Beginnings, middles, and ends: Perception of intrinsic formal functionality in the piano sonatas of W. A. Mozart

Michel Vallières

Schulich School of Music

McGill University, Montreal

August 2011

A thesis submitted to McGill University in partial fulfillment

of the requirements of the degree of Doctor of Philosophy

Abstract

This dissertation investigated the perception of intrinsic formal functionality—the out-of-context projection of beginning, middle, and end functions—in the piano sonatas of W. A. Mozart (1756–1791). We explored three core issues: (1) listeners' capacity to identify the formal function of out-of-context musical excerpts; (2) the effect of musical training (musicians vs. non-musicians) on the accuracy of functional judgments; and (3) the musical properties that influence musicians' and non-musicians' perception of beginning, middle, and end functions. These issues were addressed with listening experiments and statistical analyses of our experimental data.

Our first experiment was designed to address the first two issues. Participants heard excerpts taken from the beginning, middle, and end of themes from Mozart's piano sonatas and categorized them as a beginning, middle, or end. All functions were identified significantly and comfortably above chance level, but musicians fared significantly better than non-musicians in the evaluation task. Moreover, ends were, by far, the most accurately identified, while beginnings and middles seemed harder to distinguish from one another.

The second and third experiments sought to address the third issue mentioned above. We presented participants with modifications of Mozart's original excerpts. Each modification was based on a specific hypothesis regarding the form-functional role of a musical property. As in Experiment 1, participants categorized the excerpts as a beginning, middle, or end. We found a strong influence of tonal and harmonic factors on musicians' and non-musicians' perception of ends, but only on musicians' perception of beginnings and middles. Rhythmic, textural, and metric properties affected both groups' perception of beginnings and middles, but non-musicians relied on these properties to a greater extent than musicians. Overall, musical information located at the opening and closing time-points of excerpts was perceptually relevant for all three formal functions, whereas information located over larger time-spans was mostly used to distinguish beginnings from middles.

Experiments 2 and 3 also comprised two secondary tasks: for each excerpt, participants performed a speeded form-functional judgment task and a rating task whereby the strength of excerpts' form-functional expression was evaluated. Analyses performed on the data from these two tasks combined with analyses on participants' judgments from the main functional identification task suggested that although the three functions were evaluated within similar time delays, ends were generally more clearly expressed than beginnings and middles.

By combining music-theoretical concepts of form, stylistically relevant recompositions of Mozart's materials, and methodologies from cognitive psychology, this interdisciplinary study provides new and unique insight about the perception of musical temporality, a key issue in both fields of music theory and psychology.

Résumé

Cette thèse étudie la perception de la fonctionnalité formelle intrinsèque—la projection hors contexte des fonctions de début, milieu, et fin—dans les sonates pour piano de W. A. Mozart (1756–1791). Trois principaux problèmes sont étudiés : (1) la capacité des auditeurs à identifier les fonctions formelles (début, milieu, fin) hors contexte; (2) l'effet de l'expertise musicale (musiciens vs. non musiciens) sur l'exactitude des jugements de fonctionnalité; et (3) les propriétés du matériau musical influençant la perception des fonctions formelles chez les musiciens et les non musiciens. Ces problèmes sont explorés au moyen d'expériences d'écoute et de l'étude statistique des données expérimentales.

La première expérience examine les deux premiers problèmes énumérés ci-dessus. Les participants ont écouté des extraits tirés du début, du milieu, ou de la fin de thèmes provenant des sonates pour piano de Mozart et en ont identifié la fonction formelle. Toutes les fonctions ont été identifiées significativement et confortablement au-dessus du niveau de chance, mais les performances des musiciens ont été meilleures que celles des non musiciens. De plus, les fins ont été identifiées avec le plus haut taux d'exactitude, loin devant les débuts et les milieux, lesquels ont semblé plus difficiles à distinguer les uns des autres.

Les deuxième et troisième expériences explorent le troisième problème mentionné ci-dessus. Les participants ont écouté des extraits originaux auxquels certaines modifications avaient été apportées, chacune de ces modifications étant basée sur une hypothèse concernant le rôle fonctionnel d'une propriété musicale.

Comme pour la première expérience, les participants ont identifié la fonction formelle (début, milieu, fin) des extraits. Nos résultats ont montré une forte influence de l'harmonie et la tonalité sur la perception de la fonction de fin chez les deux groupes de participants, mais seulement chez les musiciens pour les fonctions de début et de milieu. Certaines propriétés rythmiques, métriques, et de texture ont eu un effet sur la perception des débuts et milieux chez les deux groupes d'auditeurs, mais les non musiciens se sont davantage fiés à ces propriétés que les musiciens. En général, l'information musicale située aux points temporels d'ouverture et de fermeture des extraits a été utilisée pour identifier les trois fonctions formelles alors que l'information située sur des espaces temporels plus étendus a surtout été utilisée pour distinguer les débuts des milieux.

Les deuxième et troisième expériences comprenaient également deux tâches secondaires : pour chaque extrait entendu, les participants ont fourni un jugement fonctionnel rapide et une cote évaluant le niveau de force de l'expression fonctionnelle. Nos analyses des ces données combinées à celles faites sur les jugements provenant de la principale tâche d'identification nous ont suggéré que bien que les trois fonctions formelles soient évaluées dans des délais similaires, la fonction de fin est exprimée plus clairement que les deux autres.

