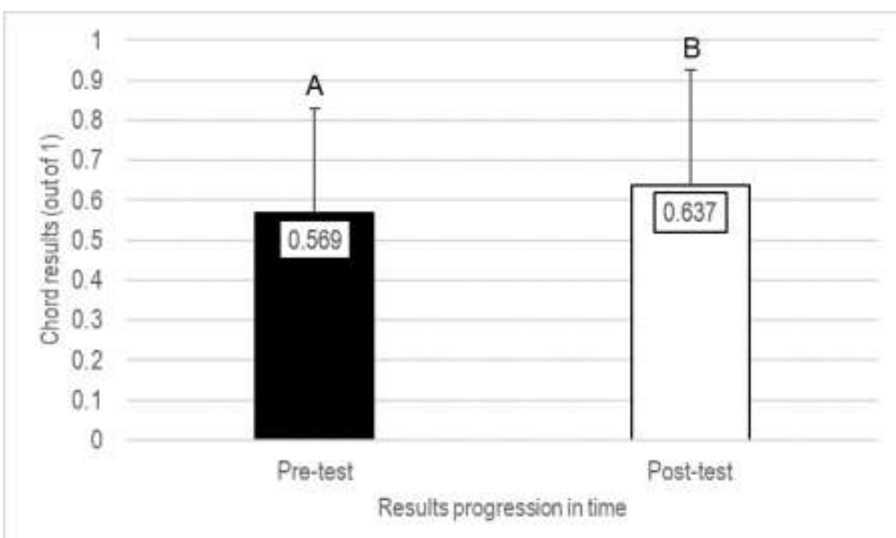
a. Dependent Variable: Result by chords.

Table 3.6. Results of Repeated measure ANOVA on determining type of strategy and time impact on dictation results per chords

The findings of this analysis will be presented in detail by each type of strategy to better understand the direction of the impact on the results per chord of the use of each type of strategy.

Progression in time

Dictation accuracy results per chord were better on post-test (*M* = .637, *SE* = 0.29) compared to pre-test (*M* = .569, *SE* = 0.26). This difference was significant (***p* = .018**) and is indicated in the next figure by letters the A and B.



Univariate Tests[a]

Numerator df	Denominator df	F	Sig.
1	89.460	5.800	**.018**

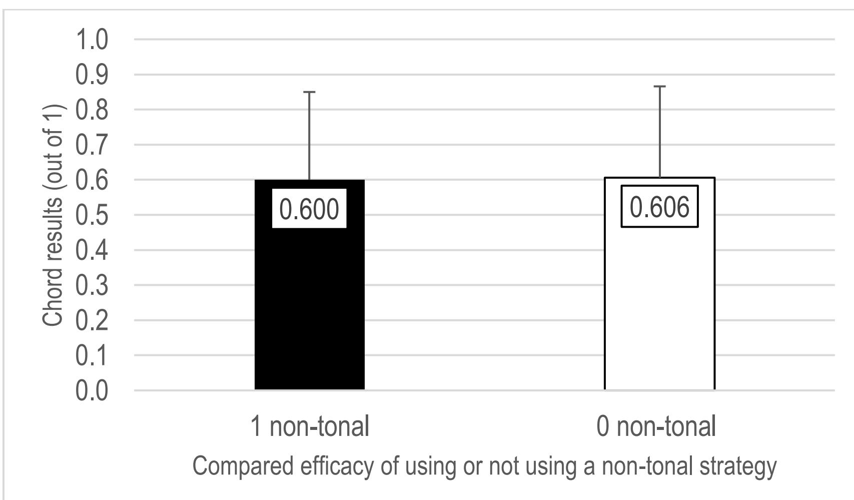
The F tests for the effect of Time (i.e., pre- vs post-test). This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

a. Dependent Variable: Result by chords.

Figure 3.12. Results of Repeated measure ANOVA on determining type of strategy and time impact on dictation results per chords

Efficacy of non-tonal strategies

The use of *Non-tonal* strategies was indifferent, i.e., the use (*M* = .600, *SE* = .026) or non-use (*M* = .606, *SE* = 0.25) of *Non-tonal strategies* did not change the *dictation results by chords* (*p* = .787). This was true for both time conditions, pre- and post-test. This means that the use of one non-tonal strategy did not contribute to a better or worse performance.



Univariate Tests[a]

Numerator df	Denominator df	F	Sig.
1	832.402	.073	**.787**

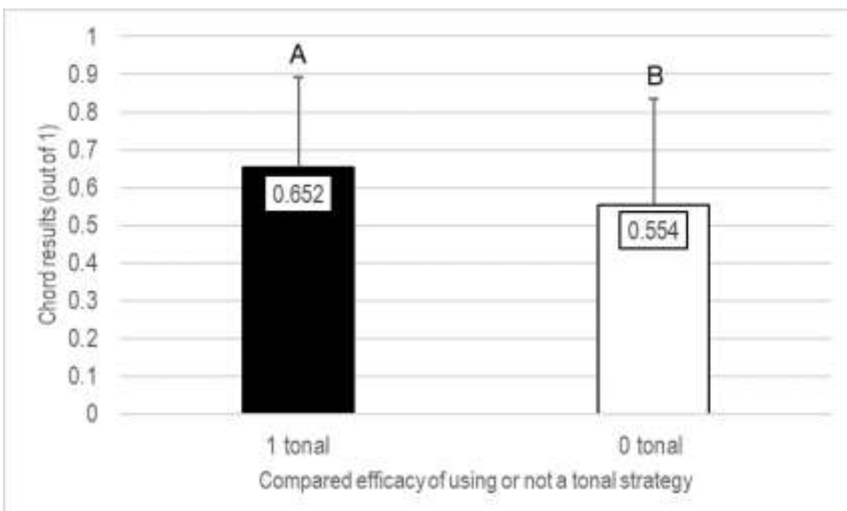
F tests for the effect of Tonal strategies category. This test is based on linearly independent pairwise comparisons among the estimated marginal means.

a. Dependent Variable: Result by chords.

Figure 3.13. Results of Repeated measure ANOVA on determining efficacy of non-tonal strategies

Efficacy of tonal strategies

The use of *Tonal strategies* had a highly significant positive impact on the results. The use of one *Tonal strategy* improved *dictation results by chords* (M = .652, SE = 0.24), compared to *not using* (M = .554, SE = 0.28). This difference was significant (***p* < .000**). This was true for both time conditions, pre- and post-test, which means that in both conditions, using a tonal strategy contributed to better results.



Univariate Tests[a]

Numerator df	Denominator df	F	Sig.
1	857.658	21.608	**.000**

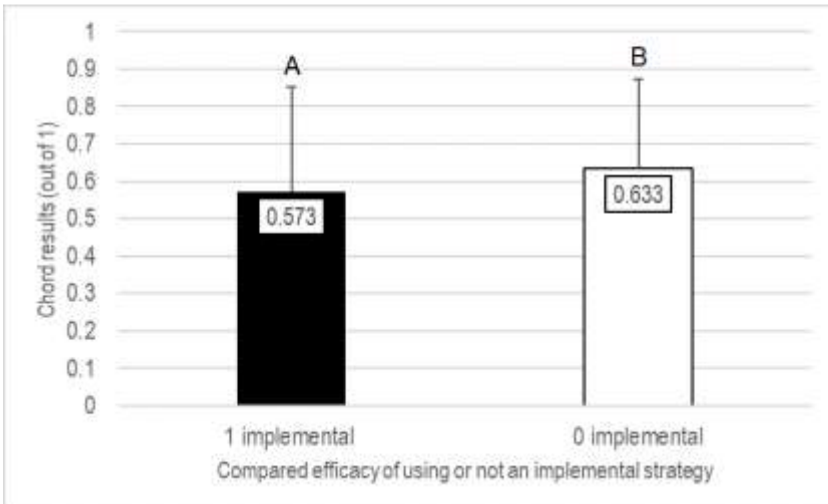
F test for the effect of tonal strategies. This test is based on linearly independent pairwise comparisons among the estimated marginal means.

a. Dependent Variable: Result by chords.

Figure 3.14. Results of Repeated measures ANOVA on determining efficacy of tonal strategies

Efficacy of implemental strategies

The use of *Implemental strategies* had a negative impact on the results. The use of one *implemental strategy* lowered the *dictation results by chords* (*M* =.573, *SE* = 0.28) compared to *not using* (*M* =.633, *SE* = 0.24) an implemental strategy (***p* = .013**). This held true for both time conditions, pre- and post-test, and means that in both conditions, using one implemental strategy contributed to worse results.



Univariate Tests[a]

Numerator df	Denominator df	F	Sig.
1	452.707	6.169	**.013**

F test for the effect of Implemental strategies. This test is based on linearly independent pairwise comparisons among the estimated marginal means.

a. Dependent Variable: Result by chords.

Figure 3.15. Results of Repeated measure ANOVA on determining efficacy of implemental strategies

Efficacy of combined strategies

The following Repeated Measures ANOVA, also using a Mixed Model analysis, reports the efficacy of different combinations of the three types of strategies previously reported (*Tonal, Non-tonal, and Implemental*) to solve dictation chords. These combinations used, only once, each type of strategy: for example, one tonal, one non-tonal, and one implemental, versus one tonal, zero non-tonal, and one implemental. The choice of counting only once each type of strategy was done to be able to compare the combinations. These combinations created 7 categories. Otherwise, the possibilities of combinations would be much larger, making comparisons difficult. Fixed factors were time (pre- and post-test), combination of strategies, and the interaction combination * time. Random factors were the interaction of participants with dictation difficulty levels, chords and time, and the interaction between dictation difficulty levels and time (dictation * time), chords and time (chords * time), and dictation and chords (dictation * chords). Random factors take into account the number of repeated measures for each participant and the possible correlations among observations of the same participants. The model indicates that there was a progression in the efficacy of strategies between pre- and post-tests (*F* = 6.134, df=1, 94.867, ***p* = .015**). However, this progression is the same regardless of the combination, since the interaction combination * time is not significant.

Type III Tests of Fixed Effects[a]

Source	Numerator df	Denominator df	F	Sig.
Intercept	1	83.837	642.848	**.000**
Time (pre-post-tests)	1	94.867	6.134	**.015**
Combination of strategies	7	852.286	6.907	**.000**
Time * Combination	7	800.262	.526	.815

a. Dependent Variable: Result per chord.

Table 3.7. Results of Repeated measures ANOVA on determining efficacy of combined strategies and time (pre- and post-test)

In the next table, the combinations always report first *Non-tonal*, second *Tonal* and third *Implemental* combinations. If one of them has been used, there is a “1”, if not used, a “0”. For example, 1-1-1 means a combination of all three strategies, 1-0-0, only non-tonal, 0-1-0, only tonal, 0-0-1, only implemental, and so on.

Table 3.8 below reports that using one *Implemental* strategy led to worse results (*M* = .424) compared to no strategy (*M* = .572). One *Tonal* strategy led to the best results (*M* = .692), while using a *Non-tonal* strategy did not greatly change the results (*M* = .596), compared to *not using* any strategy (*M* = .572). Using a combination of the three strategies also did not greatly change the results for better or worse (*M* = .583). This was probably because *Non-tonal* is neutral, *Tonal* improves and *Implemental* decreases results; so, the combined effect was to cancel each other out. The second-best combination was *Tonal* and *Non-tonal* (*M* = .673), followed by one *Tonal*, one *Implemental* (*M* = .662). This confirms the tendency observed in previous analyses. The use of one *Tonal* strategy in any combination increases *dictation results by chords*, compared to *not using* any strategies. Furthermore, using one *Tonal* strategy was better than using any other single strategy or combination of strategies.

Estimates[a]

Combination	Mean	Std. Error	Df	95% Confidence Interval	
				Lower Boundary	Upper Boundary
0-0-0	.572	.039	370.203	.495	.649
0-0-1	.424	.046	571.583	.334	.514
1-0-0	.596	.036	346.480	.526	.667
0-1-0	.692	.029	172.485	.634	.749
0-1-1	.650	.034	257.338	.583	.717
1-0-1	.662	.054	793.500	.556	.768
1-1-0	.673	.030	190.527	.614	.733
1-1-1	.583	.037	322.489	.512	.655

a. Dependent Variable: Result per chords.

Univariate Tests[a]

Numerator df	Denominator df	F	Sig.
7	848.906	6.907	.000

F test for the effect of combination of strategies. This test is based on linearly independent pairwise comparisons among the estimated marginal means.

a. Dependent Variable: Result per chords.

Table 3.8. Results of Repeated measures ANOVA on determining efficacy of each combination of strategies

Pairwise comparisons revealed that not using a strategy at all was significantly worse than using a *Tonal* strategy (***p*** **< .001**) or a combination of *Tonal* and *Non-tonal* (***p*** **< .013**). *Not using* a strategy at all was better than using an *Implemental* strategy (***p*** **< .006**). Using an *Implemental* strategy was worse than using any strategy alone or in combination (***p*** **< .05**) or even no strategy at all. As a reminder, the *Implemental* strategies are *evaluating difficulty level, evaluating time to solve dictation,* using a *kinesthetic* strategy, and *verifying* strategies. However, since there was a limited time to solve dictations, some of these strategies could be a waste of time. Instead of finding chords within the allotted time, participants were, for example, *evaluating difficulty level, evaluating time to solve dictation,* and *comparing possible answers.* This could explain why they are less efficient.

Using a *Tonal* strategy was significantly better than *not using* a strategy or using a *Non-tonal* or *Implemental* strategy (***p*** **< .05**); it was also better than using a combination of the three strategies (***p*** **< .05**); but not significantly better than using a combination of *Non-tonal* and *Implemental,* or any combination with one *Tonal* strategy (*p* > .05). Using one *Non-tonal* strategy was better than using one *Implemental* (***p*** **< .001**), worse than one *Tonal* (***p*** **< .007**) and worse than a combination of *Tonal* and *Non-tonal* (***p*** **< .026**).

Pairwise Comparisons[a]

(I) Combination	(J) Combination	Mean Difference (I-J)	Std. Error	Df	Sig.[c]	95% Confidence Interval for Difference[c]	
						Lower Boundary	Upper Boundary
0-0-1	0-0-0	-.148*	.054	734.935	**.006**	-.253	-.042
	0-1-0	-.268*	.047	798.618	**.000**	-.360	-.176
	0-1-1	-.226*	.044	991.243	**.000**	-.312	-.140
	1-0-0	-.172*	.051	805.635	**.001**	-.273	-.072
	1-0-1	-.238*	.062	1019.301	**.000**	-.360	-.116
	1-1-0	-.250*	.048	789.441	**.000**	-.344	-.155
	1-1-1	-.160*	.049	850.619	**.001**	-.256	-.063
0-1-0	0-0-0	.120*	.038	768.932	**.001**	.046	.194
	0-1-1	.042	.035	644.818	.229	-.026	.109
	1-0-0	.096*	.036	1032.584	**.007**	.026	.165
	1-0-1	.030	.055	896.925	.585	-.078	.138
	1-1-0	.018	.029	998.666	.532	-.039	.076
	1-1-1	.108*	.038	802.985	**.005**	.033	.183
0-1-1	0-0-0	.079	.045	619.725	.078	-.009	.166
	1-0-0	.054	.041	613.264	.184	-.026	.134
	1-0-1	-.012	.056	873.624	.837	-.122	.099
	1-1-0	-.023	.036	582.855	.524	-.094	.048
	1-1-1	.067	.039	1018.241	.085	-.009	.143
1-0-0	0-0-0	.025	.044	822.760	.577	-.062	.111
	1-0-1	-.066	.058	985.857	.255	-.179	.047
	1-1-0	-.077*	.035	914.811	**.026**	-.145	-.009
	1-1-1	.013	.042	791.286	.763	-.070	.096
1-0-1	0-0-0	.090	.060	808.820	.135	-.028	.209
	1-1-0	-.012	.055	900.826	.835	-.120	.097
	1-1-1	.078	.054	1327.118	.150	-.028	.185
1-1-0	0-0-0	.102*	.041	709.508	**.013**	.021	.182
	1-1-1	.090*	.038	756.915	**.018**	.015	.164
1-1-1	0-0-0	.012	.046	686.703	.798	-.079	.102

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Dependent Variable: Results per chords.

b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

c. Confidence level

Tables 3.9. Pairwise comparisons of combinations of strategies

Overall, *Tonal strategies* were the most efficient strategy among *Tonal*, *Non-tonal*, and *Implemental*. *Non-tonal* made no difference to performance. *Implemental* were the least efficient, even compared to no strategy at all. The same tendency was observed in the combinations of strategies.

Efficacy of procedural strategies

As explained previously, the change of procedural strategy during the transcription of dictations was less dynamic than other types of strategies. That is why we decided to analyze separately the three most used subcategories: starting with the bass, starting with the soprano, and starting with the chords. Moreover, the dependent variable for analyses of procedural strategies was the average score on dictation, instead of results per chords, which we used in analyzing the other types of strategies. This choice was made because these subcategories of procedural strategies were used to write all or almost all the dictations during a listening period, instead of changing the strategy chord by chord, as may happen with the other types of strategies.

The following analyses were done to verify whether success in dictation could be related to the use of procedural subcategories, that is, whether starting by writing first the bass or the soprano or the chords had an impact on dictation results. The results will be presented by dictation level (easy-level, moderate-level, and difficult-level) first for pre-test and then for post-test. For all dictations, within each level, the participants are grouped according to the writing category they chose to start the dictation (bass, soprano, chords). The number of participants changes from one analysis to another because not every participant reported the use of starting by the bass, by the soprano, or by the chords at every dictation level. Some participants reported another procedural strategy or none at all.

Pre-test

Easy-level dictation (pre-test)

The participants (N = 50) were grouped by the types of procedural categories they used to begin the dictation. The group *Bass* represents participants who wrote bass first (N = 31); the group *Soprano*, participants who wrote soprano first (N = 8); and the group *Chords* (N = 11), participants who wrote chords first. These were the most-used procedural strategies focusing on an element. The mean (out of 10) on easy-level dictation for writing bass first was 7.758 (SE = .443), soprano first was 7.458 (SE = .872), and chords first 8.909 (SE = .744). No specific order explained success in performance ($F(2, 50) = 1.083$, p = .347). Starting with bass, soprano or chords did not affect performance on the easy-level dictation.

Between-Subjects Factors

		N
Order	Bass	31
	Soprano	8
	Chord	11

Between-Subjects Effects

Dependent Variable: Results easy-level dictation

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	13.185[a]	2	6.593	1.083	.347
Intercept	2345.351	1	2345.351	385.428	.000
Order	13.185	2	6.593	1.083	.347
Error	285.997	47	6.085		
Total	3469.917	50			
Corrected Total	299.183	49			

Tables 3.10. Results of One-way ANOVA on determining the most efficient procedural strategy to start easy-level dictation at pre-test

In any case, even if there were no difference between the three strategies to start writing easy-level dictation, it would appear that starting by *Chords* led to better results and by *Soprano* to worse.