En combinant des concepts musico-théoriques relatifs à la forme, des recompositions stylistiquement pertinentes du matériau musical de Mozart et un cadre méthodologique propre à la psychologie cognitive, cette étude interdisciplinaire apporte des connaissances nouvelles et uniques concernant la perception de la temporalité musicale, un concept clé dans les domaines de la théorie et la psychologie musicales.

Acknowledgments

I want to thank my supervisors, William Caplin and Stephen McAdams, who offered me great support in pursuing this interdisciplinary project. I greatly benefited from Professor Caplin's outstanding knowledge of the high classical style and his rigorous approach to writing and editing. He made sure that the core issues of the project remained relevant to the field of music theory and that most of our results would be understandable by music theorists without a background in statistics. Professor McAdams provided me with the necessary resources to conduct the experiments reported in this dissertation, an inspiring laboratory environment, and expert guidance on experimental and statistical issues. I thank both of them for their remarkable availability towards the last stages of this project.

This study began as a group project in a graduate seminar by Professor McAdams on the perception of musical form. I thank my teammates Daphne Tan and Ian Bent for their great input in the early stages of the project. I am particularly indebted to Daphne, who pushed this project further by conducting the first experiment under the supervision of Professors Caplin and McAdams, and helped me designing and conducting the second experiment.

Bennett Smith programmed the various interfaces used in our three experiments and provided sound advice as regards their design. Jake Shenker contributed his ideas and assisted in the data collection and analysis for the third experiment. Bruno Giordano and Rhonda Amsel provided helpful suggestions and assistance with statistical analyses.

I am delighted to acknowledge the financial support of the Social Sciences and Humanities Research Council of Canada (SSHRC) and the Centre for Interdisciplinary Research in Music Media and Technology (CIRMMT). The research was also supported by a grant from the Natural Sciences and Engineering Research Council and a Canada Research Chair awarded to Stephen McAdams.

I would also like to thank my parents for their unconditional support, and Sophie, without whose patience, support, motivation, help, and love this project would not have been completed.

Contribution of authors

Chapter 2 and a part of Chapter 1 are based on materials from the following published article in a peer-reviewed journal:

Vallières, M., Tan, D., Caplin, W. E., & McAdams, S. (2009). Perception of intrinsic formal functionality: An empirical investigation of Mozart's materials. *Journal of Interdisciplinary Music Studies, 3*, 17−43.

This article presents the results of our first experiment. My colleague Daphne Tan and I co-designed this experiment, carried the data analyses, and co-wrote the article. Daphne Tan chose the stimuli and collected the experimental data. William Caplin supervised the choice of experimental stimuli and provided guidance for the interpretation of the data with respect to music-theoretical issues. Stephen McAdams provided the funding and laboratory equipment, and contributed to the conception of the experiment, the statistical analyses of our data and the interpretation of the results.

Table of contents

List of figures

List of tables

Chapter 1. Introduction

The idea that organized temporal modes of expression have a beginning, a middle, and an end dates at least as far back as Aristotle's *Rhetoric* and *Poetics*. From the middle of the 16^{th} century to the end of the 18^{th} century, theorists from the musico-rhetorical tradition such as Gallus Dressler (b. 1533) and Johann Mattheson (1681−1764) have discussed the parallel between the classical formal divisions of an oration—*exordium*, *medium*, and *finis*—and the beginning, middle, and end of a musical piece (Mattheson, 1981; McCreless, 2002; Vickers, 1984). More recently, Caplin (1998; 2009), based on the writings of Ratz (1973) and Schoenberg (1967), has embodied this tripartite paradigm in the concept of *formal functions*: the specific role—generally a beginning, middle, or end—played by a musical passage within the formal organization of the work.

A formal function in music can be identified in two ways: *contextually* and *intrinsically*. A *contextual* identification requires the assessment of a musical passage's immediate surroundings in order to determine its temporal expression as a beginning, middle, or end. For instance, a passage may be easily identified as a beginning if it opens a movement or a piece. An *intrinsic* identification involves comparing the passage's constituent elements with a set of norms—implicitly acquired by mere exposure to music or explicitly learned through formal musical training—that link certain musical properties to specific formal functions. Though this distinction between two types of formal functionality seems theoretically viable, one might wonder whether such an association between a passage's internal elements and its specific temporal location within the structural hierarchy of the work can be sustained solely on aural information derived from a real-time listening experience. As a first step in the investigation of this issue, the present study explores the ability of listeners to perceive the out-of-context expression of a temporal location, henceforth termed *intrinsic formal functionality*. To do so, we use an experimental methodology in which listeners hear out-of-context excerpts and categorize them as a beginning, middle, or end.

INTRINSIC FORMAL FUNCTIONALITY: BACKGROUND IN MUSIC THEORY

Partly due to its high level of stylistic conventionality, the music of the high classical period (c.1775–1810) has received a substantial amount of scholarly attention from music theorists and historians. As regards musical form, several authors have inquired into the relationship between certain properties of the musical materials and specific temporal locations (e.g., Berry, 1976; 1989; Bonds, 1991; Hatten, 2005; Koch, 1969; Rosen, 1988; 1997; Sisman, 1982; Stoianova, 1978). Others have pushed this relationship between materials and temporal function one step further and have proposed that, as an entirely bottom-up process, a passage's musical materials can express an intrinsic temporal location, regardless of its original contextual position (Agawu, 1991; Caplin, 1998, 2009; Hatten, 1994; Kramer, 1973, 1981, 1982, 1988; Lochhead, 1979; Levy, 1981; 1982; Meyer, 1973; 1989; Spitzer, 1996). One of the consequences of such a theoretical possibility is that the formal function expressed by the materials (its intrinsic function) may be at odds with the one expressed by the context (extrinsic, or contextual), and therefore create a *formal dissonance* (Caplin, 1998). An informal statement such as "this piece begins in the middle," for instance, constitutes a claim of formal dissonance for which the sense of "being in the middle" depends on the appraisal of the musical properties of a unit that is contextually defined as a beginning (for instance, the first notes of a piece or a movement). Authors such as Jonathan Kramer (1988) and Judy Lochhead (1979) have provided particularly detailed discussions about the way listeners should perceive such an intricate interplay between contextual and intrinsic formal elements.[1] Along with others, they agree that the aural experience of formal dissonance is contingent upon the evaluation of a passage's intrinsic formal functionality, itself dependent on one's level of familiarity with the musical conventions at play. Although they assume, like a great many music theorists, that 'educated' listeners are capable of associating musical materials with the different formal functions of beginning, middle, or end, no empirical evidence currently exists to support that view. The present endeavor was therefore undertaken to empirically examine music theorists' assumptions about intrinsic formal functionality.

Theorists have identified several musical characteristics that can help define formal functionality in the music of the classical style. Of the three functions of beginning, middle, and end, scholars have focused to a much greater

---

[1] We consider Kramer's "gestural time" and Lochhead's "absolute temporal function" to be equivalent to our concept of intrinsic formal functionality.

extent on the last one. At the surface level, the most important feature is the presence of a cadence. The degree of finality projected by a cadence depends on structural features, mostly harmonic considerations (the authentic cadence is more conclusive than the half cadence) and melodic ones (the perfect authentic cadence is more conclusive than the imperfect authentic cadence). Theorists often cite other surface features—qualified as rhetorical—such as a decrease in rhythmic intensity, a descending melodic contour, and a metrically strong position (e.g., Caplin, 1998; Kramer, 1988; Schoenberg, 1967).[2] Another theoretical property of musical endings is, as described by Kramer, the "relationship of key of the cadence to the key of the piece or movement" (Kramer, 1988, p. 138). According to this large-scale view, cadences in the home key are more conclusive or stable than those in subsidiary keys, a position concordant with that of Lerdahl & Jackendoff (1983).

As noted earlier, several authors accept the idea of intrinsic formal functionality; yet there is no clear consensus about which musical properties convey the functions of beginning and middle. Since Caplin's descriptions of these properties are fairly detailed—hence, for most of them, testable on empirical grounds—we will use them as general descriptors of beginnings and middles. He conceives a typical beginning as harmonically tonic-prolongational (with a special emphasis on root-position tonic), rhythmically varied, and melodically ascending

[2] Several music theorists have discussed the distinction between structural and rhetorical features and their respective functions in closure (see, for example, Agawu, 1987; Anson-Cartwright, 2007; Caplin, 2004; Hyland, 2009).

(with "opening-up" gestures). As regards middles, he provides four compositional devices typical of a "continuation," the intra-thematic middle function *par excellence*: (1) phrase-structural fragmentation (i.e. grouping units that are shorter than those that precede them immediately); (2) acceleration of harmonic rhythm (the rate of harmonic change); (3) increased surface rhythmic activity; and (4) sequential harmonies (Caplin 1998; 2005). The first three of these attributes of medial functionality are *relational*; that is, they depend on a comparison of the passage with the materials that precedes it in order to determine, say, if the grouping structure decreases or the harmonies accelerate. Thus whereas, from a theoretical standpoint, beginnings and ends can be determined with respect to their intrinsic properties, middles are more contextually defined—a view shared by Agawu (1991) and Kramer (1988). We will provide further details about this particularity of the middle function later in this study.

INTRINSIC FORMAL FUNCTIONALITY: BACKGROUND IN MUSIC PERCEPTION AND COGNITION

Similar to music theory, investigations on formal functionality in the field of music perception and cognition concern themselves with the end function to a much greater extent than with the beginning and middle functions. Boltz (1989a; 1989b) found that tonal, melodic, and rhythmic factors contributed to listeners' sensation of melodic completion: melodies ending on the first scale degree (a tonal factor) were the most conclusive when the final note was approached by stepwise ascending motion than by leap (a melodic factor), and when that final note corresponded with the expected moment of occurrence within a temporal accent pattern (a rhythmic factor; see also Jones, Boltz, & Klein, 1993; Schmuckler & Boltz, 1994). The results of Rosner & Narmour (1992), which focused on the harmonic properties of cadential closure, indicate that, for both musicians and non-musicians, the strongest sense of closure was achieved with the perfect authentic cadence (PAC).[3]