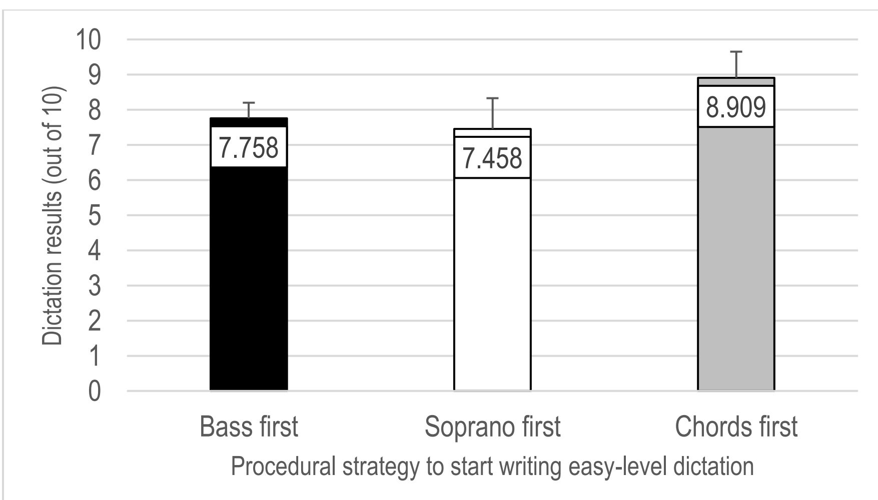


Figure 3.16. Means of easy-level dictation by procedural strategies at pre-test

Still looking at easy-level dictations (*N* = 66), after not finding any significant differences in the last analysis with three categories (bass fist, soprano first, and chords), the next analysis added two new categories: some participants did not describe using any procedural strategy and were identified as *No strategy* (*N* = 15), others described *Another strategy* (*N* = 1). In the case of easy-level dictation, only one participant described having used another strategy, *listening to the whole dictation a 1st time*. Five categories were included in the analyses: *No strategy, Another strategy*, using *Bass* first, *Soprano* first, and *Chords* first. Again, no significant difference was found ($F(4.65) = 1.177$, $p = .330$). As stated above, the mean (out of 10) in easy-level dictation for writing *Bass* first was 7.758 (*ES* = .473), *Soprano* first 7.458 (*ES* = .932), *Chords* first 8.909 (*ES* = .795), and *Another strategy* was 8.333 (*ES* = .2635); whereas the mean for the use of *No strategy* was 6.678 (*ES* = 2.635), quite a stark contrast.

Between-Subjects Factors

		N
Order	No strategy	15
	Bass	31
	Soprano	8
	Chords	11
	Another strategy	1

Tests of Between-Subjects Effects

Dependent Variable: Results easy-level dictation

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	32.692[a]	4	8.173	1.177	.330
Intercept	1164.918	1	1164.918	167.717	.000
Order	32.692	4	8.173	1.177	.330
Error	423.690	61	6.946		
Total	4345.944	66			
Corrected Total	456.382	65			

Tables 3.11. Results of One-way ANOVA on determining the most efficient procedural strategy category to start easy-level dictation at pre-test

Even if there were no significant difference between the three strategies to start writing the easy-level dictation, it seems as though *No strategy* led to the worst results and starting to write by the *Soprano* was still the least efficient.

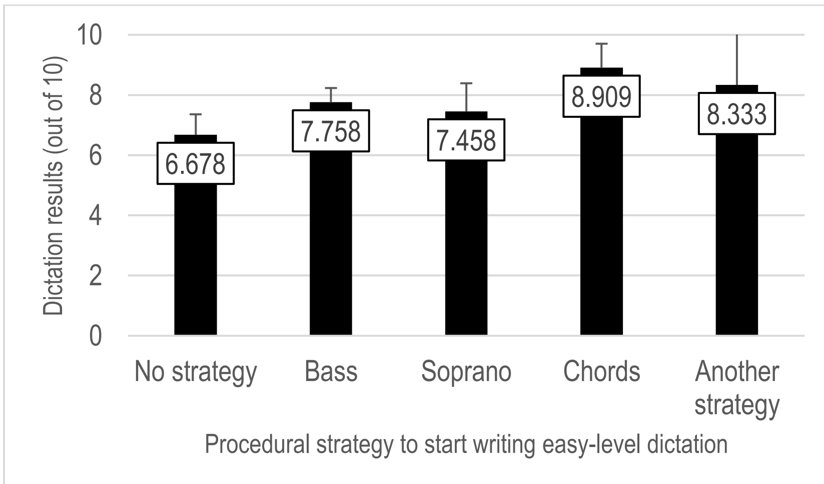


Figure 3.17. Means of easy-level dictation by 5 categories of procedural strategies at pre-test

The same sequence of ANOVA presented in Easy-level dictation will be done for Moderate-level dictation. That is, first, we will present the analyses of the effects of only the *Bass*, *Soprano*, and *Chords* categories on moderate-level dictation, then the analyses of the effects of *No strategy*, *Bass*, *Soprano*, *Chords*, and *Another strategy*. These analyses are given in the next section to verify whether these procedural strategies had any influence on performance in moderate-level dictation.

Moderate-level dictation (pre-test)

Forty-two (42) participants were observed, and the numbers of participants using each strategy differed from the easy-level dictation. The group *Bass* represents participants who wrote bass first (N = 31), the group *Soprano*, participants who wrote soprano first (N = 5), and the group *Chords* (N = 6), participants who wrote chords first. That means there was a decrease in the use of writing soprano and chords first. Reduced use of starting by writing the soprano or the chords could explain the slightly better performance in the moderate-level dictation ($F(2.42) = .490$, $p = .616$). The mean (out of 10) in moderate-level dictation for writing *Bass* first was 6.049 (SE = .374), *Soprano* first was 5.086 (SE = .932), and *Chords* first 5.690 (SE = .851). Starting the moderate-level dictation with bass, soprano, or chords did not significantly affect the dictation performance.

Between-Subjects Factors

		N
Order	Bass	31
	Soprano	5
	Chord	6

Tests of Between-Subjects Effects

Dependent Variable: results moderate-level dictation

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	4.255[a]	2	2.127	.490	.616
Intercept	709.622	1	709.622	163.443	.000
Order	4.255	2	2.127	.490	.616
Error	169.327	39	4.342		
Total	1627.227	42			
Corrected Total	173.582	41			

Tables 3.12. Results of One-way ANOVA on determining the most efficient procedural strategy to start moderate-level dictation at pre-test

However, when observing the means, starting by *Soprano* appeared to be less efficient. A similar result was observed in the easy-level dictation. Writing *Bass* first led to better results compared to writing *Chords* first in the moderate-level dictation. This result differs from the easy-level dictation, where writing *Chords* first led to the highest mean.

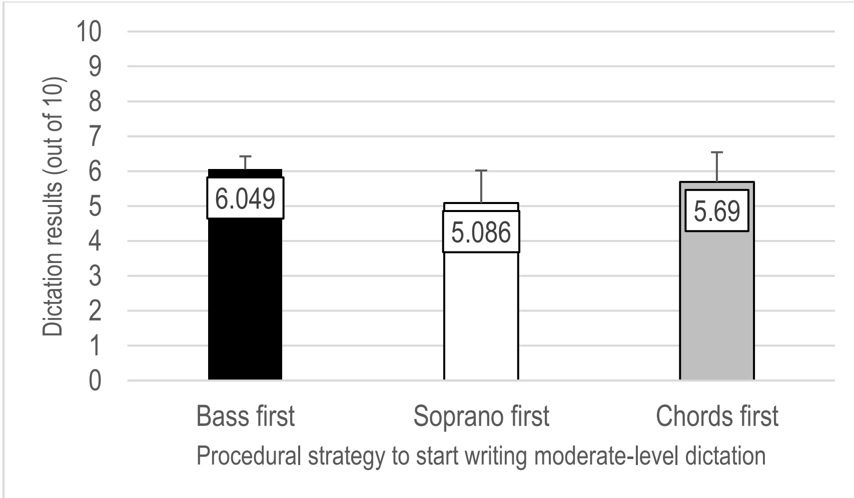


Figure 3.18. Means of moderate-level dictation by procedural strategies at pre-test

Staying at moderate-level dictation, we did analyses with the two new categories added in the previous analyses. There were five categories in total. Participants who did not describe the use of any procedural strategy to start the dictation were grouped in the *No strategy* (*N* = 18) categor*y*. Participants who described another strategy than starting by *Bass* (*N* =31), *Soprano* (*N* =5), or *Chords* (*N* =6) were grouped in *Another strategy* (*N* =6). None of these specific categories used to start writing dictation explained performance in the moderate-level dictation *(F*(2.42) = .490, *p* = .616). As stated above, the mean in moderate-level dictation for writing *Bass* first was 6.049 (*SE* = .426), *Soprano* first was 5.086 (*SE* = 1.035), and *Chords* first 5.690 (*SE* = .945). The mean for *Another strategy* was 4.649 (*SE* = .945); whereas for the use of *No strategy* it was 4.878 (*SE* = .545).

Between-Subjects Factors

		N
Order	No strategy	18
	Bass	31
	Soprano	5
	Chords	6
	Another strategy	6

Tests of Between-Subjects Effects

Dependent Variable: Results moderate-level dictation

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	21.729[a]	4	5.432	1.015	.407
Intercept	1117.972	1	1117.972	208.847	.000
Order	21.729	4	5.432	1.015	.407
Error	326.536	61	5.353		
Total	2342.409	66			
Corrected Total	348.265	65			

Table 3.13. Results of One-way ANOVA on determining the most efficient procedural strategy category to start moderate-level dictation at pre-test

Again, even if there were no significant difference among the participants' categories to start writing dictations, we can observe a tendency to start writing soprano first still leading to the worst results compared to bass or chords. Not describing any strategy led to poor results, as in the case of the easy-level dictation. The use of other strategies also led to poor results, unlike the easy-level dictation (listen to the whole dictation a 1st time (N = 2), counting the number of chords (N = 2), writing voices on the staff (N = 1), writing bass and chords at the same time (N = 1)).

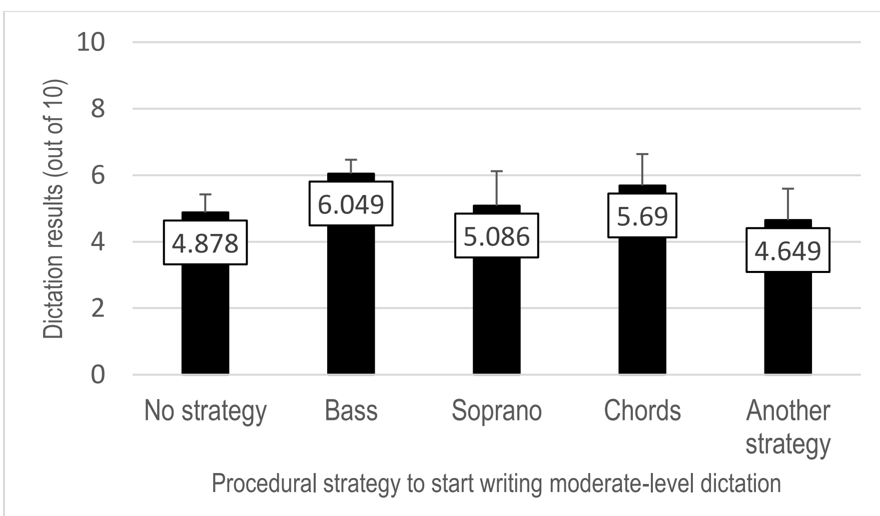


Figure 3.19. Means of moderate-level dictation by 5 categories of procedural strategies at pre-test

The same sequence of ANOVA presented in the easy-level and moderate-level dictations will be used for the difficult-level dictation. That is, first, we will present the effects of beginning the dictation with *Bass*, *Soprano*, or *Chords* on difficult-level dictation, then the analyses of the effects of *No strategy*, *Bass*, *Soprano*, *Chords*, and *Another strategy*. These analyses will be presented in the next section to verify if these procedural strategies had any influence on performance in the difficult-level dictation.

Difficult-level dictation (pre-test)

The number of participants using each procedural strategy differed from the easy-level and moderate-level dictation results. On the difficult-level dictation, 37 participants were observed. The group *Bass* represents participants who wrote bass first ($N = 26$), the group *Soprano*, participants who wrote soprano first ($N = 8$), and the group *Chords* ($N = 3$), participants who wrote chords first. None of these specific categories used to start writing dictation better explained performance in difficult-level dictation ($F(2.37) = .369$, $p = .694$). The means (out of 10) at the difficult level were markedly lower than those of the easy or moderate levels: for writing *Bass* first, the mean was 5.206 ($SE = .058$); for *Soprano* first, 4.359 ($SE = .1046$); and for *Chords* first, 5.875 ($SE = 1.708$). No significant differences were observed. Starting the difficult-level dictation by bass, soprano, or chords did not affect the performance in dictation.

		N
Order	Bass	26
	Soprano	8
	Chords	3

Tests of Between-Subjects Effects

Dependent Variable: Results difficult-level dictation

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	6.461[a]	2	3.230	.369	.694
Intercept	479.866	1	479.866	54.860	.000
Order	6.461	2	3.230	.369	.694
Error	297.399	34	8.747		
Total	1257.551	37			
Corrected Total	303.860	36			

Table 3.14. Results of One-way ANOVA on determining the most efficient procedural strategy to start difficult-level dictation on pre-test

However, as for the easy- and moderate-level dictations, *Soprano* led to the worst results. Writing *Chords* first, as in the easy-level dictation, led to better results.

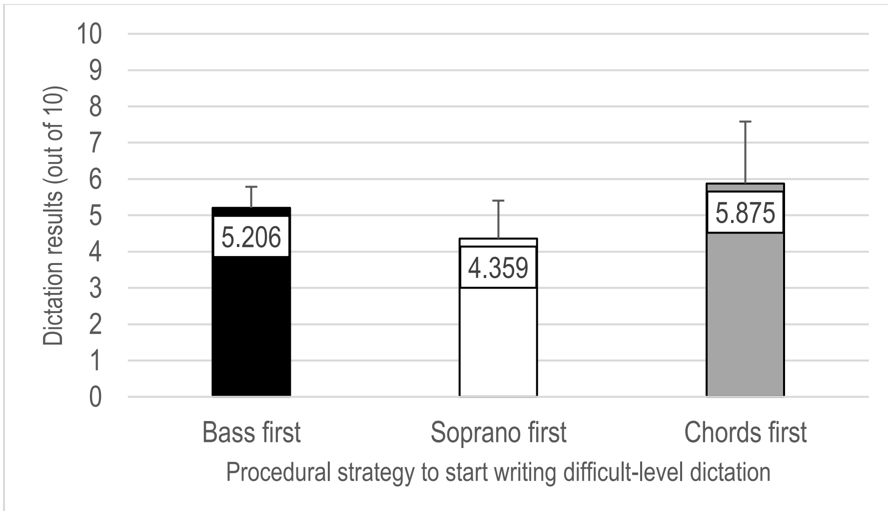


Figure 3.20: Means of difficult-level dictation by procedural strategies on pre-test

The next analysis again added two new categories: *No strategies*, representing participants who did not describe the use of any procedural strategy to start the dictation (N = 27), and *Another strategy*, representing participants who started writing the dictation by other some strategy than bass, soprano, or chords (N = 2). It was compared with using bass first, soprano first, and chords first. None of these specific categories used to start writing dictation explained performance in the difficult-level dictation (F(5.66) = 1.780, p = .144). As stated above, the mean in difficult-level dictation for writing *Bass* first was 5.206 (*SE* = .546), *Soprano* first was 4.359 (*SE* = .985), *Chords* first 5.875 (*SE* = 1.608). The mean for *Another* strategy was 2.750 (*SE* = 1.970); whereas the mean for *No strategy* was 3.404 (*SE* = 536).

Between-Subjects Factors

		N
Order	No strategy	27
	Bass	26
	Soprano	8
	Chords	3
	Another strategy	2

Tests of Between-Subjects Effects

Dependent Variable: Results difficult-level dictation

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	55.254[a]	4	13.814	1.780	.144
Intercept	451.035	1	451.035	58.127	.000
Order	55.254	4	13.814	1.780	.144
Error	473.325	61	7.759		
Total	1761.422	66			
Corrected Total	528.580	65			

Table 3.15. Results of One-way ANOVA on determining the most efficient strategy category to start difficult-level dictation on pre-test

As in the easy- and moderate-level dictations, *Soprano* led to the poor results, as did describing *No strategy.* Writing *Chords* first, as in the easy-level dictation, led to better results, while describing *Another strategy* led to the worst results (*counting the number of chords* (*N* = 1); *writing inner voices* (*N* = 1)). Overall, no specific category was significantly related to success in figured bass dictation at all dictation levels on the pre-test. However, we observed certain tends: *No strategy* led to poor results, as did *Another strategy*, in the moderate- and difficult-level dictations. However, on the easy level, only one participant used a strategy other than starting by the *Bass*, *Soprano*, or *Chords*. The three most-used strategies on the pre-test (*Bass*, *Soprano*, and *Chords*) are also the most efficient, compared to *No strategy* and *Another strategy*. Among them, starting by writing the *Soprano* was less efficient, while starting by writing the *Chords* was the most efficient at the easy and difficult levels. Starting by writing the *Bas*s was the most efficient strategy at the moderate-level.

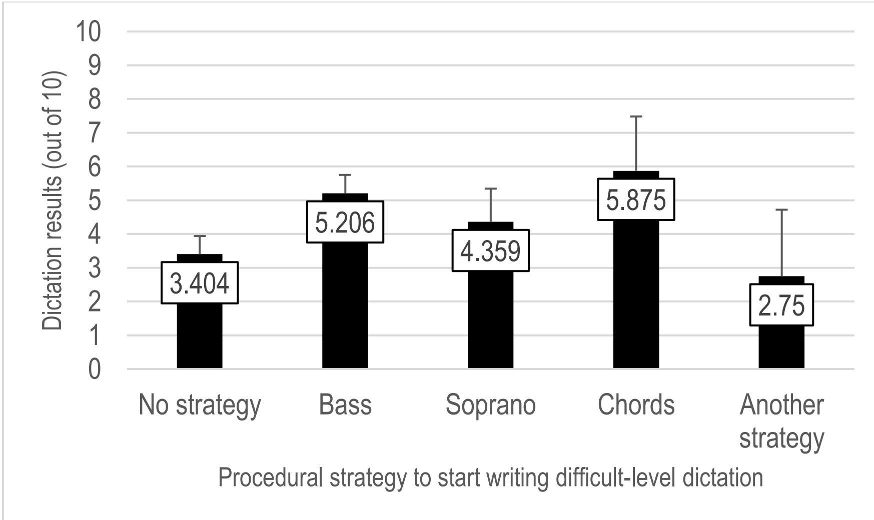


Figure 3.21. Means of difficult-level dictation by 5 categories of procedural strategies on pre-test

In the next section, we analyze the same five categories used in the pre-test (*Bas*s, *Soprano*, *Chords*, *Another strategy*, and *No strategy*) and present them by dictation level. These analyses are important to verify whether the same trends reported on the pre-test were also observed on the post-test, and if any significant differences were observed this time.

Post-test

Dictation results were not normally distributed on the post-test (Shapiro-Wilk = .012). That is why a One-Way Kruskal-Wallis ANOVA Test was conducted to examine the differences in dictation results according to the type of procedural strategies participants used to start writing their dictations. Fifty-nine (59) participants were observed. We analysed the results from 5 groups: *No strategy* represents participants who did not report any procedural strategy to start writing dictation; *Bass* represents participants who reported writing bass first; *Soprano* represents participants who started writing soprano first; *Chords* represents participants who started writing chords first; and *Another strategy* represents participants who used a strategy other than writing bass, soprano, or chords first. The results are reported by dictation level.

Easy-level dictation (post-test)

Participants (N = 59) were grouped by the types of procedural categories they used to start writing dictations: the group *Bass* (N = 24), the group *Soprano* (N = 4), the group *Chords* (N = 19), the group *No strategy* (N = 6), and the group *Another strategy*, (N = 6). No significant differences were found among the five categories of participants (x^2 = 1.790, df = 5, p = .774).

Ranks

	Order (post-test)	N	Mean Rank
Easy-level dictation results (post-test)	No strategy	6	22.58
	Bass	24	29.71
	Soprano	4	32.88
	Chords	19	30.66
	Another strategy	6	34.58
	Total	59	

Test Statistics[a,b]

	Easy-level dictation results (post-test)
Kruskal-Wallis H	1.790
Df	4
Asymp. Sig.	.774

a. Kruskal-Wallis Test

b. Grouping Variable: Easy-level dictation results (post-test)

Table 3.16. Results of One-way ANOVA on determining the most efficient strategy category to start easy-level dictation on post-test

The mean in the easy-level dictation of the post-test for writing *Bass* first was 7.611 (*SE* = .527), *Soprano* first 7.583 (*SE* = 1.290), and *Chords* first 8.079 (*SE* = 0.592). The mean for *Another strategy* was 8.667 (*SE* = 1.053); whereas the mean for *No strategy* was 6.389 (*SE* = 1.053).