Results of priming studies are also highly informative as regards the properties of the end function. To be sure, priming techniques are primarily employed to show the influence of a given series of musical events, the *prime*, on participants' speed and accuracy at evaluating some perceptual attributes of the series' final event, the *target*. Within this experimental paradigm, performance is considered optimal when the target is evaluated quickly and accurately, thus indicating that the participant perceived the target as a highly expected *conclusion* of the series of events that constitute the context. The priming paradigm constitutes therefore an indirect way to evaluate the properties of the end function. Generally speaking, these studies have shown that perceived completeness is strongest when the target is a tonic harmony (Bharucha & Stoeckig, 1986, 1987; Bigand & Pineau, 1997; Bigand, Poulin, Tillmann, Madurell, & D'Adamo, 2003; Bigand, Tillmann, Poulin, D'Adamo, & Madurell, 2001; Schellenberg, Bigand, Poulin-Charronnat, Garnier, & Stevens, 2005; Tillmann, Bharucha, & Bigand,

[3] Their work has to be interpreted cautiously, however. Prior to the experimental task itself, participants were provided concrete musical examples of what the authors conceived as strong and weak closure, thereby imparting a substantial experimental bias.

2000; Tillmann, Bigand, Escoffier, & Lalitte, 2006; Tillmann, Peretz, Bigand, & Gosselin, 2007) or, in melodic priming, the first scale degree (Marmel, Tillman, & Dowling, 2008). Poulin-Charronnat, Bigand, & Madurell (2005) confirm that completion is strongest when the voice-leading between the target and the previous chord conforms with traditional music-theoretical rules. And Marmel & Tillmann (2009) have further shown that the third scale degree is perceived as more complete than the leading tone, suggesting that from a music-theoretical perspective, notes belonging to the tonic harmony (such as the first and third scale degrees) are perceived as more conclusive than those belonging to other harmonies. Note that these effects have been found repeatedly for both musicians and non-musicians, an issue of differing "expertise groups" that will play an important role in the experiments to be discussed throughout the current study.

Among the studies investigating the perception of formal boundaries, several focused on *contextual* (rather than intrinsic) properties. Indeed, research on musical segmentation has mostly analyzed participants' perception of formal boundaries in light of the Gestalt-based contextual grouping cues proposed by Lerdahl & Jackendoff (1983) (such as Clarke & Krumhansl, 1990; Deliège, 1987, 1989, 1993, 2001b; Deliège & El Ahmadi, 1990; Krumhansl, 1996).[4] Other studies have shown explicit skepticism as regards intrinsic functionality. For instance, in Lalitte, Bigand, Poulin-Charronnat, McAdams, Delbé, & D'Adamo

---

[4] Note that the importance of such cues in the perception of phrase structure has been evidenced by research in neuroscience (Knösche, Neuhaus, Haueisen, Alter, Maess, Witte, & Friederici, 2005).

(2004), the authors explored, among others, the link between materials and temporal order in contemporary music. Participants from a first group listened to the full themes from Roger Reynold's *The Angel of Death* before judging the temporal order of pairs of fragments taken from each theme, whereas participants from a second group performed the same task without previous exposure to the piece. Participants from the second group were markedly less accurate than those from the first group, which led the authors to conclude that "the time-oriented quality is not an intrinsic quality of a musical excerpt: it emerges from the way the excerpts were temporally organized by the composer, and previous hearings of the themes are probably essential for listeners to capture these aspects" (Lalitte et al., 2004, p. 292). From a music theoretical standpoint, such an outcome is not necessarily surprising insofar as, in contemporary music, compositional gestures have a very low level of conventionality and tonal cues, which play a major role in theoretical accounts of formal functionality, are virtually absent. We indeed believe that the outcome of their study might have been different if they had investigated highly conventionalized tonal music.

Other research on the perception of formal boundaries has provided insight as regards the intrinsic properties of formal functions. For instance, some authors reported that excerpts ending on tonic harmony and on a strong metric position (Palmer & Krumhansl, 1987a, 1987b), or with a descending contour and a decrease in rhythmic activity (Jusczyk & Krumhansl, 1993; Krumhansl & Jusczyk, 1990) tend to be perceived as conclusive. Krumhansl addressed issues relative to both the end and beginning functions. In a paper published in 1998, she investigated the influence of topics (see Agawu, 1991) on the cognitive representation of musical form (Krumhansl, 1998). Among other tasks, participants were asked to make judgments of "openness," defined as the "sense that the music must continue." Participants rated some topics as "open," which the author interpreted as judgments of beginning. Even though "opening" and "beginning" may be conceptually similar, in light of our own form-functional perspective, "openness" should be interpreted as "open-ended-ness," a slightly different concept—a more general one—that includes both functions of beginning and middle.[5] To that extent, a fundamental characteristic of the beginning function was left undefined by Krumhansl, that is, the junction between the respective *starting points* of a musical gesture and the larger formal unit that this gesture "opens." In an earlier study, Krumhansl (1996) had found that variations in melodic contour, note density, dynamics, and predicted tonal tension (based on the model of Lerdahl, 1996; see also Bigand, 1993; Bigand & Parncutt, 1999; bigand, Parncutt, & Lerdahl, 1996) tended to correlate positively with participants' evaluations of musical tension, which themselves showed marked "increase-decrease" patterns at phrase boundaries. As concerns beginnings, however, the author describes them systematically with respect to contextual properties (for instance, *changes* in register, dynamics, surface features, figures, etc.), all of which involved a comparison with surrounding musical materials.