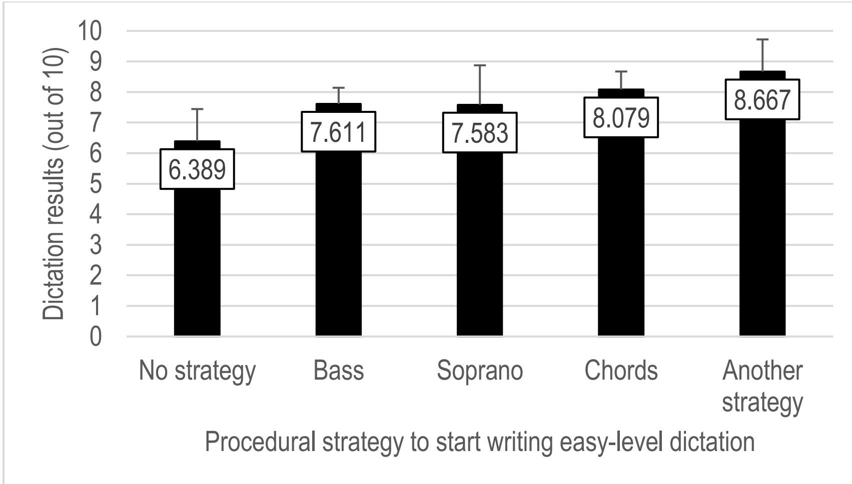


Figure 3.22. Means of easy-level dictation by 5 categories of procedural strategies on post-test

The same results were reported on the easy-level dictation as on the pre-test. That means that no specific strategy better explained the results, as in the easy-level dictation. As in the easy-level dictation on the pre-test, describing *No strategy* led to worse results.

Moderate-level dictation (post-test)

A one-way Kruskal-Wallis ANOVA Test was run to examine the differences on dictation results according to the type of procedural strategies participants used in starting to write the dictation. We analyzed the results from 5 groups: *No strategy* (*N* = 8), *Bass* (*N* = 37), *Soprano* (*N* = 5), *Chords*, (*N* = 6); and *Another strategy* (*N* = 3). A significant difference was found among the five categories of participants (x^2 = 10.855, *df* = 5, ***p* = .028**), as reported by the letters A and B below.

Ranks

	Order	N	Mean Rank
Moderate-level dictation results (post-test)	No strategy	8	13.63
	Bass	37	33.76
	Soprano	5	21.50
	Chords	6	32.58
	Another strategy	3	36.33
	Total	59	

Test Statistics[a,b]

	Moderate-level dictation results (post-test)
Kruskal-Wallis H	10.855
Df	4
Asymp. Sig.	.028

a. Kruskal-Wallis Test

b. Grouping Variable: Moderate-level dictation results (post-test)

Table 3.17. Results of One-way ANOVA on determining the most efficient strategy category to start moderate-level dictation on post-test

The mean for moderate-level dictation in the post-test for writing *Bass* first was 6.985 (*SE* = .284), *Soprano* first 5.714 (*SE* = .774), *Chords* first 7.19 (*SE* = .706). The mean for *Another strategy* was 7.381 (*SE* = .999); whereas the mean for the use of *No strategy* was 5.125 (*SE* = .612).

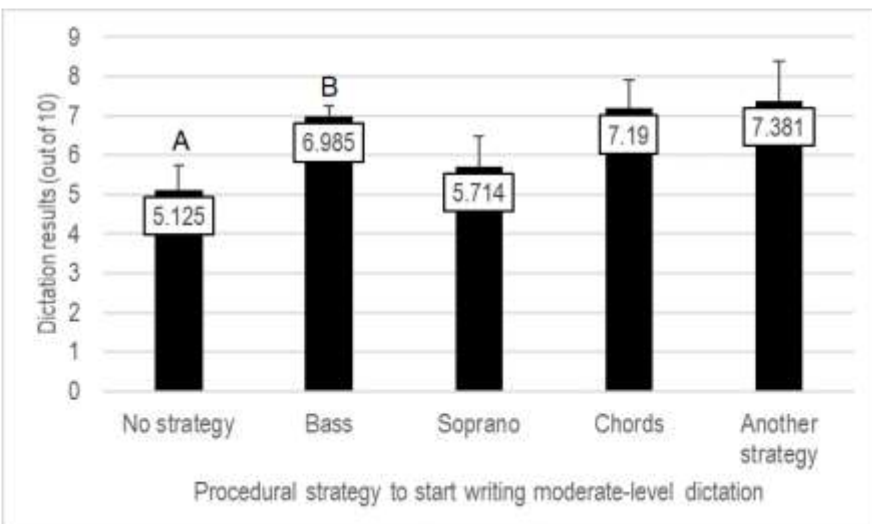


Figure 3.23. Means of moderate-level dictation by 5 categories of procedural strategies on post-test

Pairwise comparisons showed that starting with the *Bass* (*M* = 6.985) led to better results compared to *No strategy* (***p* = .026**). The mean for *No strategy* was the lowest compared to the other strategy categories (*M* = 5.125). Furthermore, among the described strategies, starting by writing the *Soprano* revealed the lowest mean (*M* = 5.714).

Pairwise Comparisons

Sample 1 – Sample 2	Test statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig
No strategy – Soprano	-7.875	9.771	-.806	.420	1.000
No strategy – Chords	-18.958	9.257	-2.048	.406	.406
No strategy – Bass	-20.135	6.683	-3.012	.003	**.026**
No strategy – Another strategy	-22.708	11.604	-1.957	.50	.504
Soprano – Chords	-11.083	10.379	-1.068	.286	1.000
Soprano – Bass	12.257	8.167	1.501	.133	1.000
Soprano – Another strategy	-14.833	12.517	-1.185	.236	1.000
Chords – Bass	1.173	7.543	.156	.876	1.000
Chords – Another strategy	-3.750	12.120	-.309	.757	1.000
Bass – Another strategy	-2.577	10.289	-.250	.802	1.000

Each row tests the null hypothesis that Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is .05.
Significance values have been adjusted by the Bonferroni correction for multiple tests.

Table 3.18. Pairwise comparisons of the five strategy categories to start moderate-level dictation on post-test

These results confirm the tendency observed in the moderate-level dictation on the pre-test, where *Soprano* was also the less efficient strategy, describing *No strategy* led to the worst results, and *Bass* was the most efficient strategy. Even if for the post-test *Another strategy* showed a higher mean (*M* = 7.381) than *Bass*, they were not significantly different. Neither was *Another strategy* significantly different from describing *No strategy*, while the difference was significant between writing *Bass* and describing *No strategy*. Writing *Bass* first led to better results compared to *No strategy* (***p* = .026**).

Difficult-level dictation (post-test)

A one-way Kruskal-Wallis ANOVA Test was conducted to examine the differences on dictation results according to the type of procedural strategies participants used to start to write the dictation. We analyzed the results from 5 groups: *No strategy* (*N* = 14), *Bass* (*N* = 27), *Soprano* (*N* = 6); *Chords* (*N* = 7); and *Another strategy* (*N* = 5). No significant difference was found among the five categories of participants (x^2 = 4.198, *df* = 5, *p* = .380).

Ranks

	Order	N	Mean Rank
Difficult-level dictation (post-test)	No strategy	14	27.82
	Bass	27	32.74
	Soprano	6	18.33
	Chords	7	29.86
	Another strategy	5	35.50
	Total	59	

Test Statistics[a,b]

	Difficult-level dictation (post-test)
Kruskal-Wallis H	4.198
Df	4
Asymp. Sig.	.380

a. Kruskal-Wallis Test

b. Grouping Variable: Difficult-level dictation (post-test)

Table 3.19. Results of One-way ANOVA on determining the most efficient strategy category to start difficult-level dictation on post-test

The mean on the difficult-level dictation of the post-test for writing *Bass* first was 5.968 (*SE* = .553), *Soprano* first 3.500 (*SE* = 1.173), and *Chords* first 5.554 (*SE* = 1.086). The mean for *Another strategy* was 6.475 (*SE* = 1.285); whereas the mean for using *No strategy* was 5.214 (*SE* = .768).

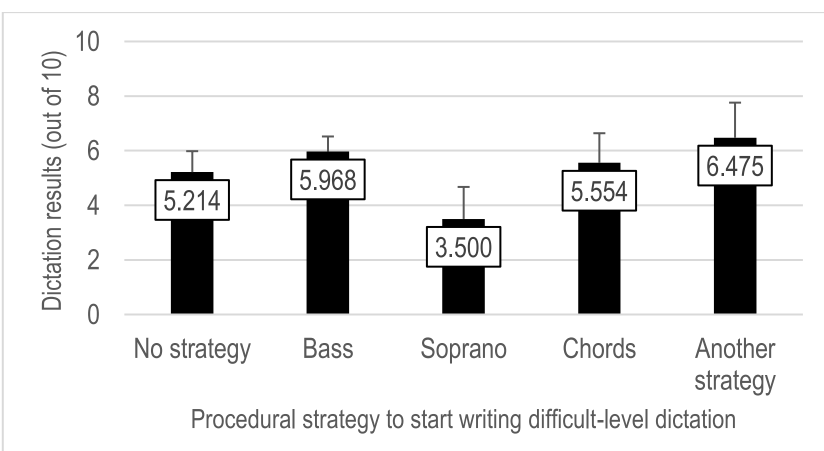


Figure 3.24. Means of difficult-level dictation by 5 categories of procedural strategies on post-test

Again, compared to the other described strategies, writing *Soprano* first appeared to be related to the worst results, as shown by the mean (*M* = 3.500). *No strategy* also appeared to be related to poor results.

Summary of results to answer question 3

It was found in answer to our third question (If strategies are listed in response to the first objective (finding strategies), which ones are the *most used* and which ones are the *most effective* in solving the transcription of tonal harmonic dictations?) that *tonal* strategies were the most used strategies, followed by procedural, non-tonal, and implemental (see Descriptive statistics: Utilization of strategies from details on subcategories). Concerning the efficacy of strategies, *tonal strategies* were the most efficient strategy among the tonal, non-tonal, and implemental strategies. *Non-tonal* made no difference to performance. *Implemental* was the least efficient, even compared to *no strategy* at all. Concerning procedural strategies, only writing *Bass* first was significantly better than describing *No strategy* on the moderate-level dictation on the post-test. Moreover, for the other difficulty levels, we observed the tendency that writing *Bass* or writing *Chords* first were the best strategies, while writing *Soprano* first seemed to lead to the worst results among the observed strategies. *No strategy*, in general, led to the poorest results, which means that it is better to start to write a dictation with any procedural strategy whatsoever than with no strategy at all.

Analyses of Auditory Memory Span

This section explores what the results suggest in response to the following question:

4. Pre- and post-tests, is acquisition/utilization of strategies influenced by mnemonic factors and/or other variables?

To answer this question, participants had to perform two types of auditory memory span tests: musical and non-musical. As a brief reminder, both auditory memory tests consisted of listening to pairs of sound sequences in order to identify if the second sequence of the pair was the same as or different from the first. We used sounds from an octave divided into 7 logarithmic intervals to create the non-musical memory test, and notes from the C major scale to create the musical memory test (see also Chapter 2 Methodology).

For the next analyses, 58 participants were retained, for whom we had both pre-memory and post- memory test results. Students who participated in only one of the auditory memory test sessions were excluded. Before answering our main question by relating memory performance to other variables, we examined whether there were any differences between memory tests. First, we compared the musical and non-musical auditory memory tests separately to see if there were differences between the pre- and on post- test scores. Then, we related the results on memory tests to those in dictation, using Spearman correlation. Finally, we compared the results on both memory tests with the use of the strategies regarding the type and number of different strategies used, on the pre- and post-tests, also using Spearman correlation, to verify if there might be a relation between auditory memory and the use of strategies.

Comparison between musical and non-musical memory tests on pre- and post- tests

The memory tests were scored out of 10. Participants performed better (Z = 282.500, ***p* = .000**) on the *Musical* test than on the *Non-musical*, with means of M = 8.43, (SD = 1.3) and M = 8.01 (SD = 0.97), respectively. The same significant difference was observed on the post-test (Z = 181.500, ***p* = .000**), with means of M = 8.65 (SD=0.77) and M = 8.18 (SD = 0.86). These significant differences are indicated in the figure below by different letters. These results indicate that on both pre- and post- memory tests, participants performed better on the musical test, possibly because of their familiarity with the tonal system.

Comparison between the same memory type on pre- and post-tests

Comparing *Musical memory* pre- and post-tests, the average score on the pre-test was M = 8.43 (SD = 1.3), while on the post-test it was M = 8.65 (SD = 0.77). The mean result on the pre-test for the *Non-musical memory* test was M = 8.01 (SD = 0.97), while for the post-test it was M = 8.18 (SD = 0.86). Neither score was significant: musical pre/post: (Z = 865.000, p = .057); non-musical pre/post: Z = 1.024,000, p = 1.16.

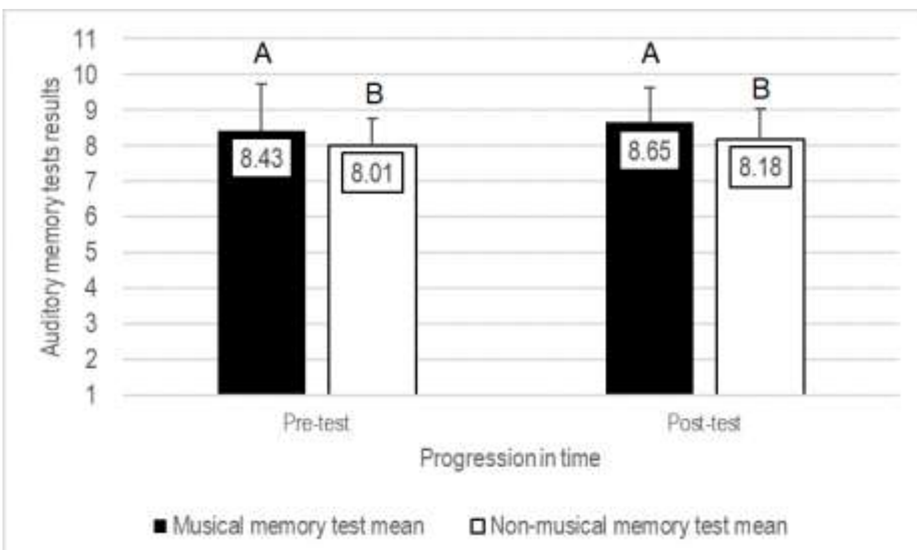


Figure 3.25. Difference between musical and non-musical memory measures on pre- and post-tests

This means that there was no difference observed over time between the pre- and post-tests regarding the two types of auditory memory. The scores on the tests were effectively the same. The difference noted was between the types of auditory memory, as the scores on *Musical memory* test are higher than on the *Non-musical.*

Spearman correlations between harmonic dictation results and auditory memory types

To explore whether the dictation results were related to the memory test results, Spearman correlations were done. For these tests, we retained the same 56 PTs as reported earlier in the analyses of efficacy of strategies because this is the number of participants who participated in the musical test and in the pre- and post-tests.

In the pre-test, the *dictation results* did not correlate with *musical memory* test scores (r_s = 0.172, *p* =. 204). In contrast, in the post test, the *dictation results* did correlate quite strongly with the *musical memory* test scores (r_s = 0.411, ***p* = .002**). The *dictation average score* did not correlate with the *non-musical memory* test on either occasion (pre-test: r_s = -*.021, p* = .880, post-test: r_s = .213, ***p* = .115**). The *dictation results* were not related to the auditory *non-musical memory* capacity in either condition, pre- or post-test. Also, on the pre-test, the *dictation results* were not related to *musical memory*. However, by the time of the post-test, the subjects who obtained better results on dictation seemed to use more of their *musical memory*.

Spearman correlations between strategies, harmonic dictation results, and auditory memory

To investigate whether the strategies (number of strategies and types) were related to *dictation results* and auditory memories, Spearman Correlations were done.

On the pre-test, the *total number of different strategies* did not correlate with the *dictation results* (r_s = .099, *p* = .469), *musical memory* (r_s = -.012, *p* = .931), or *non-musical memory* (r_s = .039, *p* = .777).

On the post-test, the *total number of different strategies* used correlated positively with the *dictation results* (r_s = .348, ***p* = .009),** *musical memory* (r_s = .461, ***p* = .000),** and *non-musical memory* (r_s = .306, **p = .022)**. The *total number of different strategies* used did not correlate with *non-musical memory* (r_s = .217, *p* = .109) on the post-test.

On the pre-test, the *dictation results* did not correlate with the number of any of the types of strategies: *number of Tonal strategies* (r_s = .164, p = .226), *Procedural strategies* (r_s = .129, *p* = .344), *Non-tonal strategies* (r_s=-.085, *p* = .533), and *Implemental strategies* (r_s = -.243, *p* = .071).

On the post-test, the *dictation results* correlated with the number of *Tonal strategies* (r_s =. 411, ***p* = .002**) and with the number of *Procedural strategies* (r_s = .313, ***p* = .019**). The *dictation results* did not correlate with the number of *Non-tonal strategies* (r_s = -.096, *p* = .483) or the number of *Implemental strategies* (r_s = .177, *p* = .192).

These results mean that at the time of the pre-test, the number of different strategies used was not related to any auditory memory capacity (musical or non-musical) nor to dictation results. In contrast, by the time of the post-test, the number of different strategies used did appear to be related to both musical memory and non-musical memory and to the scores on dictation. Moreover, on the post-test, those participants who better solved harmonic dictation used more tonal and procedural strategies and displayed stronger musical memory.

Given the correlation results showing that the *number of strategies* used was not related to *auditory memory* (musical or non-musical), we decided to verify this observation and test for other variables, such as *instrument* and *starting age of musical studies*. A general linear univariate model was chosen. This analysis allowed us to determine whether musical and/or non-musical memories or other variables could predict the use of strategies; notably the number of different strategies participants used.

Variables affecting the total number of strategies used on the pre-test

Participants used fairly high numbers of different strategies on the pre-test, (*M* = 10.51, *SD* = 4.58). A simple linear regression was used to predict the total number of different strategies used to solve figured bass dictation on the pre-test; it was based on the number of years of musical studies (β = .290, *t*(54) = 2.089, ***p* = .042)**. A significant regression was found with an adjusted R^2 of .059. This means that the variance in the *Number of strategies* was explained (5.9%) by the *Number of years of musical studies*. Only the number of years of musical studies predicted the number of different strategies used on the pre-test (***p* = .042**), as reported in the table below.

Parameter Estimation

Dependent Variable: Number of different strategies on pre-test

Parameter	B	Std. Error	T	Sig.
Intercept	8.441	1.157	7.294	.000
Number of years of musical studies	.290	.139	2.089	**.042**

a. R Squared = .076 (Adjusted R Squared = .059)

Table 3.20. Results of simple linear regression on factors affecting the number of strategies used on pre-test

No other variable predicted the variance in the number of strategies used on the pre-test. *Musical* (p = .857) and *Non-musical* (p = .559) *memory* spans did not predict the *Number of strategies* used on pre-test. Moreover, there were no significant differences observed for *Instrument* type (p = .568), *Musical genre* (classical vs pop/jazz) (p = .789), *Gender* (p = .551), and the *Starting age of formal* (p = .919) or *informal* (p = .357) *musical studies*. This means that musical memory capacity and non-musical memory capacity were not predictors of the number of strategies used. Also, playing a melodic, harmonic, or percussion instrument was not significantly related to the number of strategies used in this study; nor did playing classical, pop/jazz, or a mix of these genres. There were no significant differences between males and females in the number of different strategies used during figured bass dictation. Starting musical studies early did not affect the number of strategies used; rather, it was the number of years of musical studies that was significant (***p* = .042**) and predicted the number of strategies used, independent on the age at which participants started their musical studies. After testing the total number of strategies, we analyzed them separately by type: *Tonal*, *Procedural*, *Non-tonal*, and *Implemental*.

Variables affecting the number of implemental strategies used on the pre-test

A simple linear regression was calculated to predict the number of different *implemental* strategies used to solve dictations on the pre-test; it was based on the number of years of musical studies (β = .105, $t(54)$ = 2.215, ***p* = .031**). A significant regression was found, with an adjusted R^2 of .067. This means that the variance in the *Number of implemental strategies* was explained (6.7%) by the *Number of years of musical studies*. Only the number of years of musical studies predicted the number of different implemental strategies used on the pre-test (***p* = .031**), as reported in the table below.