[5] In other words, her conception of beginning and end relied on an opposition between "openness" and "closeness," while it should be limited to "end" and "non-end," the latter being potentially a beginning or a middle.

Other scholars have addressed the cognitive representation of beginnings and ends from a slightly different perspective. Tafuri, Baldi, & Caterina (2003) investigated 792 improvisations on a glockenspiel by 7- to 10-year olds. The authors described qualitatively six beginning and fifteen ending archetypes that were commonly used. This study shows that, even without extensive musical training, some musical conventions regarding fundamental form-functional "moments" (such as the beginning and the end of a piece) can be acquired intuitively, a conclusion that perceptual studies on infants by Krumhansl and Jusczyk corroborate (Jusczyk & Krumhansl, 1993; Krumhansl & Jusczyk, 1990).

It is hard to predict, from the perceptual research mentioned above, whether participants would be able to identify out-of-context formal functions, especially those of beginning and middle. However, a study carried out by Ch'ng, Rasmussen, Stockwell, and Huron (reported in Huron, 1999) suggests that both musician and non-musician listeners can identify the "rhetorical character" of musical passages even when removed from their original context. In their study, participants heard excerpts (20 s.) of string quartets by Haydn and Mozart and judged their character as closing (end), expository (from the exposition), developmental (from the development), or transitional (from the exposition's transition). Listeners fared significantly better than chance when evaluating the rhetorical character of these excerpts. To be sure, these categories do not correspond exactly with the formal functions of beginning, middle, and end. Whereas 'expository' and 'closing' may correspond to 'beginning' and 'end' functions at the piece level or at the movement level, 'developmental' and 'transitional' relate to two constituents of sonata form that occupy a middle function, although on different structural levels (the former is at the section level while the latter is at the theme level). Indeed, formal functions are similar to, but distinct from, rhetorical functions—a concept that refers to the disposition of ideas as originally defined by classical rhetoric. Although the categories of formal and rhetorical functions may overlap at the structural level of the entire piece or even movement, they do not do so at lower hierarchical levels. In any case, these results show that listeners can identify certain forms of temporal functions based on the evaluation of musical materials alone.

Another important topic in perceptual research on form concerns formal syntax (that is, the logical ordering of events) at high or moderately high structural levels. On the one hand, a group of studies tested listeners' response to alterations made to the global structure of musical pieces. Some studies compared listeners' ratings of preference, aesthetic criteria, or structural features on the original version of a piece and scrambled versions of the same piece (Gotlieb and Konečni, 1985; Karno & Konečni, 1992; Konečni, 1984; Tillmann & Bigand, 1996); one study compared listeners' ratings on the original version of a piece and a harmonically altered one (Cook, 1987). Others sought to evaluate if listeners could distinguish original pieces from those that were harmonically altered (Marvin & Brinkman, 1999) or from those whose constituent parts were scrambled (Tillmann & Bigand, 1996). As a whole, these studies have consistently shown that listeners, regardless of their level of musical training, do not notice medium- or large-scale formal alterations, even when these alterations represent radical violations of traditional tonal, harmonic and formal schemas. Moreover, studies on musical puzzles have indicated that participants tend to overlook large-scale harmonic relationships in favor of local ones when making decisions about musical form (Deliège, Mélen, Stammers, and Cross, 1996; Tillmann, Bigand, and Madurell, 1998a). Such results unavoidably challenge traditional music-theoretical assumptions about the aesthetic value of large-scale structural coherence (Batt, 1987; Konečni, 1987; Tillmann & Bigand, 2004) and rather give credit to music-listening philosophies such as Levinson's (1997) concatenationist thesis, according to which music perception consists of a succession of brief moments, only local relationships being perceptually relevant (see also Gurney, 1880).

On the other hand, another group of studies has provided some evidence for the influence of large-scale structure on perception. Clarke & Krumhansl (1990), Deliège (1989), and Lalitte et al. (2004) have shown that listeners, after hearing a piece of music, can recall with reasonable accuracy the location at which its constituent passages belonged. McAdams, Vines, Vieillard, Smith, & Reynolds (2004) noted listeners' preference for one ordering of the two main sections of Reynold's *The Angel of Death* over the other ordering. Lalitte & Bigand (2006) reported that heavy scrambling on musical pieces affected negatively listeners' ratings of aesthetic value and increased their impression of incoherence. All those effects were found with contemporary music except for Clarke & Krumhansl (1990), who used both tonal and atonal pieces, and Lalitte & Bigand (2006), where the described effect was found in a piece of popular music.

Overall, the extent to which large-scale structure affects the listener remains at issue. The evidence currently available in the field of music perception and cognition nevertheless suggests that listeners' sense of temporality is stronger within small-scale structures than large-scale ones and, consequently, that an investigation, such as ours, of perceptually salient form-functional markers should focus on lower-level strata of musical form. With this in mind, we examined the *intra-thematic* level—that is, the functions of beginning, middle, and end within the boundaries of a musical theme. These intra-thematic functional units—normally about two bars long—have been regarded by music theorists as the fundamental building blocks of the musical structure of the high classical style (Caplin, 1998; Ratz, 1973; Schoenberg, 1967).

We have also seen that research in music perception and cognition abounds with characterizations of the contextual properties that help listeners define structural boundaries, as well as descriptions of the intrinsic properties of ends. However, very little is known about the intrinsic properties of beginnings, and even less about those of middles. In that respect, our research will strongly contribute to the understanding of listeners' perception of distinct types of temporality and, ultimately, musical form.

CONCEPTUALIZING OUT-OF-CONTEXT BEGINNINGS, MIDDLES, AND ENDS

Let us discuss briefly some of the categorical properties of beginning and ending. Scholars in cognitive psychology generally agree that categorization is optimal when the object to be categorized is sufficiently *similar* to the other members of the same category ("high within-category similarity") and sufficiently *different* from the members of other categories ("low between-category similarity"; Barsalou, 1992; Biederman, 1987; Markman & Wisniewski, 1997; Rosch, 1978). The latter criterion (difference) was explicitly addressed by Caplin (2005), who emphasized that the musical properties defining a specific formal function must be sufficiently differentiated from those that define other formal functions in order for an association between a musical passage and a *single* function to occur. As regards the former criterion, the degree of within-category similarity may differ between members of the beginning category and those of the end category: whereas beginnings are often considered as highly variable from piece to piece, as "detachable abstraction[s]" with a "life of [their] own" (Agawu, 1991, p. 57), ends are seen as highly conventionalized formulaic functions (Caplin, 1998). Similar to beginnings, middles can be considerably different from one another, although their materials tend to be much less "identifiable" (Agawu, 1991, p. 57) than beginnings. At the surface level, beginnings and, to a lesser extent, middles thus have a much lower within-category similarity than ends. It is nevertheless possible that, despite these surface-level differences, some abstract configurations of musical properties (i.e., configurations that may be realized differently at the surface) could be consistent enough for participants to categorize beginnings and middles accurately.

Beginnings and ends are relatively simple to intuit. A beginning is a passage that starts with a structural unit's opening point while an end is a passage that closes with a unit's final point. Conceptually, a middle represents any musical passage that does not include any of those two structural points. This negative definition strongly relates to the contextual (or relational) aspect of middles' descriptive properties (such as acceleration, fragmentation, etc.) and underlines this function's dependent status. As such, it is entirely possible that middles could be negatively categorized by listeners (that is, as a "fall-back" or "last-resort" option). But it is also possible that musical passages may convey an intrinsic impression of "being in the middle" (Caplin, 2009). Whether middles are evaluated positively or negatively, it is methodologically important to provide participants with a third categorical option (that is, other than 'beginning' or 'end'). Indeed, we suspect that the end function can be conveyed with such a level of clarity that a two-category paradigm would likely entail "end vs. no-end" decisions, which would undermine our capacity to investigate the musical properties that define beginnings.[6] Overall, a three-option categorization remains relatively simple, especially with the use of common terms like 'beginning,' 'middle,' and 'end,' which require no technical explanation to participants and therefore minimize the risks of experimental biases. The following chapters will discuss those questions in light of our experimental results.

GENERAL AIMS AND DISSERTATION OUTLINE

The aims of this interdisciplinary research are threefold. First, we want to determine if listeners can identify the formal functions (beginning, middle, or end)

---

[6] See the discussion about Krumhansl (1998) above.

of out-of-context musical excerpts taken from themes in the instrumental style of the high classical period. As the title of this dissertation indicates, we investigate the piano sonatas of W. A. Mozart (1756–1791), whose output strongly reflects the conventions of this musical style. Second, we want to assess the influence of musical training on listeners' accuracy in evaluating formal functions; as a result, we divide our participants into two expertise groups—musicians and non-musicians. Third, we want to investigate the musical properties that best project the functions of beginning, middle, and end for both expertise groups.

To address these questions, we run a series of three experiments. Experiment 1, presented in Chapter 2, explores the first two questions. In that experiment, we present musician and non-musician participants with excerpts taken from the beginning, middle, and end of themes from Mozart's piano sonatas. The results mainly assess the two expertise groups' accuracy in the form-functional evaluation task. From participants' functional judgments, we also derive hypotheses about the properties that musicians and non-musicians use for evaluating formal functions.

The goal of Experiments 2 and 3 is to answer the third question mentioned above. We test several hypotheses—including those discussed in chapter 2—regarding the form-functional effect of musical parameters on musicians and non-musicians. In these two experiments, we mostly use excerpts that we modified according to our experimental hypotheses about the form-functional influence of musical properties. Chapter 3 presents the results of Experiments 2 and 3 with respect to a first type of statistical analyses, which we term *associational*. We perform these analyses on excerpts that a clear majority of participants of a group identify as a beginning, a middle, or an end. Based on the high level of consensus that they generate, those excerpts provide valuable insight as regards the properties that most musicians or non-musicians associate with a specific function. Statistical analyses compare the distribution of several musical properties in consensual beginnings, middles, and ends, and we use multiple regression to determine the magnitude of individual musical properties' contribution to statistical models that sought to explain participants' functional judgments.

Chapter 4 presents the results of Experiments 2 and 3 with respect to a second type of statistical analyses, which we term *comparative*. These analyses consist in comparing participants' judgments of an excerpt before and after a musical modification was made. Contrary to associational analyses, comparative analyses allow us to infer causal relationships between a given property and its functional effect on participants' judgments.