Parameter estimation

Dependent variable: Number of implemental strategies on pre-test

Parameter	B	Std. Error	T	Sig.
Intercept	.577	.396	1.456	.151
Number of years of musical studies	.105	.048	2.215	**.031**

a. R Squared= .085 (Adjusted R Squared=.067)

Table 3.21. Results of linear regression on determining factors for number of implemental strategies used on pre-test

Variables affecting the number of procedural strategies used on the pre-test

A simple linear regression was calculated to predict the number of different *procedural* strategies used to solve figured bass dictation on the pre-test; it was based on the number of years of musical studies (β = .111, $t(54)$ = 2.037**, *p* = .047**). A significant regression was found with an adjusted R^2 of .055. This means that the variance in the *Number of procedural strategies* was explained (5.5%) by the *Number of years of musical studies*. Only the number of years of musical studies predicted the number of different procedural strategies used on pre-test (***p* = .047**), as reported in the table below.

Parameter estimation

Dependent variable: Number of procedural strategies on pre-test

Parameter	B	Std. Error	T	Sig.
Intercept	1.977	.452	4.378	.000
Number of years of musical studies	.111	.054	2.037	**.047**

a. R Squared= .073 (Adjusted R Squared=.055)

Table 3.22. Results of simple linear regression on determining factors for number of procedural strategies used on pre-test

These results indicate that on the pre-test, participants with more years of musical studies used more strategies, in general, and more implemental and procedural strategies, in particular.

Variables not affecting the number of tonal and non-tonal strategies used on the pre-test

A simple regression was calculated to predict the number of different *Tonal* (β = .040, $t(55)$ = .415, p = .680) and *Non-tonal* strategies (β = .034, $t(55)$ = .479, p = .634) used to solve figured bass dictation on the pre-test; it was based on the number of years of musical studies. No significant regression was found. The number of years of musical studies did not predict the use of *Tonal* (p=.680) or *Non-tonal* strategies (p=.634), as reported in the table below.

Parameter estimation

Dependent variable	Parameter	B	Std. Error	T	Sig.
Tonal strategies pre-test	Intercept	3.766	.812	4.641	.000
	Number of years of musical studies	.040	.098	.415	.680
Non-Tonal strategies pre-test	Intercept	2.121	.591	3.587	.001
	Number of years of musical studies	.034	.071	.479	.634

a. R Squared= .003 (Adjusted R Squared= -.016)

b. R Squared= .004 (Adjusted R Squared= -.014)

Table 3.23. Results of simple linear regression on factors not affecting the number of tonal and non-tonal strategies used on pre-test

In summary, on the pre-test, the number of strategies used was not predicted by the *Musical* and *Non-musical* memory capacities. Rather, the number of strategies used were predicted by the *Number of years of musical studies*.

Variables affecting use of strategies on the post-test

A simple linear regression was employed to predict the *Total number of different strategies* used to solve figured bass dictation on the post-test; it was based on *Musical memory* on the post-test (β = .694, $t(54)$ = 3.431, ***p* = .001**). A significant regression was found with an adjusted R^2 of .158. This means that the variance in the number of strategies used on the post-test was explained (15.8%) by the musical memory span. On the post-test, the only variable that explained the number of strategies used was musical memory (***p* = .001**), just as suggested by the correlations (see page 105). Participants with a larger musical memory span used more different strategies on the post-test. The data was normally distributed (Shapiro-Wilk = 2.57).

Parameter estimation

Dependent Variable: Number of different strategies post-test

Source	B	Std. Error	T	Sig.
Intercept	-2.763	1.769	-1.562	.124
Musical memory post-test	.694	.202	3.431	**.001**

a. R Squared = .174 (Adjusted R Squared = .158)

Table 3.24. Results of simple linear regression on factors determining the number of different strategies used on post-test

However, no other variable explained the number of strategies used on the post-test. This means that there were no *Gender* differences in the number of strategies used (p = .337). There were no differences in *Instrument* type (p = .238), whether harmonic, melodic, or percussion, or in *Musical genre*, classical, pop/jazz, or a mix of the two (p = .530). *Non-musical memory* capacity did not explain the number of strategies used (p = .457), nor did the *Starting age of formal* (p = .848) or *informal musical studies* (p = .554) or the *Number of years of musical studies* (p = .400).

After testing the total number of strategies, we analyzed them separately by type: *Tonal, Procedural*, *Non-tonal*, and *Implemental*, as we did for the pre-test. A simple linear regression was employed to predict the total number of different *Tonal* strategies used to solve figured bass dictation on the post-test; it was based on *Musical memory* on the post-test, (β = 1.830, $t(54)$ = 3.981, ***p* = .000**). A significant regression was found with an adjusted R^2 of .213. This means that the variance in the number of *Tonal* strategies was explained (21.3%) by *Musical memory* span. On the post-test, the only variable that predicted the number of Tonal strategies used (*M* = 5.13, *SD* = 2.67) was *Musical memory* (***p* = .000**). The data was normally distributed (Shapiro-Wilk =.411).

Parameter estimation
Dependent Variable: Number of tonal strategies post-test

Parameter	β	Std. Error	T	Sig.
Intercept	-10.818	4.018	-2.693	**.009**
Musical Memory post-test	1.830	.460	3.981	**.000**

a. R Squared = .227 (Adjusted R Squared = .213)

Table 3.25. Results of simple linear regression on determining factors of number of tonal strategies used on post-test

A simple linear regression was calculated to predict the total number of different *Implemental* strategies used to solve figured bass dictation on the post-test; it was based on *Musical memory* on the post-test (β = .523, $t(54)$ = 2.133, ***p* = .038)**. A significant regression was found with an adjusted R^2 of .061. This means that the variance on the number of *Implemental* strategies was explained (6.1%) by *Musical memory* span. On the post-test, the only variable that predicted the number of implemental strategies (*M* = 1.55, *SD* = 1.30) was musical memory capacity. The data was normally distributed (Shapiro-Wilk = .085). Participants having a larger musical memory capacity used more different strategies and more tonal and implemental strategies on the post-test.

Parameter estimation

Dependent Variable: Number of implemental strategies post-test

Parameter	B	Std. Error	T	Sig.
Intercept	-2.999	2.141	-1.400	.167
Musical Memory post-test	.523	.245	2.133	**.038**

a. R Squared = .078 (Adjusted R Squared = .061)

Table 3.26. Results of simple linear regression on factors affecting the number of different implemental strategies used on post-test

These results indicate that on the post-test participants with a larger musical memory used more strategies, in general, and more tonal and implemental strategies, in particular.

Variables not affecting the number of non-tonal and procedural strategies used on the post-test

A simple regression was calculated to predict the number of different *Non-tonal* (β = .059, *t*(56) = .146, *p* = .884) and *Procedural* strategies (*β* = .366, *t*(56) = 1.349, *p* = .183) used to solve figured bass dictation on the post-test; it was based on *Musical memory* span. No significant regression was found. *Musical memory* span did not predict the use of *Non-tonal* (*p*=.680) or *Procedural* strategies (*p*=.634), as reported in the table below.

Parameter estimation

Dependent variable	Parameter	B	Std. Error	T	Sig.
Non-tonal strategies post-test	Intercept	2.790	3.519	.793	.431
	Musical memory	0.59	.403	.146	.884
Procedural strategies post-test	Intercept	-.026	2.369	-.011	.991
	Musical memory	.366	.271	1.349	.183

R Squared = .000 (Adjusted R Squared = -.018)

R Squared = .033 (Adjusted R Squared = .015)

Computed using alpha = .05

Table 3.27. Results of simple linear regression on factors not affecting the number of non-tonal and procedural strategies used on post-test

Summary of results to answer question 4

It was found in answer to our fourth question (Can the utilization of the strategies used by students be influenced by mnemonic cognitive factors on pre- or post-tests? If not, can it be predicted by other variables from the questionnaire?) that, on pre-test, the variable that explained the number of strategies used was the number of years of musical studies. This same variable also predicted the number of different procedural and implemental strategies used. On the post-test, it was musical memory that predicted the number of different strategies, especially the number of tonal and implemental strategies. Therefore, on the post-test, it was no longer the number of years of musical studies before university that explained the number of strategies used, but (after a term of university ET courses) it was musical memory that had the greatest impact on the number of strategies used. Now we will turn to the following question:

5. To what extent do the number of years of musical studies, age of beginning of musical studies, gender, musical genre (e.g. classical versus jazz), the type of instrument, the type of strategy, and memory capacity contribute to the prediction of performance in harmonic dictation?

To answer this question, first a Spearman correlation was run to see if the variables were linked to one another; if they were, we could create a model based on the correlations. Then, a General Linear Model was used to test the contribution of the variables to explaining the results in harmonic dictation. This Model allows us to arrive at the most appropriate analysis to predict the results in harmonic dictation: ANOVA, ANCOVA, or regression.

First, we present the correlations concerning the continuum variables of the questionnaire (number of years of musical study, starting age of formal and non-formal musical studies), musical dictation results, and musical and non-musical memory tests in the pre- and post-tests. Second, the General Linear Model results are reported with all of the variables from the questionnaire. For the following correlational analyses, the same group of *N* = 56 participants was used.

Spearman correlations between starting age of informal musical studies and harmonic dictation results

Starting age of informal musical studies correlated only with the *Starting age of formal musical studies* (r_s = 708, ***p* = 000**). This means that participants who started their musical studies informally earlier also started their formal studies earlier. However, the *Starting age of informal studies* did not correlate with *Dictation results* on the pre-test (r_s = .132, *p* = .346) or the post-test (r_s = -.106, *p* = .451). In short, performance on dictation was not related to the starting age of informal musical studies in this study.

Spearman correlations between starting age of formal musical studies and harmonic dictation results

Starting age of formal musical studies correlated negatively with *Difficulty level of dictation* on the pre-test (r_s = -.289, ***p* = .033**) and approached a significant correlation with the overall pre-test *Dictation results* (r_s = -.262, *p* = *.053*). In the same way, *Starting age of formal musical studies* correlated negatively with *Dictation results* on the post-test (r_s = -.273, ***p* = .044)** but no longer with the *Difficulty level of dictation* on the post-test (r_s = -.225, *p* = .098). Rather, *Starting age of formal musical studies* correlated with the *Moderate-level* dictation (r_s = -.299, ***p* = .026).** This means that participants who started their formal music studies earlier performed better on harmonic dictations at difficulty levels for the pre-tests, on the overall dictation average on the post-test, and on the moderate-level dictation on the post-test.

Spearman correlations between number of years of musical studies and harmonic dictation results

The *Number of years of musical studies* did not correlate with *Dictation results* on either the pre-test (r_s = .191, *p* = .162) or the post-test (r_s = .180, *p* = .190). Participants who started their formal musical studies earlier performed better on harmonic dictation. Starting early informal musical studies seems not to be related to performance on dictation. Similarly, the number of years of musical studies is not related to performance in harmonic dictation.

Spearman correlations between dictation difficulty levels

The *average of the three pre-test dictations* correlated strongly with the *average of the three post-test dictations* (r_s = .685, ***p* = .000)**. This means that participants who performed better on dictations on the pre-test also performed better on the post-test. The three dictation difficulty levels on the pre-test correlated among themselves as follows: *Easy-level* with *Moderate-level* (r_s = .537, ***p* = .000**); *Easy-level* with *Difficult-level* (r_s = .495, ***p* = .000**), and *Moderate-level* with *Difficult-level* (r_s = .652, ***p* = .001**), and with their average. This means that participants who were better at solving the easy level on the pre-test did just as well on the other two dictations. Furthermore, *each level* on the pre-test correlated with the *average of three dictations on the post-test*: *Easy-level* on the pre-test (r_s =.388, ***p* = .003**), *Moderate-level* on the pre-test (r_s =.565*,* ***p* = .000**), and *Difficult-level* dictation on the pre-test (r_s =.662, ***p* = *000***). This means that participants who performed better on the pre-test also performed better on the post-test. In short, strong participants tended to be internally consistent, remaining strong throughout the semester.

On the post-test, the *three dictation difficulty levels* correlated among themselves as follows: *Easy-level* with *Moderate-level* (r_s = .479, ***p* = .000**), *Easy-level* with *Difficult-level* (r_s = .482, ***p* = .000**), and *Moderate-level* with *Difficult-level* (r_s = .618, ***p* = .000**), and with their average. This means that participants who solved the easy level better on the post-test, did as well on the other two dictations. Furthermore, each level correlated with the average of the three dictations of the pre-test: *Easy-level* on the post-test (r_s = .403, ***p* = .002**), *Moderate-level* on the post-test (r_s = .575, ***p* = .000**), and *Difficult-level* on the post-test (r_s = .710, ***p* = .000**). Again, this means that participants who performed better on pre-test, also performed better on post.

Spearman correlations between harmonic dictation results and auditory memory types

Musical memory on pre-test did not correlate with *Dictation results* on the pre-test (r_s = -115, *p* = .192), but did correlate with *Dictation results* on the post-test (r_s = 371, ***p* = .005)**. The *Non-musical memory* on the pre-test did not correlate with the *Dictation results* on either the pre-test (r_s = -.022, *p* = .870) or the post-test (r_s = .238, *p* = .077).

Musical memory correlated with *Dictation results* on the post-test (r_s = .411, ***p* = .002)** but not with *Dictation results* on the pre-test (r_s = .197, *p* = .145). *Non-musical* memory on the post-test did not correlate with the *Dictation results* on either test (pre-test: r_s = .009, *p* = .947; post-test: r_s =. 213, *p* = .115).

This means that participants who performed better on dictations on the post-test also had a larger musical capacity memory in both conditions, pre- and post-test. Moreover, performance on harmonic dictation on the pre- and post-tests did not correlate with non-musical memory capacity in this study.

Spearman correlations between number of strategies and memory types

On the pre-test, the *Number of different strategies* did not correlate with either kind of auditory memory (*Musical*: r_s = -.012, *p* = .931; *Non-musical*: r_s = .039, *p* = .777). Similarly, none of the individual strategies correlated with *Musical memory* (*Implemental*: r_s = -.034, *p* = .806, *Procedural:* r_s = .190, *p* = .161, *Non-tonal*: r_s = -.005, *p* = .970, and *Tonal* r_s = -.026, *p* = .850). Once again, the *Number of different strategies* did not correlate with *Non-musical* memory (*Implemental* r_s = .132, *p* = .331, *Procedural* r_s = .104, *p* = .447, *Non-tonal* r_s = -.028, *p* = .840, and *Tonal* r_s = .005, *p* = .970).

On the post-test, the *Number of different strategies* correlated with both memory tests (*Musical*: r_s =.461, *p* =.000, *Non-musical* r_s = .306, ***p* = .022**). Separately by type, only the number of *Tonal* (r_s =.504, ***p* = .000**) and *Implemental* (r_s =.283, ***p* =.034**) strategies correlated with *Musical memory*. *Procedural* (r_s = 52, *p* = .706) and *Non-tonal strategies* (r_s = 101, *p* = .457) did not correlate with *Musical memory*. *Non-musical* memory correlated only with the number of *Tonal strategies* (r_s = .373, ***p* = .005**), but did not correlate with *Procedural* (r_s = .245, *p* = .069), *Implemental*, (r_s = .092, *p* = .501), and *Non-tonal strategies* (r_s = -.117, *p* = .391).

Spearman correlations between number of strategies and harmonic dictation results

On the pre-test, the *Dictation results* did not correlate with the *Total number of different strategies* (r_s =.099, *p* = .469) nor with any of the strategies separately: *Tonal* (r_s = .164, *p* = .226); *Non-tonal* (r_s = -.085, *p* = .533); *Implemental* (r_s = -.243, *p* = .071), and *Procedural* (r_s = .129, *p* = .344).

On the post-test, the *Dictation results* correlated with the *Total number of different strategies* used (r_s = .348, ***p* = .009**), the number of *Tonal strategies* (r_s = .411, ***p* = .002**), and the number of *Procedural strategies* (r_s = .313, ***p* = .019**). The *Dictation results* did not correlate with the number of *Non-tonal strategies* (r_s = -.096, *p* = .483) or *Implemental strategies* (r_s = .177, *p* = .192).

Further analyses

We created two General Linear Models to verify which variables observed in the Spearman correlations would be more important to predict performance in figured bass dictation. The Spearman correlations revealed that performance on dictation on the pre-test was related to the *Starting age of formal musical studies* only, whereas on the post-test, performance on dictation seems to be related to the *Number of strategies used* and *Musical and Non-musical memory*. The following figure presents the model for the pre- and post-tests and the correlation between the results observed between performance on dictation on the pre- and post-tests. Figure 3.26 shows the dictation results as dependent variables (DV) and potential independent variables (IV) that could explain the DVs.

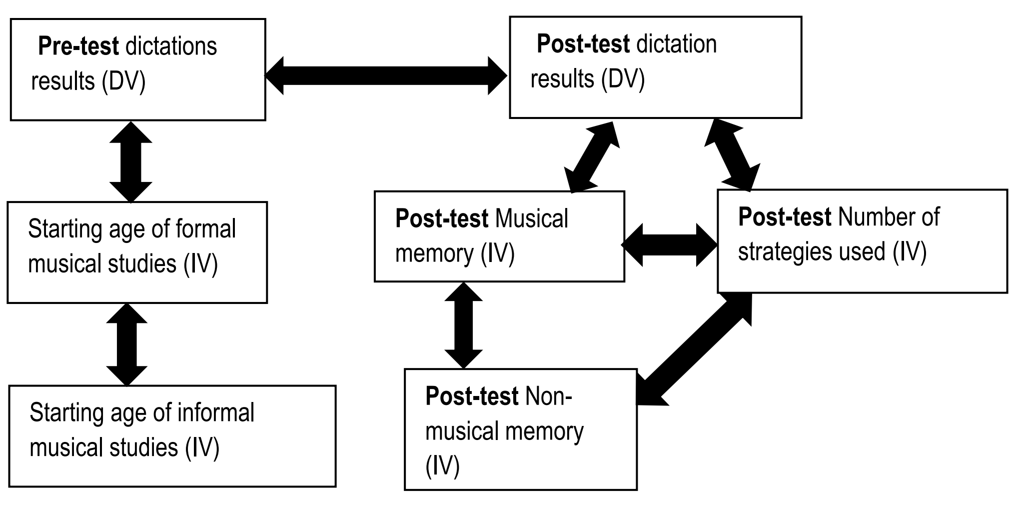


Figure 3.26. Potential model for predicting dictation results in pre- and post-tests

In the following analysis we can see the direction of the relations observed; for example, whether the starting age of formal music studies does indeed explain the performance in harmonic dictation on the pre-test, and also whether musical memory and the number and type of strategies used can predict performance on harmonic dictation (the average of the three dictation levels) on the post-test. In addition, other categorial variables can be added to the model to verify their contribution in predicting performance in harmonic dictation, such as: gender (female, male); a participant's performing music style (jazz/pop, classical, jazz/pop/classic); and type of instrument (melodic, harmonic, percussion). We used the General Linear Model to construct our pre-test model and verify the direction of the relations. At the beginning, all the variables were included; then, we kept only the significant ones in our final model, an ANCOVA.

Variables affecting dictation results on the pre-test

A one-way ANCOVA was conducted to determine whether the kind of instrument or the starting age of formal musical studies had any effect on the performance in dictation on the pre-test. The table below shows the classification of instruments.

Melodic	**Harmonic**	**Percussion**
Voice Violon Viola Cello Saxophone Clarinet Bassoon Flute Oboe Trombone Horn Electric Bass	Piano Guitar Harp Sytnhesizer (*N*=1)	Drums

Table 3.28. Classification of instruments

Starting age of formal musical studies was a predictive factor on dictation results: β = -.123, $t(55)$ = -2.572, ***p* = .013.** The negative β indicates that participants who started their formal musical studies younger obtained better results in harmonic dictation. Moreover, *instrument type* seems to affect dictation results, *after controlling for starting age of formal musical studies* ($F(2, 51) = 3.411$, *p* = **.041**). The analysis revealed that both variables have an impact on dictation results. It seems percussion instruments have the greatest impact on performance, compared to other instruments.

Between-Subjects Factors

Dependent Variable: Dictation averages pre-test

Instrument	Mean	Std. Deviation	N
Melodic or voice	5.19	2.33	20
Harmonic	6.01	2.11	33
Percussion	9.00	.19	2
Total	5.82	2.26	55

Tests of Between-Subjects Effects

Dependent Variable: Dictation averages pre-test

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	59.535[a]	3	19.845	4.660	.006
Intercept	406.927	1	406.927	95.557	.000
Instrument	29.051	2	14.525	3.411	**.041**
Starting age of formal musical studies	30.192	1	30.192	7.090	**.010**
Error	217.181	51	4.258		
Total	2142.392	55			
Corrected Total	276.716	54			

a. R Squared = .215 (Adjusted R Squared = .169)

b. Computed using alpha = .05

c. β = -.123

Table 3.29. Results of one-way ANCOVA on variables predicting dictation results on pre-test

As indicated by pairwise comparisons, participants who played percussion instruments performed better than participants who played harmonic or melodic instruments. Despite the fact that it was quite a small group of participants (2 people) who played percussion instruments, they performed better (M = 9, N = 2, SD = 0.19). The mean in dictation for the 20 participants who played melodic instruments or sang was M = 5.19, N = 20, SD = 2.33, and for participants who played harmonic instruments, M = 6.01, N = 33, SD = 2.11. The difference between these last two groups was not significant. The data was normally distributed (Shapiro-Wilk = .154).

Pairwise Comparisons

Dependent variable: Dictation averages pre-test

(I) Instrument	(J) Instrument	Mean difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Boundary	Upper Boundary
Melodic	Harmonic	-.552	.593	.357	-1.743	.639
	Percussion	-3.964*	1.531	**.013**	-7.039	-.890
Harmonic	Melodic	.552	.593	.357	-.639	1.743
	Percussion	-3.413*	1.511	**.028**	-6.446	-.379
Percussion	Melodic	3.964*	1.531	**.013**	.890	7.039
	2 Harmonic	3.413*	1.511	**.028**	.379	6.446

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustment).

Table 3.30. Pairwise comparisons by instrument types on dictation results on pre-test

The next figure reports marginal means, that is, group means after controlling for the influence of *Starting age of musical formal studies on dictation results*. The letter “A” indicates there is no significant difference between melodic and harmonic instruments, while “B” indicates the better results achieved by the two participants who played percussion instruments.

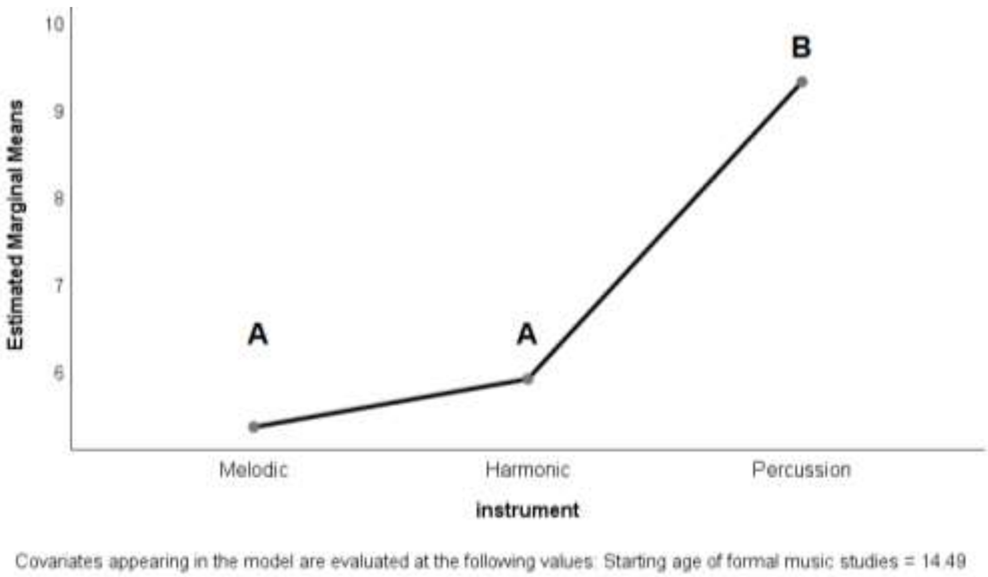


Figure 3.27. Estimated marginal means of instruments after controlling for starting age of musical formal studies.

The other variables did not help to explain the performance on harmonic dictation on the pre-test. They are as follows: *Starting age of informal musical studies* (*p* = .606); *Number of years of musical studies* (*p* = .206); *Musical memory* (*p* = .094) and *Non-musical memory* (*p* = .377) span; number of *Tonal* (*p* = .311), *Non-tonal* (*p* = .574), *Implemental* (*p* = .142), and *Procedural* strategies (*p* = .452); *Gender* (p = .876); *Musical genre* (*p* = .152); and interaction between *Gender* and *Musical genre* (*p* = .778). Note that the only variable even remotely approaching significance on the pre-test is *Musical memory*, at (*p* = .094), which is interesting given how important musical memory became in the post-test.

As we did for the pre-test data, we analyzed independent variables with the harmonic dictation results from the post-test, which allowed us to verify which variables could explain the performance in harmonic dictation (average of the three dictation levels) and whether they were the same as those on pre-test or, rather, those indicated by correlations (*Musical memory* and the *Number of strategies*). As for our pre-test model, we used the General Linear Model to construct our post-test model and verify the direction of the relations. At the beginning, all the variables were included; then, we kept only the significant ones in our final model, a Multiple Linear Regression.

Variables affecting dictation results on the post-test

A Multiple Linear Regression was calculated to predict *Dictation results* on the post-test based on the number of *Tonal, Non-tonal*, and *Procedural* strategies and on *Musical memory* span. Significant regressions were found, with an adjusted R^2 of .355. This means that the variance of dictation results is explained (35.5%) by the number of *Tonal*, *Non-tonal, Procedural* strategies and by *Musical memory*. Post-test dictation results were predicted first by the *Number of procedural strategies* (β = .434, *t*(54) = 2.609, ***p* = .012**); next, by *Musical memory span* (*β* = .843, *t*(54) = 2.249, ***p* = .029**); and, finally by the *Number of tonal strategies* (β = .220, *t*(54) = 2.190, ***p* = .033),** as shown by all the positive βs. This means that participants performing better on harmonic dictation used more procedural strategies, had a larger musical memory capacity, and used more tonal strategies. A negative β was found for non-tonal strategies (*β* = -.251, *t*(54) = -2.212, ***p* = .032**), indicating that the participants who performed better on the post-test used fewer non-tonal strategies. The data was normally distributed (Shapiro-Wilk = .608).

Parameter Estimation

Dependent variable: Dictation averages post-test

Parameter	B	Std. Error	T	Sig.
Intercept	-2.423	3.097	-.782	.438
Number of Tonal strategies	.220	.100	2.190	**.033**
Number of Non-tonal strategies	-.251	.113	-2.212	**.032**
Number of Procedural strategies	.434	.166	2.609	**.012**
Musical Memory	.843	.375	2.249	**.029**

a. R Squared =.402 (Adjusted R Squared =.355)

Table 3.31. Results of Multiple Linear Regression on variables affecting dictation averages on post-test

As stated above, the correlations indicated a relation between the *Total number of strategies* (all types together) and *Dictation results*, as well as between *Musical memory* and *Dictation results* (see pages 114-115). The difference is that the correlations also revealed a significant relation between the *Starting age of musical studies* and *Dictation results* on the post-test. In our model, it no longer seems to be a predictor of performance. Therefore, participants who performed better, in the first place, used more procedural strategies; in the second place, had a larger musical memory capacity; and in third place, used more tonal strategies and fewer non-tonal strategies.

However, no other variable explained the performance in dictation on the post-test. These variables are: *Starting age of informal musical studies* (*p* = .750); *Starting age of formal musical studies* (*p* = .532), N*umber of years of* *musical studies* (p = .905); *Non-musical memory span* (p = .166); *Implemental strategies* (p = .453); *Gender* (p = .563); *Musical genre* (p = .700); and *Instrument* (p = .247).

These results indicate that, after a session of ET courses, it was no longer the instrument or the starting age that mattered in predicting harmonic dictation post-test performance; but instead, it was musical memory capacity and the number of different procedural and tonal strategies used.

Summary of results to answer question 5

To answer our fifth question (For pre- and post-tests, to what extent do gender, number of years of musical studies, age of beginning of musical studies, musical genre (e.g. classical versus jazz), type of instrument, type of strategy, and memory capacity contribute to the prediction of performance in figured bass dictation?), we created and tested a model with all these variables. Our model, constructed from the correlation results, represented well the predictive independent variables of harmonic dictation performance. The final model included details and adjustments according to the last results reached with the General Linear Model. For the pre-test, we removed the *Starting age of informal musical studies*, which correlated only with *Starting age of formal musical studies*. We kept *Starting age of formal musical studies* because it was the variable that better predicted variance in performance in dictation on the pre-test (participants who started younger succeeded better). We added *instrument*, as it was the second independent variable that explained the variance in performance in dictation after controlling for *Starting age of formal musical studies* (the two percussionists performed better than the participants who played melodic or harmonic dictations). For the post-test, we kept both independent variables from the first version of the model, *Musical memory* and *Number of strategies*, and we added details about the contribution of the types of strategies explained significantly the variance on performance in dictation, namely, *Procedura*l and *Tonal*, which explained better results, and *Non-tonal*, which explained worse results.

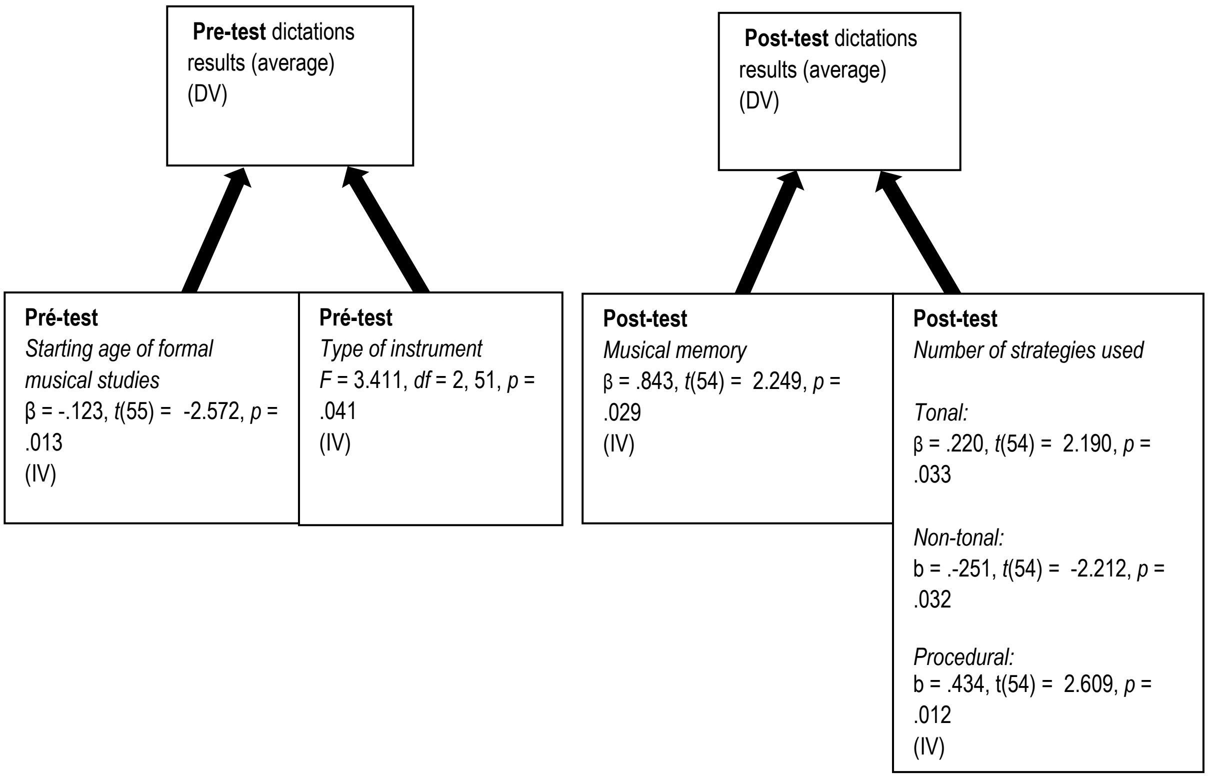


Figure 3.28. Final model for predicting dictation results in the pre- and post-tests

The last research question addressed whether participating in ET courses would help participants in this study improve their use of strategies and their harmonic dictation performance. Please note that the author did not exert any influence over the ET teachers in the participants' respective schools and courses, i.e., no specific treatment was adopted, only the usual general ET teaching focusing on developing strategies to solve all sorts of dictations.

6. Can cognitive strategies and performance in figured bass dictation be improved by participating in ET?

To answer this question, all 56 participants were observed through a Paired Sample T-test. First, we compared the averages of the three dictation levels on the pre- and post-tests. The average of the three dictation levels on the pre-test was M = 5.78, (minimum= 0.33, maximum = 9.61, SD = 2.26), and the average on the post-test was M = 6.59, (minimum = 1.42, maximum = 9.54, SD = 2.10). The increase in *Dictation results* from 5.78 to 6.59 was significant: $t(55) = -3.03$, $\mathbf{p = .004}$. The data was normally distributed (Shapiro-Wilk = .398).

Next, we compared the averages of the number of different used strategies. Since the normality test reported a non-normal distribution of this data (Shapiro-Wilk = .034), a non-parametric test, the Wilcoxon signed rank test, was done (Z = -3.459, ***p* = .001**). Comparable to the increase in *Dictation results*, there was an increase in the use of *Number of strategies.* The average on the pre-test was M = 3.53, SD = 1.52, and that on the post-test was M = 5, SD = 1.65. These significant differences are indicated in the figure below by different letters.

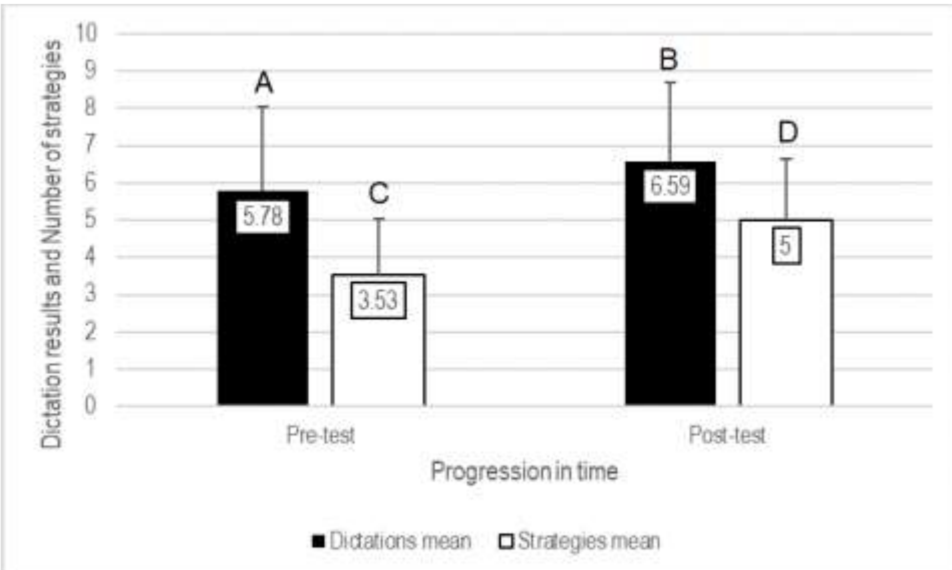


Figure 3.29. Increase in dictation results and number of strategies used between pre- and post-tests

Summary of results to answer question 6

In answer to our sixth question (Can cognitive strategies and performance in figured bass dictations be improved by participating in ET courses?), the T-tests indicated that on the post-test, participants performed better and used more strategies. This probably means that ET courses contributed to the participants' improving their performance in harmonic dictation and increasing the number of strategies used to solve harmonic dictations.

Summary of Chapter 3

Overall, the main findings of this study are the following:

- Students at the start of first-year university music training use in a non-controlled condition a wide variety of strategies to do harmonic dictation; in this study, a total of 41 strategies (level 2, specific actions) were reported.

- Participants in this study described their strategies by writing as they worked (Written Think Aloud, or WTA).
- Analysis of all 41 strategies showed 4 main categories (tonal, procedural, non-tonal, and implemental); each one had 2 or even 3 levels of sub-categories.
- Participants were stronger on musical memory tests compared to non-musical memory tests; these results were consistent from the pre-test to the post-test.
- Both memory types did not correlate with the harmonic dictation results on the pre-test, but *musical memory* did correlate with the harmonic dictation results on the post-test, along with the number of tonal and procedural strategies.
- The number of strategies used on the pre-test related to the number of years of musical studies. However, on the post-test, the number of strategies did correlate with both auditory memory types, but only *musical memory* appeared as a predictive variable of the number of strategies in linear regression.
- Tonal strategies were the most efficient for success in harmonic dictation; using a single tonal strategy was more effective than using any of the other main category strategies.
- On the pre-test, the dictation results were correlated with starting age of formal musical studies; but on the post-test, they were correlated with musical memory and the number of tonal and procedural strategies used.
- However, overall, on the post-test, higher scores on harmonic dictation were predicted by the *increased number* of procedural and tonal strategies and memory capacity at the end of one term of ear training.
- It seems that university ear-training (ET) courses compensate for starting age of formal musical studies, giving students strategies that can be learned to help increase harmonic dictation results. Furthermore, the new strategies seemed to activate and make more use of auditory memory on the post-test, while on the pre-test, auditory memory was not related to the dictation results, probably because of the automatism used by the most experienced students who started their formal musical studies early.

In the next chapter, an overview of the conclusions of all the results reported in this Chapter 3 will be presented and discussed.

Conclusion

This research project contributes to the advancement of knowledge about figured bass (harmonic) dictation, as we hoped for (page 42, 43). This contribution is made in several ways: first, by exploring cognitive processes engaged during harmonic dictation in terms of strategy use and efficacy; second, by looking at the role of auditory musical and non-musical memory in harmonic dictation performance and the use of strategies; third, by analyzing other individual differences that could influence performance in harmonic dictation, such as the number of years of musical studies and the instrument played; fourth, by studying participants' progress over time via pre- and post-tests using three dictation levels and two auditory memory tests, which yielded data concerning dictation performance and strategy use and efficacy as well as memory performance.

The results obtained in answering the six research questions of this project report for the first time a rich variety of strategies used to solve figured bass dictations. Strategy reports about cognitive processes were obtained from PTs by using Written Think Aloud, an adaptation of the most reliable approach (Think Aloud) according to the literature (Ericsson & Simon, 1993). With other approaches, such as interviews, some previous studies investigated small samples, such as six subjects (Buonviri, 2014), less than 20 per experiment (Krumhansl, Bhachura, & Castellano, 1982; Rosner & Namour, 1992) or 30 participants per experiment (Potter, 1990; Dowling, 1986). Small samples limit the power of statistical analyses and the conclusions that can be drawn from them. Our sample of 66 participants allowed an in-depth study of strategies, first by listing each strategy (N = 43) and, then, by categorizing them according to their shared characteristics, as well as the role other variables, such as auditory memory in harmonic dictation tasks.

The results reported in this thesis and discussed further in this chapter could guide ET course teachers and professors in choosing which strategies to privilege in teaching figured bass dictations and which not to waste time on (those types of strategy that decreased results in dictation, for example).

To better understand the conclusions and discussions presented in this chapter, let us restate the six objectives of this project: a) *list all cognitive strategies* used by music students while transcribing tonal harmonic dictations (the students are at the start of the first term of an undergraduate degree program in music); b) *categorize* the cognitive strategies listed in the previous step; c) *identify the most effective strategies* for tonal harmonic dictation transcription; d) *analyze other cognitive factors* that may influence use of some strategies and their learning, such as auditory musical and non-musical working memory capacity; e) *analyze the relationships* between strategy use, dictation success, and: gender, number of years of musical studies, age at beginning of musical studies, type of music program studied (e.g. classical versus jazz), main type of instrument, and musical and non-musical auditory memories capacity; and f) *ascertain if the acquisition of new strategies is possible* due to the intervention of ET courses (*post hoc* work done at the end of the participants' first term in an undergraduate degree program in music).