Chapter 5 presents the results of some subsidiary hypotheses that we test in Experiments 2 and 3. Whereas the main task of these experiments is to evaluate formal functions, they also contain secondary tasks, namely, a speeded-judgment task and a rating task, which evaluate the perceived strength of excerpts' form-functional expression. This chapter also presents analyses of the frequency distributions of participants' functional judgment. As a whole, the results of these analyses allow us to assess the localization (for instance, at the excerpt's opening or closing points, or throughout the excerpt) of important musical properties within the excerpts and compare the relative strength of expression of beginnings, middles, and ends.

Chapter 6 is a general discussion of the results of Experiments 2 and 3. It first explains the importance of the musical information's localization and the relative influence of several musical properties. It then presents a series of musical analyses of excerpts that propose conjectural interpretations about the combined effect of musical properties on participants' responses. Analyses of larger musical segments then illustrate some ideas about the way intrinsic functional information may interact with contextual information to convey different perceptual impressions at a larger scale than that of the intra-thematic level. It closes with methodological issues and suggestions to improve our methodological apparatus. Finally, Chapter 7 summarizes the study and proposes avenues for future research based on our findings.

References

Agawu, K. (1987). Concepts of closure and Chopin's opus 28. *Music Theory Spectrum, 9*, 1–17.

Agawu, K. (1991). *Playing with signs*. Princeton: Princeton University Press.

Anson-Cartwright, M. (2007). Concepts of closure in tonal music: A critical study. *Theory and Practice, 32*, 1–18.

Batt, R. (1987). Comments on 'The effects of instrumentation, playing style, and structure in the Goldberg variations by Johann Sebastian Bach.' *Music Perception, 5*, 207–213.

Barsalou, L. W. (1992). *Congitive psychology: An overview for cognitive scientists*. Hillsdale, N.J.: L. Erlbaum.

Berry, W. (1976). *Structural functions in music*. Englewood Cliffs: Prentice-Hall.

Berry, W. (1989). *Musical Structure and performance*. New Haven & London: Yale University Press.

Bharucha, J., & Stoeckig, K. (1986). Reaction time and musical expectancy: Priming of chords. *Journal of Experimental Psychology: Human Perception and Performance, 12*, 403–410.

Bharucha, J., & Stoeckig, K. (1987). Priming of chords: Spreading activation or overlapping frequency spectra? *Perception & Psychophysics, 41*, 519–524.

Biederman, I. (1987). Recognition-by-components: A theory of human image understanding. *Psychological Review, 94*, 115–147.

Bigand E. (1993). The influence of implicit harmony, rhythm and musical training on the abstraction of "tension-relaxation schemas" in tonal musical phrases. *Contemporary Music Review, 9*, 123–137.

Bigand, E., Madurell, F., Tillmann, B., & Pineau, M. (1999). Effect of global structure and temporal organization on chord processing. *Journal of Experimental Psychology: Human Perception and Performance, 25*, 184–197.

Bigand, E., & Parncutt, R. (1999). Perceiving musical tension in long chord sequences. *Psychological Research, 62*, 237–254.

Bigand, E., Parncutt, R., & Lerdahl, F. (1996). Perception of musical tension in short chord sequences: The influence of harmonic function, sensory dissonance, horizontal motion, and musical training. *Perception & Psychophysics, 58*, 124–141.

Bigand, E., & Pineau, M. (1997). Context effects on musical expectancy. *Perception & Psychophysics, 59*, 1098–1107.

Bigand, E., Poulin, B., Tillmann, B., Madurell, F., & D'Adamo, D. A. (2003). Sensory versus cognitive components in harmonic priming. *Journal of Experimental Psychology: Human Perception and Performance, 29*, 159 –171.

Bigand, E., Tillmann, B., Poulin, B., D'Adamo, D. A., & Madurell, F. (2001). The effect of harmonic context on phoneme monitoring in vocal music. *Cognition*, *81*, B11–B20.

Boltz, M. (1989a). Perceiving the end: Effects of tonal relationships on melodic completion. *Journal of Experimental Psychology: Human Perception and Performance, 15*, 749–761.

Boltz, M. (1989b). Rhythm and "good endings": Effects of temporal structure on tonality judgments. *Perception & Psychophysics, 46*, 9–17.

Bonds, M. E. (1991). *Wordless rhetoric: Musical form and the metaphor of the oration*. Cambridge, MA: Harvard University Press.

Caplin, W. E. (1998). *Classical form: A theory of formal functions for the instrumental music of Haydn, Mozart, and Beethoven.* New York: Oxford University Press.

Caplin, W. E. (2004). The classical cadence: Conceptions and misconceptions. *Journal of the American Musicological Society, 57*, 51–117.

Caplin, W. E. (2005). On the relation of musical *topoi* to formal function. *Eighteenth-Century Music, 2*, 113−124.

Caplin, W. E., Hepokoski, J., & Webster, J. (2009). *Musical form, forms, &* Formenlehre: *Three methodological reflections*. P. Bergé (Ed.). Leuven: Leuven University Press.

Clarke, E., & Krumhansl, C. (1990). Perceiving musical time. *Music Perception, 7*, 213−252.

Cook, N. (1987). The perception of large-scale tonal closure. *Music Perception, 5*, 197−206.

Deliège, I. (1987). Grouping conditions in listening to music: An approach to Lerdahl & Jackendoff's grouping preference rules. *Music Perception, 4*, 325–360.