To reach these objectives, a methodology employing both qualitative and quantitative analyses was chosen. Qualitative analyses were applied to reach the first two objectives, concerning the coding and classification of strategies; quantitative analyses were applied to reach the other objectives, that is, all the variables in relation to dictation performance, use and efficacy of strategies, and memory capacity. All the results are reported in Chapter 3, Results, and organized by research question. In this chapter, we will revisit the most important results of Chapter 3, as well as the studies presented in Chapter 1, Literature Review, highlighting the specific contribution of the current results. Then, the pedagogical contribution of this research will be presented. Finally, this chapter will conclude with recommendations for future research.

Harmonic dictation

No work in ear training is more difficult than taking harmonic dictation (Karpinski, 2000, p. 120). Indeed, after reviewing Jonassen (2000), we concluded that harmonic dictation is a complex well-structured problem that requires decision-making and troubleshooting prerequisites. English (1998) explains difficulty as a function of complexity. Since harmonic dictation is a complex task that integrates various subtasks (such as writing the bass, chords, and sometimes the soprano voice), it is also a difficult task (Murphy,1989). Furthermore, in this thesis, we added decision-making and troubleshooting (identifying and correcting errors) as prerequisites for solving harmonic dictation. All the results presented in this thesis contribute to a better understanding of this complex task.

Consideration of the validity of measurement tests and the Written Think Aloud (WTA) approach

All the results reported in Chapter 3 and discussed below validated our tests, since we obtained significant results with the tests developed for this project, and the approach chosen. First, we will discuss the musical test, then the auditory memory tests, and last the Written Think-Aloud approach chosen to collect information about cognitive processes. It is important to discuss them because the tests were designed especially for this study. Regarding the Written Think Aloud, it is the first time this approach has been chosen to study strategies used during harmonic dictation transcriptions.

The test scores showed that the three difficulty levels of dictation represented a useful gradient of difficulty, with the easiest showing good performance on the pre-test but no significant improvement on the post- test, in contrast to significant improvements for the moderate and difficult dictations. This validates the relative increasing difficulty level of the three dictations, which was an essential element to control in this study because difficulty is a function of problem complexity (English, 1998). Each difficulty level was designed with a different level of complexity concerning chords and the number of chords (see Methodology for details).

Musical and non-musical memory tests were designed to assess auditory memory capacity and subsequently to examine its relation to dictation performance. Participants performed better on the musical memory test than on the non-musical memory test. The non-musical test used sound intervals not commonly heard in music, while the musical test used notes from the C major scale, which probably permitted participants to identify more easily the musical sound sequences, as one would expect. Musical familiarity should contribute to successful musical memory results.

The approach chosen for participants to report strategies was Written Think Aloud, an adaptation of the Think Aloud (TA) approach, in order to collect descriptions from as many participants as possible. This choice was based on the literature showing that TA increases information about cognitive processes that are available in the working memory by collecting verbalizations at the same time one is solving a task. In contrast, with retrospection and interviews, participants report what they remember about the task or an interpretation of what they did, possibly resulting in the loss of important information about cognitive processes (Ericsson & Simon, 1993; Van Someren, Barnard, & Sandberg, 1994).

The Written Think Aloud (WTA) proved to be pertinent for collecting information about the cognitive processes engaged in during harmonic dictation, especially while working in groups. A pilot study reported that Think Aloud (TA) and Written Think Aloud (WTA) collected similar content from participants' strategy reports concerning the number of described strategies, whether verbalized or written. Thus, recommendations to collect reliable and valid verbalizations have been respected (Ericsson & Simon, 1993; Van Someren, Barnard, & Sandberg, 1994). The large amount of information collected about strategies used by participants in this study contributes to the validation of the WTA approach as a reliable research tool. The tests used in this study as well as the WTA approach allowed us to collect and analyze important results about performance in harmonic dictation, the strategies used, and the relation of both dictation results and strategies to auditory memory span.

No previous study of harmonic dictation has presented analyses concerning categorization of strategies in a non-controlled research study (without specific treatments between pre- and post- tests), using Think Aloud or Written Think Aloud while solving a task, and with a large number of participants (*N* = 66). To the best of our knowledge, this study is also the first to examine such a large number of strategies (43, grouped into four main categories) and their relative efficacy and frequency of utilization. Most previous studies compared a few isolated strategies and criteria. Alvarez (1980) compared the effectiveness of using two different strategies (scalar and root harmonic aural perception) in harmonic dictation, Potter (1990) the effectiveness of using intervals or degrees to solve melodic dictation, Rosner and Narmour (1992) harmonic closure to verify whether two cadences (plagal and authentic) were perceived as closurally synonymous or rather alike, and so on.

All the strategies described in this project emerged from participants' descriptions, that is, they were not selected *a priori*; and no strategy was excluded, allowing for a complete representation of how participants solve harmonic dictation. We also propose a definition of harmonic dictation, report strategies never mentioned before in this field, and explicate the relation between strategies, performance in dictation, and auditory memory.

Strategies, number of strategies, and their efficacy

We propose in this research a novel definition of strategies used in musical dictation; we believe this is the first time in the literature that dictation strategy has been so defined. This definition guides the categorizations reported in this thesis. Specifically, we framed the definition as follows: Strategy is a category of mental procedure selected through specific actions, comparing the stimulus with the knowledge of the individual, to perform a dictation task. We applied this definition to our data, and it has guided our analyses and categorizations as follows: *Category of mental procedure* refers to the four main categories we have identified: Tonal, Procedural, Non-tonal, and Implemental; *selected through specific actions* refers to the next 2 levels of categorization (see Table 3.1, page 52), where we see the emergence of verbs such as evaluate, compare, concentrate, and identify; comparing *the stimulus with the knowledge of the individual* is observed in participants' written descriptions of how they worked, for example, participants cannot label chords and cadences if they do not have a specific kind of knowledge (all strategy has a knowledge component recovered in memory (Bégin, 2008, Buonviri, 2014; Sisley, 2008)); and, *to perform a dictation task* denotes the end goal of participants' activities during the three harmonic dictation tasks, for example, finding the chords and writing them down.

As proposed by the definition of strategies used in harmonic dictation, we could observe that a strong knowledge component is evident in using strategies. This knowledge component has been reported before in scholarly learning (Bégin, 2008), musical improvisation (Després, 2016), chord perception (Krumhansl et al., 1982), and melodic dictation (Buonviri, 2014; Sisley, 2008). In problem solving, Jonassen (2000) indicates that well-integrated domain-specific knowledge is essential to problem solving based on Think-Aloud (TA) protocols. Indeed, we observed the same need when using WTA during harmonic dictation. Music students or musicians cannot search for chord quality if they do not have domain-specific knowledge, as mentioned by Jonassen (2000), on how to identify and name chords. Tonal strategies, in particular, require well-integrated music theory knowledge in order to be used, since it is related to tonal context.

As regards the two separate participant samples, from Laval and Concordia Universities, analysis was done to see whether their performance and results differed in any systematic or significant way (i.e., were there distinct or similar populations?). There was no significant difference between pre- and post- test results for easy-level dictation results; by the post-test, the groups displayed similar increases in dictation results for the moderate and difficult levels; all the other results also trended constantly in the same direction. As all the data was so closely aligned, the data from both samples were collapsed into a single group for purposes of further analysis and to enable us to do deepen qualitative and quantitative analysis.

In analyzing the participants as a single group, the first two stages of work (list, categorize), saw the emergence of four main categories of strategies: Tonal, Procedural, Non-tonal, and Implemental (T, P, N, I). These emerged from a total of 41 *level 2* strategies that the participants described by WTA (*level 2* involved *specific actions* to solve dictations). Compared to other studies, our study presents a large number of strategies reported by students to solve dictation. Dowling (1989) reported that the most used strategies were degrees and intervals. Potter (1990) also studied only these two types of strategies. He examined the efficacy of degrees versus intervals and suggested degrees were more efficient than intervals. Our study confirms and agrees with his results but in a more complete way, because our main category, Non-tonal (N-T), includes various strategies and subcategories in addition to the traditional intervals strategies studied previously (Dowling, 1986; Potter, 1990). Our main category, Tonal (T), also encompasses more elements than the degrees category studied before (Alvarez, 1980, 1981; Dowling, 1986; Moreno Sala & Brauer 2007; Potter, 1990). For example, concerning N-T's strategy *interval*, three more complements have been added (level 3) as subcategories in our study: identifying intervals without specifying how; by filling; or by use of a reference song, as reported previously by Cruz de Menezes (2010). These strategies depend strongly on strategies that have been done otherwise in other research on melodic dictation (Cruz de Menezes, 2010). Furthermore, in the Non-tonal category, we included four strategies in addition to interval. Concerning degrees, our main Tonal category includes identifying degrees and pillars (that work together) as well as 19 other tonal strategies, to which we will return later.

In a general way, concerning Tonal and Non-tonal strategies, we found many of them in previous studies about melodic dictation (Cruz de Menezes, 2010; Cruz de Menezes et al. 2009; Moreno Sala, et al., 2008; Moreno Sala & Brauer, 2007), perhaps because in harmonic dictation we traditionally write the bass as a melodic line. Moreover, participants may have used a reductionist method to write the dictation (Karpinsky, 2000), that is, they may have decided about the whole chord on the basis of its smallest and detailed parts (Rahn & Mackay, 1988). These participants may have heard the dictation entirely by parts, i.e., bass as a melodic line, soprano as a melodic line, and all the other inner voices as melodic lines. Comparably, though it is something of a reversal perceptually, some people hear melodic dictation with an underlining implicit harmony that is not heard overtly (Cruz de Menezes, 2010; Cruz de Menezes et al. 2009; Moreno Sala & Brauer, 2007). Some Procedural strategies addressed issues such as in what order to start writing the dictation (Beckett, 1997; Murphy, 1989), or writing from the end (Cruz de Menezes, 2010). As for Implemental strategies, this is the first time this category has been reported in the field of musical dictation, to the best of my knowledge. Furthermore, all four categories will be further discussed below in decreasing order of utilization from the most used strategies to the least used strategies. The efficacy of strategies will also be discussed by strategy type.

Tonal strategies

This study analyzed the frequency of use and efficacy of the main categories of strategies for harmonic dictation. This included two main new elements: analysis of strategies mentioned in previous studies in only a descriptive way, without reporting much about their frequency of use or efficacy in harmonic dictation, and analysis of strategies never before mentioned in studies about harmonic dictation.

One of the first main categories emerging out of our study was Tonal strategies. These are used to identify notes or chords by comparing or associating them with the tonal context of the dictation. In this main category we include *using tonal reference, identifying scalar patterns, singing scale or degrees (mentally or not), using moveable do/transposing, identifying passing notes, identifying chord color (M/m), identifying chord position, calculating 1st note or tonic, tonality and/or mode by using first degree of previous tonality, identifying cadences, analyzing notes from different voices, identifying 7th chords, identifying chord function, memorizing/singing harmony internally, vocalizing the melody, identifying arpeggios, anticipating the next chord, identifying consonant or dissonant chords,* and *mentally building the triad from the bass notes/scale.* We will discuss in the following paragraphs the new subcategories and some others mentioned in other studies, contrasting the results and adding our news findings.

Some tonal strategies have been identified in previous studies on melodic dictation, such as *scale degrees* (Cruz de Menezes, 2010; Cruz de Menezes et al., 2009; Dowling, 1986; Moreno Sala et al., 2008; Moreno Sala & Brauer, 2007; Potter, 1990), and *vocalizing the melody* (Hoppe 1991). *Identifying degrees* was the most used tonal strategy focusing on functional degrees (N = 27/66). Since harmonic dictation integrates writing the bass, which can be considered as a melodic line, finding strategies also used in melodic dictation would be expected. Others, such as *Building the triad from the bass notes/scale* are categorized for the first time in this study. *Anticipating next chord* was reported by Reimer (1989), not in studies concerning dictations but as part of active hearing. Active training can help listeners react to music in an anticipative way, that is anticipating musical phenomena present in the music. For example, when hearing a cadence, one can imagine the resolution of V to I before actually hearing it. In this study, the anticipatory strategy was used by only two participants. A*nalysing notes from different voices* was reported in Karpinski's book (2000) as part of approaches to solve harmonic dictation. In fact, one of the main approaches Karpinski explains for transcribing harmonic dictations, without specifying its efficacy in empirical studies, is the reductionist method, which involves hearing musical elements separately (for example, hearing harmonic dictation as various melodic lines). This is closely related to the strategy found in the present study, *analysing notes from different voices*, used by 13 participants.

Tonal strategies have been previously related to performance in melodic dictation (Cruz de Menezes, 2010; Cruz de Menezes & Moreno Sala, 2016; Cruz de Menezes et al., 2016; Cruz de Menezes et al., 2009; Moreno Sala & Brauer, 2007; Potter, 1990). In this study, in reference to harmonic dictation, we observed that tonal strategies have a strong music theory knowledge component. This finding converges with the study by Krumhansl et al. (1982), who reported that harmonic relations between chords are mediated by a knowledge system that interprets chord functions according to tonality.

In a controlled condition, Alvarez (1980; 1981) compared the effectiveness of using two different strategies: a) scalar, which consists of attending to the seventh and eighth scale degrees in the progression, no matter the voice or root harmonic aural perception, or b) the root procedure, which consists of attending to the root movement of the bass line. The scalar technique appears to be a more effective procedure in teaching general music students to identify primary harmonic functions.

Following the root movement of the bass line and identifying 7^{th} and 8^{th} scale degrees were two strategies identified by participants in this present study, but it should be stressed that these strategies were not imposed (as by Alvarez, 1980, 1981): all the strategies reported in our study were chosen unprompted by the participants. In fact, we did not impose any specific strategy or treatment, as has been done in previous studies (Alvarez, 1980, 1981; Beckett, 1997). Identifying degrees proved to be a highly efficient strategy, which is logical as it is one part of the most efficient category, Tonal strategies. However, following the root movement of the bass line, the strategy mentioned by Alverez, seems to be arguably a more complex operation than merely identifying degrees, as it probably includes other sub strategies, such as identifying the bass's ascending/descending motion, conjunct/disjunct motion, intervals, and so on.

Tonal strategies were the strategies used most, which is a good thing, since the analyses showed that tonal strategies are the most efficient strategies. Use of tonal strategies increased participants' success in the harmonic dictation tasks. Using degrees (focusing on functional degrees) and identifying chord quality (focusing on harmonic function) were the two most-used tonal strategies.

Strategies classified as non-tonal were analyzed as less important for harmonic dictation performance and are discussed below, after procedural strategies, in the Non-tonal strategies section.

Procedural strategies

Procedural strategies were used to plan the dictation writing. Some of these strategies focused on specific elements, such as *writing bass, writing soprano, writing chords, writing the inner voices, dissociating voices, writing on the staff, writing the bass and the chords at the same time,* and *writing the rhythm first.* Other procedural strategies focused on the structure of the dictation, such as *listening to the whole dictation the first time, counting the number of chords, writing from the end,* and *naming the steps to solve figured bass dictation.*

Some procedural strategies were reported in previous studies, such as the order in which to write the harmonic dictation, for example, or starting with the bass, soprano, or rhythm. For Beckett (1997), starting two-voice dictation by writing the rhythm increased results significantly in a controlled condition. For Murphy (1989), starting figured bass dictation by writing harmonic functions seemed to be more efficient, also in a controlled condition. For the present study, in a non-controlled condition, I analyzed the most used procedural strategies that focused on specific elements when starting to write the dictation: starting by the bass, starting by the soprano, and starting by chords. Starting with rhythm was not studied because it was little used (N=1). Harmonic progressions in ear training classes are often (but not always) delivered as rhythmically isochronous sequences. However, this is the first time that procedural strategies have been studied in a non-controlled condition.

When comparing writing bass first, soprano first or chords first, on the pre-test, none of these procedural strategies proved to have an advantage over the others as a way to start harmonic dictation; they were all equally efficient. Compared to not describing any strategy, the first-choice procedural strategy (bass, soprano, or chords) used to start to write easy-level harmonic dictation was not related to better performance. By contrast, at the moderate-level dictation, starting to write bass first came close to being significantly better than not describing any procedural strategy, though it was still only equally efficient to writing soprano first or chords first. For difficult-level dictation, writing bass first was significantly better (***p* = .016**) than not describing any procedural strategy, but was still only equally efficient compared to writing soprano or chords first. On the post-test, the same tendencies were observed: only at the moderate-level, starting to write with the bass was more efficient compared to not describing any strategy.

While none of the what-to-write-first strategies reported above seem to have any great advantages over the others (compared to having no plan at all), the *number* of procedural strategies appears to affect the results in dictation. That is, our analyses suggest that the more procedural strategies used, the better the results in dictation, probably because the participants were able to change procedural strategies in a flexible way during the dictation. Also, it seems that participants with numerous procedural strategies were more likely to use a voice leading approach, as explained by Karpinski (2000), in which listeners follow and write the bass and trace certain voices at specific crucial locations to draw conclusions about chord functions. It would appear that the most successful dictation takers change their procedural strategy as many times as it takes to adapt their procedure to what they are hearing in the dictation.

The three most used procedural strategies were starting to write the dictation by the bass, then by the soprano, and then by chords. *Writing from the end* was very little used (*N* = 3). Indeed, Hoppe (1991) observed in melodic dictation that most students and professionals write dictations in a continuous manner from the beginning to the end.

Non-tonal strategies

Non-tonal strategies were used to find the notes or the chords in a purely perceptual way, i.e., without relying on the tonal context of the dictation or on the note functions. *Using intervals, using a sound reference*, *focusing on ascending/descending motion*, and *focusing on conjunct/disjunct* have already been reported (Cruz de Menezes, 2010; Cruz de Menezes et al., 2009; Moreno Sala et al., 2008; Moreno Sala & Brauer, 2007). *Identifying a note/context using a memorized piece* is reported in this study for the first time. This is not the same thing as finding intervals by comparison with a known song. Rather, participants reported they recognized some elements of the music in a general way without recognizing and naming the chords, for example, they had already heard a similar progression (e.g., "sounds like Pachelbel's *Canon*"). The use of intervals as a strategy has already been studied; for instance, Potter (1990) compared intervals' efficacy with that of scale degrees in melodic dictation. Intervals proved to be less efficient than degrees. Our category of Non-tonal strategies includes *interval* strategy among other strategies with the same perceptual characteristics.

Repeated Measures ANOVA was used to verify the role of non-tonal strategies in solving harmonic dictation. Compared to the other main categories (tonal, procedural, implemental), in general, the use of non-tonal strategies at first seemed neutral; they neither raised nor lowered success rates on harmonic dictation. This stood in stark contrast to the strong efficiency of *Tonal strategy* use, where making use of even one single tonal strategy improved success rates significantly. However, further analysis revealed a negative correlation between *Non-tonal strategy* use and dictation success: the more a participant used non-tonal strategies, the lower his/her dictation score was likely to be.

Overall, the two most used non-tonal strategies were *identifying intervals* and *ascending/descending motion*. It would seem that non-tonal strategies were not the most important strategies for successful performance in harmonic dictation. Non-tonal strategy in general, though, may have an auxiliary role. So far, the most efficient strategy type is still *Tonal* strategies. As the last main strategy category, we will look at the role of implemental strategies in the next section.

Implemental strategies

Implemental strategies are a completely new main category in music dictation research, to the best of my knowledge, compared to previous studies that only reported some aspects of tonal, non-tonal, and procedural strategies (Beckett, 1997; Buonviri, 2014; Cruz de Menezes, 2010; Cruz de Menezes et al., 2008; Moreno Sala et al., 2008; Moreno Sala & Brauer, 2007). Our classification of implemental strategies was inspired by Begin

(2008), who studied strategies in school situations and grouped all strategies related to regulating, such as evaluating, verifying, and choosing answers.

Implemental strategies in this study included *evaluating the time needed to solve a dictation, evaluating the difficulty level, comparing possible answers, making negative judgments on answers, verifying*, and *using a kinesthetic strategy.* Evaluating difficulty level and comparing possible answers were the two most-used implemental strategies, but analysis revealed that implemental strategies comprised the least efficient strategies category.

Evaluating time to solve dictation and *evaluating difficulty level* (e.g., participant 13 wrote "*N.B. difficult test at the beginning of the session after 3 months without taking ET"*) seem to relate to what Jonassen describes as *Affective elements*, rather than to specific music knowledge (in contrast to tonal strategies). Jonassen and Tessmer (1996) explain *self-confidence in ability* as a problem-solver's belief in his/her own abilities to solve the problem; this self-confidence or lack of it is a core affective element that predicts the level of mindful effort and perseverance a person will apply to solving a problem. It can also influence what Jonassen and Tessmer call *Conative* (motivational and volitional) elements, such as exerting effort and persisting on a task to solve a problem. If from the beginning, a participant was to judge that after summer vacation taking dictation is too hard, it would probably affect his/her self-confidence and engagement in taking dictation, which could consequently affect the results negatively—as reported in our results.

When someone is making negative judgments on answers, such as "I'm not really sure of my answers" (participant 5), this draws upon not only affective elements but also troubleshooting, because the participant is detecting that there is something wrong with his/her answers. It also validates this study's newly-proposed definition of harmonic dictation as requiring decision making and troubleshooting as essentials. Making negative judgments on the participants' own answers were found in the least efficient strategy category in this study (Implemental). Possibly, this reveals a situation in which (given that the dictation had a limited time to be solved) participants may have wasted time trying to find what was wrong with what they had already written instead of using the time to solve other elements of dictation. However, on the whole, making negative judgments on one's answers may not be inherently a poor strategy; literature from non-musical fields indicates that strategies such as self-judging and orienting are important metacognitive skills that are positively related to problem-solving performance, and they can be learned (Masui & DeCorte, 1999).

Comparing possible answers has not been evoked in previous studies of musical dictation. Eleven (11) participants reported comparing and trying possible answers, usually in the form of questions. However, as we generally tend to try to find answers to questions for which we do not yet have the answer during problem solving

(Ericsson & Simon, 1993), I believe this procedure may have been used unconsciously by a number of the participants.

Verifying strategies has also been reported in previous studies on melodic dictation (Buonviri, 2014; Cruz de Menezes, 2010) and seemed, at first, efficient. Authors studied combined strategies to identify intervals (Cruz de Menezes, 2010; Cruz de Menezes et al., 2016; Cruz, Bissonnette, Guiton, & Moreno Sala, 2009) and reported that the more strategies are combined to solve a single interval, the better chances participants have to succeed. In light of this finding, they suggested that verifying strategies might be efficient, but the researchers did not specifically study their efficacy. Buonviri (2014) reported that musicians often check their melodic dictation by inner singing, but without calculating its efficacy either. The results presented in this thesis suggest that verifying strategies may or may not be efficient, depending on how participants verify their answers. For example, they may be useful when using a tonal strategy but not when using a non-tonal strategy. Bégin (2008) classifies comparing (e.g., possible answers in this present study) and verifying and evaluating as implemental strategies. That is why, inspired by his study, I integrated verifying into the implemental strategies category.

Using a kinesthetic strategy (*N* = 6) was also classified as implemental because it is a type of comparison (such as comparing possible answers). Using this strategy, participants compare what is actually heard with what they imagine playing on their instrument. Cruz de Menezes (2010) reported the use of a kinesthetic strategy during melodic dictation. It was little used (*N* = 2), but well used (100% efficacy) in melodic dictation. As early as 1969, Gibson showed that some individuals reproduce what they hear on the basis of kinesthetic feedback. It follows that individuals may be able to identify tonal events by using tactile instrumental fingering associations. Having laid out the various main strategy categories that emerged in this study, we turn now to the work of Buonviri, who has also examined emergent dictation strategies for melodies, in order to compare and contrast what we have found.

Buonviri (2014) used a research design completely different from that of the present study, employing an interview protocol after the dictation task to permit six successful participants to describe the strategies they used during melodic dictation. The participants reported above all those strategies they believed to be efficient (therefore there was less emphasis on identifying the less efficient strategies). The real efficacy of the strategies reported in Buonviri's work was not actually calculated; but he describes some of the strategies found in this present study, although under different category names.

For instance, in his category task *prioritization*, Buonviri (2014) reported that his participants' plan of attack seems to have been set from the beginning, with alterations when necessary. For example, whether participants focused on pitch or rhythm, and whether they focused on the beginning, middle, or end of the melody, he reported that participants clearly chose their plan before they even heard the dictation. This corresponds to what

I have called procedural strategies and includes focusing on specific elements (bass, soprano or chords). However, the procedural strategy used to start harmonic dictation seems to be chosen after hearing the task, not before as in Buonviri's melodic dictation work. In my research, I observed that the same participant could start to write different dictations by using different strategies, adapting to what he or she had heard. In agreement with Buonviri's observations, the participants in this study made changes in procedural strategies during dictation.

In his category *attention direction*, Buonviri reported (2014) the importance of participants' focusing their attention on what they deemed most important while ignoring other distracting aural information. Keeping an open mind in preparation for the first listening heightened their attention to missing information and their ability to recognize patterns. In my study, keeping an open mind in preparation for first listening was also categorized under procedural strategies as listening to the whole dictation the first time. However, it was not the most used procedural strategy in my study (N=9).

About his category *skill coordination*, Buonviri (2014) observed that participants used musical skills learned through performance and academic studies to process musical percepts accurately, and that they coordinated these cognitive skills when checking their completed work. For example, two participants reported being able to hear notes internally, an ability which they used to sing them back later. Inner singing or silent singing was the primary mode of checking work for most participants. Participants also discarded wrong possibilities in search of the correct pitch or rhythm. Once again, I categorized these observations otherwise, on the basis of the literature review. For example, music knowledge in my study is a component of tonal strategies, especially because they relate to tonal context. Verifying strategies and comparing possible answers have been classified as implemental strategies, as by Bégin (2008). Singing (overtly or internally) I classify among tonal strategies, according to what the participants sang (degrees or harmony). Moreover, the singing strategy was used not only to check answers, but also to memorize the harmonic dictation, to find the tonality, and for other operations (following the individual lines melodically, especially the bass).

Brief summary of analyses of strategy efficacy

The methodology used in our study allowed us to measure the effectiveness of a wide range of dictation strategies for the first time. From the four main categories that emerged from the qualitative analyses, *Tonal strategies* were more efficient when compared with other strategies in both conditions, pre- and post-test. Participants using tonal strategies were more successful in solving dictations on both occasions. The procedural strategies were not related to performance in dictation under either condition; only starting with the bass seemed to be better than having no strategy at all (on moderate-level dictation on the post-test). Moreover, even if no significant differences were found among the other procedural strategies, some trends were observed: starting with the soprano led to poor results, starting with the bass, or with the chords led to better results, and describing no strategy was the worst choice. On the pre-test, performance in dictation negatively correlated with age at start of formal musical but did not correlate directly with the number of strategies. On the post-test, performance in dictation correlated with the total number of strategies and, separated by type, with tonal and procedural. Linear regression also revealed these same strategies as predictors of success in dictation. The use of non-tonal was a predictor of failure in dictation, and implemental strategies did not explain the variance on dictation results. However, the ANOVA of efficacy of strategies reported non-tonal strategies as neutral, implemental as inefficient, and tonal as efficient strategies. That is, when counted once, the use of one non-tonal strategy did not change chord results, the use of one implemental decreased them, and the use of tonal strategies increased them. However, when the number of different strategies was counted, the more non-tonal strategies were used, the lower dictation results; the number of implemental strategies did not affect dictation results; and the use of tonal strategies, even one single strategy, increased results in dictation. The number of procedural strategies used was also related to success in dictation results.

Correlations of memory tests, strategies, and harmonic dictation on pre- and post-tests

In the comparison of musical and non-musical tests on both the pre- and post-tests, participants performed better on the musical memory test than on the non-musical memory test. It is possible that their familiarity with the tonal system helped them to produce better results on the musical memory test. A small, non-significant increase in both memory test scores was observed between the pre- and post-tests.

Participants' performances on the *musical* and *non-musical memory tests* were correlated. Even if they performed better on the musical memory test than on the non-musical one, it seems that the memory capacities for both types of auditory stimuli are related, and participants who performed better on the musical memory test also performed better on the non-musical.

On the pre-test, neither musical nor non-musical memory correlated significantly with the harmonic dictation results, nor with the number of strategies. Musical memory scores correlated only with results in dictation on the post-test (r_s = 0.411, ***p* = .002**), whereas non-musical memory did not (r_s = .213, *p* = .115). This indicates that participants who performed better on the post-test had larger musical memory capacity.

We can ask why, on the pre-test, we did not obtain the same relationship between musical memory and results in dictation that we obtained on the post-test, since the performance on the musical memory test itself was effectively the same at both times. One reason could be that, even if the musical memory capacity had the same potential on both occasions, it was not well activated and used on the pre-test to solve dictations. On the post-test, musical memory capacity was better activated and used to solve dictations. Corroboration that this might be so comes from participants' having observed an increased number of strategies that demanded more auditory memory to use them, i.e., to compare stimuli from dictation with musical knowledge recovered from long-term memory, and to manipulate the strategies chosen. Indeed, correlation analysis showed that the *number of strategies* used correlated with the *performance in dictation* and with *musical memory* only on the post-test. On the pre-test, there was no correlation between the number of strategies used and musical memory or performance in dictation. These results incline us to think that on the pre-test, the musical and non-musical memories were as large as on post-test, but not used with *enough strategies* to lead to better performance in dictation. On the post-test, the mnemonic abilities of the subjects became relevant to the *use of more strategies* in a way that was not the case on the pre-test. That is, participants who learned more strategies used more of their memory capacity to apply their new strategies. Finally, participants who performed better on harmonic dictation on the post-test privileged more tonal strategies (r_s =. 411, ***p* = .002**) and procedural strategies (r_s = .313, ***p* = .019**). Furthermore, the number of non-tonal strategies did not correlate with any auditory memory. This may be because, as perceptive strategies by definition, non-tonal strategies do not demand as much from auditory working memory as do tonal and procedural strategies.

Predictive variables of number of strategies

*Starting age of **informal** musical* studies correlated only with starting age of formal studies, which means that participants starting their informal musical studies earlier also started their formal studies earlier. However, starting age of informal musical studies was not related to performance in dictation or any of the other variables studied.

Concerning *starting age of* formal *musical studies*, participants who started their formal music studies earlier performed better on the difficult-level harmonic dictation on the pre-test and on the overall dictation average on the post-test. This means that starting musical studies at an early age is related to developing good hearing for harmonic dictation, rather than the number of years of studies. Participants who performed better in dictation on the pre-test also performed better on the post-test. In short, strong participants tended to be internally consistent and remained strong across the semester.

Summary of all predictive variables of harmonic dictation results on pre- and post-tests

After correlations, a model was created and verified using General Linear Model analyses. Analysis of variance was done to verify the observed tendencies. We integrated memory test results, number of strategies, and other variables from the questionnaire as predictive variables on performance in dictation. Significant results are discussed below.

On the pre-test, *starting age of formal musical* studies was the first variable to explain the variance of performance in dictation (***p* = .010**). Then, controlling for the starting age of formal musical studies (*M* = 14.49), the participant's *instrument* explained in second place the variance on performance in dictation (***p* = .041**). There was a significant difference between percussion and the other two instrument categories: melodic instruments and harmonic instruments. Participants who played percussion performed better than participants who played melodic or harmonic instruments, after controlling for age. There was no significant difference between melodic and harmonic instruments. The same relation was observed in Cruz de Menezes (2010) concerning melodic and harmonic instruments. There was no difference between these categories on melodic dictation. However, the tendency observed for percussion instruments was the opposite. In melodic dictation, the percussionists' scores were lower than those of the melodic and harmonic instrument players; but that study did not control for age, as was done in this study.

On the post-test, variables that explained performance in dictation positively were the *number of procedural strategies (p = .012)*, *musical memory (p= .29)*, and the *number of tonal strategies (p=.033).* Better performance on harmonic dictation, after the students had received three months of ET training in courses, was predicted by the number of procedural strategies in first place, then by musical memory capacity, and thirdly by the number of tonal strategies. The more tonal and procedural strategies the participants used, the more the musical memory was activated, and the better were the results on harmonic dictation. Conversely, the number of non-tonal strategies used on the post-test accounted for the worst results. The more non-tonal strategies used, the worse were the results on harmonic dictation (***p* = .032**).

In summary, the variables that explained the performance in dictation were not the same on the pre- and post-tests, suggesting an effect of taking ear-training courses during the semester; but the same tendencies were observed by different analyses concerning the pre- and post-tests. The results of analysis of variance confirmed the tendencies reported by the correlations, adjusting the model created from the correlations (see Figure 3.28. Final model of predicting dictation results in pre- and post-tests). On the pre-test, in both analyses (correlation and analysis of variance), we observed the relationship between *starting age of formal musical studies* and performance in dictation. Participants' instrument was also a predictive variable in the analysis of variance, after controlling for starting age of formal musical studies. This relationship with instruments was not analysed in correlation because it is a categorical variable and was added only in the analysis of variance. Whereas on the post-test, performance on dictation appears to be related to the number of procedural strategies, the musical memory capacity, and the number of tonal strategies used. Indeed, as has been observed in previous studies about melodic dictation, the most successful participants have a more holistic approach to solving melodic dictation and use many strategies at the same time (Cruz de Menezes, 2010; Cruz de Menezes et al. 2016; Cruz, Bissonnette, Guiton, & Moreno Sala, 2009; Potter, 1990). Also, Cruz de Menezes and Moreno Sala (2016) reported a relation between visual and auditory memory capacities in the highest-performing subjects in melodic dictation.

Gender

Gender was among the basic information obtained from the questionnaire and we included gender as a factor in the ANOVAs on harmonic dictation results to see if there were any differences of performance between males and females. There was no significant difference between female and male participants concerning performance on figured bass dictation, as was also reported by Cruz de Menezes (2010) for melodic dictation, unlike the findings of Murphy (1989), who reported better performance among males. This probably means that in 2010's men and women may have the same opportunities for musical education in Quebec, with a more complete and elaborate musical curriculum, including ET courses.

Ear-training courses

In this section, we will discuss the results observed across time concerning strategies, performance in harmonic dictation and memory tests, and their relationship to ET courses. On the post-test, all the participants performed better (***p* = .004**) and used more strategies (***p* = .001**), according to results of the *t*-tests. This suggests that ET courses contributed to participants' improvement of their performance in harmonic dictation and helped them to increase the number of strategies used to solve harmonic dictations.

It seems that in a single semester of university ear-training courses, participants developed more strategies to solve harmonic dictation. This did not depend on a specific treatment, but only on the fact of practicing harmonic dictation each week. The acquisition and application of new strategies may have imposed a greater load on participants' auditory working memory through the need to activate or manipulate their strategies and to compare them with stimuli and musical knowledge recovered from long-term memory. Both the number of strategies and musical memory capacity were related to better performance in dictation on the post-test. It seems that after the first session of university ear-training courses, the starting age of formal musical studies had diminished relevance to performance in harmonic dictation.

Consequently, university ET courses appear to compensate for participants' disparity in years of prior musical studies, providing students with strategies that demand more from working memory during the transcription of harmonic dictation. Participants who were able to use more strategies on the post-test had larger musical (r_s =.461, ***p* =.000**) and non-musical (r_s = .306, ***p* = .022**) memory capacities. However, the performance in dictation related only to musical memory (not non-musical). Participants who performed better on dictation on the post-test had a larger musical memory. These findings suggest that only the contribution of musical memory is important to performance in harmonic dictation (***p* = .002**), but both non-musical and musical memory (strongly) are important to the number of strategies used.

Since participants who performed better on the pre-test also performed better on the post-test (r_s = .685, ***p* = .000**), and an increase in their dictation results was observed by the *t*-test ***(p = .004)***. The relation between their performance with different variables depending on the condition (pre- and post-test) could be explained as follows. On the pre-test, the participants who started their formal musical studies earlier performed better on dictation because of the factors mentioned by Sweller (1988). Sweller stated that a strong problem-solving ability is the solver's familiarity with the problem type. Experienced problem solvers have better developed problem schemas, which can be employed more automatically. Automatism could explain the lack of relation with auditory memory on the pre-test, as it did not use memory capacity. In contrast, during ET courses, students acquired new strategies (as reported by the *t*-tests) that demanded more from auditory working memory on the post-test to use the learned strategies, and the musical knowledge to solve harmonic dictation, increasing even more their performance. Montreuil (1994) analyzed the use of strategies in relation to certain mechanisms in the human cognitive system and reported that the use of strategies could be especially influenced by the capacity of retention and manipulation of short-term information, i.e., working memory, which supports our findings.

Pedagogical contribution of the study

This research reports the large *variety of strategies* participants used to solve harmonic dictation. Therefore, the strategies described in this thesis are the ones students beginning their university courses use in a real-life task. No specific treatment was imposed, but all the students participated in university courses during 13 weeks of normal ear-training instruction, including harmonic dictations, with two instruction sessions per week in both institutions for a total of 26 sessions. The positive results concerning the efficacy of certain types of strategies could have a great impact on the field. Helping teachers to become aware of the strategies' utility and assisting ET professors to focus on better strategies they could use in their course might increase success rates in this task.

Of the four types of strategies found in this research, *Tonal strategies* proved to be the most efficient. The use of even one strategy of this type improved performance on dictation more strongly than a single strategy from the other main categories (non-tonal, procedural, implemental). Moreover, the more types of *tonal strategies* used, the better were the results in harmonic dictation. Conversely, the main category of *Non-tonal* strategies at first seemed neutral in analyses counting each type of strategy only once, but was related to the worst results when many *non-tonal* strategies were used. Concerning *Procedural strategies*, flexibility in changing procedural strategies in order to adapt the procedure to what was heard, rather than working all the time in the same way, proved to be important for success in harmonic dictation. Besides flexibility, the total number of procedural strategies was also related to success in this task. It is to be noted that *which particular* procedural strategy was used to start the harmonic dictation was not important (i.e., whether a participant started with the bass, soprano, or chords); however, compared to not describing any strategy to start the dictation, starting with the bass proved to be more efficient. These findings converge with those of previous studies on melodic dictation. Some authors have reported that to identify intervals in melodic dictation, not describing any strategy was related to failure (Cruz de Menezes, 2010; Cruz de Menezes et al., 2016; Cruz de Menezes et al.,2009). The use of a single tonal strategy led to success, whereas using non-tonal strategies led to failure (the more non-tonal strategies used, the worst were the results in dictation). Dowling (1986) observed that music professionals have a flexible system of strategies. Indeed, in this study performance in dictation is positively related to the number of tonal and procedural strategies. The highest-performing participants used a more varied repertoire of tonal and procedural strategies, suggesting that they possess a more flexible system of strategies to adapt to the stimuli. Moreover, from the pre-test to the post-test, there was an increase in the number of strategies, which indicates that developing and/or learning new strategies is possible. The increase in the dictation results between the pre- and post-tests also suggests that ET courses are important to improve musical hearing and labeling. These findings also support the importance and the place of ET courses in universities as very important courses to develop hearing abilities in a professional curriculum.

Overall, the teaching of tonal strategies should be prioritized in ET classes, as tonal strategies have been proven to be more efficient than non-tonal strategies in both this study and others (Cruz de Menezes, 2010; Cruz de Menezes et al., 2006; Cruz de Menezes et al. 2009; Moreno Sala & Brauer 2007; Potter, 1990). For example, professors should stimulate students to identify cadences, listen by degrees instead of intervals, and keep in memory the tonic to compare with other chords. In addition, as suggested by Karpinski (2000), a voice leading approach and harmony would be the best way to take figured bass dictation. Voice leading and harmony involve developing perception of voice leading and its relationship with harmonic function, which in turn suggests that listeners follow and write the bass and trace certain voices at specific crucial locations to draw conclusions about chord functions. This approach is also to be favored in ET courses, because it combines an increase in the number of procedural strategies with the use of many tonal strategies. When participants write the bass and trace other voices, they change procedural strategies as they adapt their listening to the stimuli. They listen to the bass, then, at some strategic point in the harmonic progression, to the soprano or other voices, for example, when hearing an altered note, increasing by the end of the listening period the number of procedural strategies. Participants switch which voices they listen to at important points in order to understand the relationship between voices, and of both voices to harmonic function. Tonal strategies are, by definition, used to identify notes or chords by comparing or associating them with the tonal context of the dictation. If the association of writing the bass with listening to other voices in certain important moments is made by tonal strategies, students will probably achieve better results in harmonic dictation.

Limitations of the research, recommendations for future studies

In this section, we will first discuss some limitations of this research, such as musical activities that might be used as a predictive variable for harmonic dictation results, and the lack of specific treatments in ET courses between the pre- and post-tests. Then, we will discuss possible future research divided into three themes. The first theme relates to our results: the inefficacy of implemental strategies (when counted once), suggesting cues to future research; the potential contribution of studying subcategories of the four main categories of strategies; the important influence of starting formal musical studies early and the possibility of studying strategies in children. The second theme relates to the area of harmonic dictation, for example, using other instruments in class, and integrating real music in activities. The third theme relates to other pedagogical levels (such as teenagers and children) and the need to develop a methodology to study strategies used by children.

The variables in this research were fairly comprehensive for the required task: strategies, dictation results, auditory memory tests, participants' instruments, musical genre, number of years of study, starting age of formal musical studies, and starting age of informal musical studies. They proved to be important variables in the project, as they allowed us to observe an increase in harmonic dictation results after one session of ear training. The results also revealed that the best dictation results on the post-test were explained by the number of procedural and tonal strategies, and by musical memory capacity.

However, other activities/variables that might potentially explain an increase in harmonic dictation results pre- to post-test were not measured, such as: the number of hours participants practiced their instruments per week; the number of hours participants played in musical groups per week; and whether they were taking music theory classes, or practicing ET outside classes. All of these (and possibly other elements) could contribute to improving hearing strategies and harmonic dictation performance. The possible contribution of such variables, and other related musical activities, should be included in future research. Krumhansl et al. (1982) observed no significant individual differences based on theoretical knowledge or musical experience of their participants in perceiving harmonic stability and musical tension. In other words, there was no musician advantage for those with the most training compared to those with the least. To test this observation, in future research, it would be best to account for as many activities and variables as possible that could impact participant performance on harmonic dictation tasks.

Another aspect of this study that could be viewed as a possible limitation (although it was a planned element of the design) is that the teaching strategies used by each professor, at Laval University and Concordia University, were not controlled between the pre-test and the post-test. This was done specifically because we did not want to do a study focussing on teaching methods. Rather, we wanted to ascertain whether, by the post-test, there might be any impact of ET classes, even if teaching approaches were not specific treatments assigned by the researcher. In any case, the ET professors did not yet have any scientific data to rely on as to which teaching strategies were most effective for student success in dictation.

Even now, after seeing that tonal strategies are the most effective in this study for taking harmonic dictation accurately (and they may well be the best strategies to work on in ET courses), it could be problematic to test the effect of the more efficient strategies with multiple groups including a control group. It would not be ethical to provide only some students with a teaching approach focused on a strategy known to be efficient while other students did not receive the same education opportunity. This could be approached with very short-term studies; but, on the other hand, it might now allow enough time for changes in strategies and the ability to manipulate them in participants' memory.

Concerning *Implemental strategies*, all the subcategories of this main category should be analyzed separately to verify the efficacy of each subcategory individually, as this is a new category of strategies used during figure bass dictation. This analysis would provide us with details about each subcategory's efficacy in order to suggest pedagogical cues on which subcategory to privilege in ET courses. Our analyses of the main categories' efficacy suggest that implemental strategies are inefficient. However, this analysis counted each type of strategy (tonal, procedural, non-tonal and implemental) only once and the first implemental strategy used in dictation. This means that *verifying strategies* were only counted if the participants did not use another implemental strategy first, because verifying strategies are normally used at the end of a dictation to check the answers. Moreover, it remains to be determined whether, in a harmonic dictation situation, *verifying strategies* are as efficient as they seem to be for solving intervals in melodic dictation (Cruz de Menezes, 2010; Cruz de Menezes et al., 2016; Cruz de Menezes et al., 2009). In fact, authors have studied the combination of strategies to solve intervals in melodic dictation. The more types of strategies combined, the better were the results; and tonal strategies increased the results even with the utilization of one strategy of this type. From these results, authors have suggested that verifying strategies would be an efficient strategy; but no study has focused specifically on verifying strategies. At some level, *verifying* seems to be different from the other strategies in this category. Participants already have their answers and want to check them—that should actually be a good thing, but it can also be a bad thing, depending on which strategy they choose to use in verifying (tonal, non-tonal, or implemental). Probably, if participants choose *tonal strategies* to verify, it would be efficient, if they choose *non-tonal*, less efficient. For other implemental strategies, such as *comparing possible answers*, participants do not yet know what the answer is; they are looking for it and trying tonal and non-tonal strategies without having decided. Such an approach may indeed not be efficient. The strategy of *evaluating the difficulty level* seems to show that the task is difficult; if participants have difficulty solving the task, this may produce poor scores. In the same way, in *making negative judgment on one's own answers*, participants reported they did not get the right chord, a strategy again related to poor scores. Instead of looking for answers related to the chords they had not yet found, they were wasting time on chords that seemed not to be right and were probably forgetting the stimuli (musical extract). In the same way, when participants were *evaluating time to solve dictation*, they reported that they did not have enough time to do it, which is perhaps because they thought it was too difficult; and this is again related to poor scores. Using *kinesthetic* strategies and *verifying* strategies could be better understood. Participants seemed to use their kinesthetic memory to find notes; and that might or might not be a good thing, depending on the quality of kinesthetic memory. The role of verifying and kinesthetic approaches is at present unclear, and future research is needed. Overall, even if in the analysis of strategies counted only once, *Implemental strategies* seemed to be less efficient, the *Number of implemental strategies* did not explain the variance in *Dictation results.* Success in *Dictation results* was explained by the *Number of tonal* and *Procedural strategies,* while failure in *Dictation results* was explained by the *Number of non-tonal strategies*.

Further exploration of the efficiency of all the subcategories of the three remaining main strategy categories (*Tonal*, *Procedural*, and *Non-tonal*) would add to our knowledge of which subcategories are the most useful. For example, studying separately the compared efficacy of some *Tonal strategies*, such as identifying degrees, singing the scale or degrees, or using moveable do, could provide information on which are the most efficient in order to prioritize their teaching in ET courses. Consequently, further research should give teachers more details about the most efficient main category of strategies and indicate which subcategories of the four main categories should be prioritized in ET courses. For now, in a general way, *Tonal strategies* have proved to be the most efficient, since the utilization of even one such strategy improved results. Furthermore, the more types of *Tonal* and *Procedural* strategies used, the better were results in harmonic dictation. On the basis of these new cues, it is important to develop teaching materials to facilitate the learning of *Tonal strategies* and leading voice and harmony approach in ET classes.

Another important variable in this study was the *Starting age of formal musical studies*. Participants who started their musical studies earlier had better results in dictation on the pre-test. Given the importance of this result, studying the strategies used by young children and developing pedagogical materials to work with children would be interesting. Furthermore, the methodology used in this project could be used with teenagers and in colleges or secondary schools. Nevertheless, Think Aloud is not an appropriate tool for children, as reported by Van Someren, Barnard, and Sandberg (1994). To work with children, it is necessary to develop an adapted methodology and measurement tools to collect information about strategies used during musical dictation and musical listening.

Other future research in the area of harmonic dictation could observe whether using other instruments and multi-instrument orchestrations (beyond piano) to deliver the dictation materials would increase dictation results and the subjects' ability to play music by ear in real-life situations. Using real music in ET courses could improve students' inner audition (the ability to hear musical relationships with precision and understanding (Rogers, 1984)). Also, if students use a keyboard or their own instrument to *play back* the progression they are hearing, it might help them find chords more easily.

In closing

The study of young adult musicians taking harmonic dictation has not been much done in the field of music education research, or in the field of music perception and cognition research. It is hoped that the present study will instigate replication, as well as much future research, as proposed in this conclusion. The proposed extensions of the results in this thesis would enrich our understanding of strategies used in harmonic dictation in addition to creating teaching materials to encourage learning tonal strategies and leading voice and harmony approaches. The proposed research in harmonic dictation would document the effects of other tasks and stimuli in musical listening and harmonic dictation at different levels of teaching and learning, as well as contribute to developing new methodologies to study listening strategies, especially in children.

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Appendix A- Recruitment announcement

Hello, my name is Ruth Cruz de Menezes. I am here today to invite you to participate in my Doctoral research. The participation is volunteer, not obligatory, and takes place today in class time, plus one other later date (December).

The TITLE OF MY RESEARCH is: Analysis of cognitive strategies used by students in the transcription of musical harmonic dictation, and the memory span which might influence their performance. The project is for my Ph.D. in music, directed by Dr. Maria Teresa Moreno Sala (Laval University). Codirected by Dr. Christine Beckett, and in collaboration with Dr. Patrick Bermudez of BRAMS lab.

PROJECT INFORMATION: This study is for students enrolled in ear training starting their Bachelor music program. It involves participation in three tests: a dictation test during which you write statements about your strategies, and two memory tests. There is also a short questionnaire for identification and basic info.

The project has several aims. The first aim is to analyze how students do harmonic dictation, by studying their strategies. The research tries to access the thinking of the students through the written statements. The second aim is to investigate if auditory and/or musical memory spans influence how effective the strategies are. A third aim is to retest participants some months later, again during an ear training class, to see if there is improvement and whether the improvement is linked to specific strategies. Finally, if I am allowed to use the final dictation ear training marks for academic years 2012-2013, 2013-2014 I can compare course results with research study results.

Finding out which strategies prove to be the most efficient for harmonic dictation could suggest to professors wihich strategies to emphasize in teaching harmonic dictation. So the study could lead to tools for students who are looking for effective solutions for their difficulty in this task.

YOUR PARTICIPATION: Participation in this study is ***on a volunteer basis***, which means there is no remuneration and it is not a required part of this ear training course. Results obtained in all test sessions are important to this research, but you remain free to end your participation at any time without having to justify stopping, and with no negative consequences. Volunteers' role in the research is simply to participate in test sessions. There is no risk involved.

STATEMENT ABOUT PRIVACY: Your participation in this project is ***confidential;*** it will never be possible to identify you. Your professors will never have access to test results. This research is completely independent of the curriculum and is in no way be connected to your courses or academic assessments. The data collected are reserved for the exclusive use of this project until Dec 31, 2015. After this date, they will be destroyed.

CONTACT INFORMATION: If you have questions about the research, the implications of your participation, or results, contact:

Ruth Cruz de Menezes: ruth.cruzdemenezes.2@ulaval.ca, or

Maria Teresa Moreno Sala: maite.moreno@mus.ulaval.ca, or

Christine Beckett: christine.beckett@concordia.ca

ETHICALA PPROVAL: This project was approved by the Ethics Research Committee of the Université Laval: No. of approval: 2012-281 / 07-02-2013; and of Concordia University: and of Concordia University: No. of approval: 30001948

THANK YOU for listening. Your cooperation is indispensable for us to conduct this study, and to those who volunteer, we gratefully thank you for your participation.   WHAT ARE YOUR QUESTIONS?

Appendix B- Consent Form

TITLE OF THE RESEARCH: Analysis of cognitive strategies used by students in the transcription of musical harmonic dictation and the memory span which might influence their performance.

Presentation of the researcher and the context:

Student researcher: Ruth Cruz de Menezes, a doctoral student in Music Education.

This research is carried out in the framework of her doctoral study under the supervision of Maria Teresa Moreno Sala, Faculty of Music at Laval University.

Researcher members of a research team: Christine Beckett, codirector of research, Concordia University, Patrick Bermudez, project collaborator for testing auditory memory

Introduction

Before agreeing to participate in this research project, please take the time to read and understand the following information. This document explains the purpose of the research project, its procedures, potential advantages and disadvantages. We invite you to ask the person who presents this document any questions that you consider useful.

Nature and objectives of the project

This study concerns students enrolled in ear training starting their Bachelor of Music. First, this project aims to analyze how students arrive at transcribe musical harmonic dictations. It is studying the cognitive processes involved in this task, such as strategies. To do this, it is necessary to access the thinking of the students by their statement. Second, it will be investigated if the auditory and/or musical memory span may influence the efficacy of the use of the strategies. Third, if allowed, the use of the results in the writing examinations of ear training during the academic years 2012-2013, 2013-2014 will allow us to compare these results with those obtained in the specific tests of this study. In addition, retesting students after a few months will allow us to determine whether there has been improvement in the tests results.

Conducting of participation

This study takes the form of two testing sessions that each comprises a music test and two memory tests. The first testing will be administered in a 75-minute session while the second one in a 60-minute session. Both of sessions will be conducted during the ear training classes. In addition, before the first testing period, a short questionnaire will be administered for the purpose of identification (name, gender, primary instrument, years of musical studies, possession of absolute pitch), as well as a training with the chosen approach.

Summary table of participation

First testing (September)		**Second test (December)**	
Training	5 minutes	Musical Test	30 minutes
Questionnaire	5 minutes		
Musical test	30 minutes		
Memory tests	30 minutes	Memory tests	30 minutes
Consent Form	5 minutes or more		

Possible advantages and disadvantages of participation

Among the benefits of participating in this research, it is possible to know the results. A summary of results will be sent to interested students. This can allow students to discover a new way to improve their strategies and consequently improve their performance in dictation. In addition, participating in a research can motivate students to continue their post-graduate studies.

Participation in this study involves no risk. Moreover, given that the tests will be administered during the course of ear training, students will not have to move outside of previously scheduled class times. In addition, a report outlining the results of this study will be released at specialized conferences. Thus, the results disclosed will allow ear training professors to better understand the underlying factors in the resolution of musical dictation; so, this understanding is likely to guide their pedagogical choices to help students to overcome their difficulties.

Right to withdraw

You have the right to refuse to participate in this study or to withdraw from this study at any time without having to provide any particular reason or to suffer any prejudice. In case of withdraw, the student researcher will check with the participant concerned if he agrees that his data should be retained for study or if he prefers them to be destroyed. If you want to withdraw from this research, you can contact the student researcher (Ruth Cruz de Menezes) or her thesis supervisor (Maria Teresa Moreno Sala) or her codirector (Christine Beckett) by email. On the other hand, you have the freedom to revoke the specific consent for the use of the results obtained in the writing examinations during ear training (2012-2013, 2013-2014), and maintain your consent to participate or not in the project.

Privacy and data management

Regarding the confidentiality of information provided by the participants, the following measures are planned:

- The names of the participants will not appear in any report;
- A unique code will be used in the various documents of the research to identify the participants. Only the student researcher will have access to the list of names and codes;
- In no case the individual results of participants and participants will not be disclosed to anyone or be divulged;
- The data will be preserved during the years of the PhD program of the student researcher, until December 2015. However, they will be destroyed immediately after this period. In addition, if the participant wishes to withdraw from the study, the data will be destroyed, if desired;
- Computerized and anonymous files containing research data in digital format will be protected by a password. Only the student researcher and co-researchers (Maria Teresa Moreno Sala, Christine Beckett, Patrick Bermudez) will have access to the password for analysis;
- The research will be the subject of publications in scientific journals, but no participant will be identified;
- Professors will never have access to test results since this research is completely independent of the curriculum. You will in no way be connected to the courses or academic assessments.

Any questions about this project can be addressed to the researchers:

Ruth Cruz de Menezes (student researcher): ruth.cruz-de-menezes.2@ulaval.ca
Dr Maria Teresa Moreno Sala: maite.moreno@mus.ulaval.ca
Dr Christine Beckett: christine.beckett@concordia.ca

Your cooperation is precious for the realization of this research. Thank you for the time and the attention that you have put into your participation.

I Yes_____/No______ freely consent and authorize the use of the results obtained in written examinations during ear training classes followed at the Faculty, and a copy of my examinations to connect them to the results obtained in this research (2012-2013 , 2013-2014).

I undersigned ____ freely consent to participate in the research entitled " Analysis of cognitive strategies used by students in the transcription of musical harmonic dictation and the memory span which might influence their performance." and authorize the use of the results obtained in these tests for this search. I have read the form and understand the purpose, nature, advantages and disadvantages of the research project. I am satisfied with the explanations, clarifications and answers that the researcher has provided me, as appropriate, regarding my participation in this project.

____ ________

Signature of the participant Date

____

Name of the participant in capital letters.

I have explained the purpose, nature, advantages and disadvantages of the research project to the participant. I have answered to the best of my knowledge the questions raised and I have checked the understanding of the participant.

____ ________

Signature of the researcher Date

This project has been approved by the Research Ethics Committee of Laval University: No. of approval: 2012-281 / 07-02-2013, and of Concordia University: No. of approval: 30001948

Any plains or critics may be addressed to the Office of the Ombudsman at Laval University. this process will be treated confidentially.

Bureau de l'ombudsman

Pavillon Alphonse-Desjardinsm Bureau 3320

Renseignements – Secrétariat : 656-3081

Courriel : ombuds@ombuds.ulaval.ca

Appendix C- Read Instructions of Tests

Questionnaire

"Please, answerer the questionnaire on the first page of your answer sheet. You have 5 minutes. Do not hesitate to ask question if you have any doubts".

Training to the musical test

"The first dictation of four is for training and will be repeated 4 times. Between repetitions, there is 1-minute pause to give you time to write. Questions? Before starting the musical test, itself, I will check if you have other questions. Start your statements where it says Training to the musical test."

Musical test

"Please write everything that you think while transcribing the harmonic dictation. Please use blank pages of your answer sheet to write your statements. First, write your strategies to find the chords (for example, if you think of a familiar song, or if you perceive the tension of the chord, or use other reasoning). Then, write the bass notes names, and the chords in the order they occur to you. If you find first the notes of the bass, write them down, the chords or vice-versa, depending in the order you hear them. You can write the chord and the bass note in the notation of your choice, such as Roman numerals, or jazz notation, or even in words. (Show examples if necessary). Questions?"

"You will transcribe three different dictations. Between repetitions, there is a minute pause to give you time to write. The first dictation will be played four times, the second 6 times, and the third 8 times. Before each new dictation, you will hear four beats to indicate the change of dictation. Please number each dictation from 1 to 3. The dictations beginning on G in the bass. Questions?"

Memory test

"Now, to the gray grid at the end of your answer sheet. You will hear 120 pairs of sound sequences: each sequence will be played 2 times. Listen carefully to the two repetitions, and then indicate on the grid if the second sequence was the same or different from the first. Mark an x in the column corresponding to the answer. Before starting each pair of sequences, you will hear a voice telling you where we are, for example, 1, 2, 3, etc. Questions?"

Appendix D- Questionnaire and Answer Sheet of Tests

Questionnaire and Musical test

Name:

Before starting the musical test, please answer the questions below:

1) Gender:_______________________________

2) Instrument:_____________________________

3) Musical genre:___________________________

4) At what age did you begin studying music (informally, if applicable)?

5) At what age did you start taking formal music courses?

6) For how many years have you studied music – formal course? (Considering the yeras you stopped, if applicable)

7) Do you have absolute pitch?

TRAINING TO THE MUSICAL TEST

MUSICAL TEST

Memory test

Name:

Sequence	Same	Different
1		
2		
3		
4		
5		
6		
7		
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11		
12		
13		
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16		
17		
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24		
25		
26		
27		
28		
29		
30		

Sequence	Same	Different
31		
32		
33		
34		
35		
36		
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57		
58		
59		
60		

Name:

Sequence	Same	Different
61		
62		
63		
64		
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66		
67		
68		
69		
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71		
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88		
89		
90		

Sequence	Same	Different
91		
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93		
94		
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