Deliège, I. (1989). A perceptual approach to contemporary musical forms. *Contemporary Music Review, 4*, 213−230.

Deliège, I. (1993). Mechanisms in cue abstraction for memory in musical time. *Contemporary Music Review, 9*, 191−205.

Deliège, I., & El Ahmadi, A. (1990). Mechanisms of cue extraction in musical groupings: A study of perception on Sequenza VI for viola solo by L. Berio. *Psychology of Music*, *18*, 18–44.

Deliège, I. (2001). Similarity perception ↔ categorization ↔ cue abstraction. *Music Perception, 18*, 233−243.

Deliège, I., Mélen, M., Stammers, D., & Cross, I. (1996). Musical schemata in real-time listening to a piece of music. *Music Perception, 14*, 117−160.

Gotlieb, H., & Konečni, V. J. (1985). The effects of instrumentation, playing style, and structure in the Goldberg Variations by Johann Sebastian Bach. *Music Perception, 3*, 87−102.

Gurney, E. (1880). *The power of sound*. London: Smith, Elder.

Hatten, R. S. (1994). *Musical meaning in Beethoven: Markedness, correlation, and interpretation*. Bloomington: Indiana University Press.

Hatten, R. S. (2005). *Interpreting musical gestures, topics, and tropes: Mozart, Beethoven, Schubert*. Bloomington: Indiana University Press.

Huron, D. (1999). Music and Mind: Foundations of Cognitive Musicology. *The 1999 Ernst Bloch Lectures*, University of California, Berkeley. http://musicog.ohio-state.edu/Music220/Bloch.lectures/1.Preamble.html.

Jones, M. R., Boltz, M. G., & Klein, J. M. (1993). Expected endings and judged duration. *Memory & Cognition, 21*, 646–665.

Jusczyk, P. W., & Krumhansl, C. (1993). Pitch and rhythmic patterns affecting infants' sensitivity to musical phrase structure. *Journal of Experimental Psychology: Human Perception and Performance, 19*, 627−640.

Karno, M., & Konečni, V. J. (1992). The effects of structural interventions in the first movement of Mozart's Symphony in G minor K. 550 on aesthetic preference. *Music Perception, 10*, 63−72.

Koch, H. C. (1969). *Versuch einer Anleitung zur Composition*. Hildesheim: G. Olms. (Original work published 1782−1793).

Konečni, V. J. (1984). Elusive effects of artists' "messages." In W. R. Crozier & A. J. Chapman (Eds.), *Cognitive processes in the perception of art* (pp. 71−93). Amsterdam: North-Holland Press.

Konečni, V. J. (1987). Response to Robert Batt. *Music Perception, 5*, 215−217.

Knösche, T. T., Neuhaus, C., Haueisen, J., Alter, K., Maess, B., Witte, O. W., & Friederici, A. D. (2005). Perception of phrase structure in music. *Human Brain Mapping, 24*, 259−273.

Kramer, J. (1973). Multiple and non-linear time in Beethoven's opus 135. *Perspectives of New Music, 11*, 122−145.

Kramer, J. (1981). New temporalities in music. *Critical Inquiry, 7*, 539−556.

Kramer, J. D. (1982). Beginnings and endings in western art music. *Canadian University Music Review, 3*, 1−14.

Kramer, J. D. (1988). *The time of music*. New York: Schirmer Books.

Krumhansl, C., & Jusczyk, P. W. (1990). Infants' perception of phrase structure in music. *Psychological Science, 1*, 70−73.

Krumhansl, C. (1996). A perceptual analysis of Mozart's piano sonata K. 282: Segmentation, tension, and musical ideas. *Music Perception, 13*, 401−432.

Krumhansl, C. (1998). Topic in music: An empirical study of memorability, openness, and emotion in Mozart's String Quintet in C Major and Beethoven's String Quartet in A Minor. *Music Perception, 16*, 119−134.

Lalitte, P., & Bigand, E. (2006). Music in the moment? Revisiting the effect of large-scale structures. *Perceptual and Motor Skills, 103*, 811−828.

Lalitte, P., Bigand, E., Poulin-Charronnat, B., McAdams, S., Delbé, C., & D'Adamo, D. (2004). The perceptual structure of thematic materials in *The angel of death*. *Music Perception, 22*, 265−296.

Lerdahl, F., & Jackendoff, R. (1983). *A generative theory of tonal music*. Cambridge, MA: MIT Press.

Lerdahl, F. (1996). Calculating tonal tension. *Music Perception, 13*, 319–363.

Levinson, J. (1997). *Music in the moment*. Ithaca, NY: Cornell University Press.

Levy, J. M. (1981). Gesture, form, and syntax in Haydn's music. In J. P. Larson, Howard Serwer, and James Webster (Eds.), *Haydn Studies* (pp. 355−62). New York: Norton.

Levy, J. M. (1982). Texture as a sign in classic and early romantic music. *Journal of the American Musicological Society, 35*, 482−531.

Lochhead, J. (1979). The temporal in Beethoven's opus 135: When are ends beginnings? *In Theory Only, 4*, 3−30.

Markman, A. A., & Wisniewski, E. J. (1997). Similar and different: The differentiation of basic-level categories. *Journal of Experimental Psychology: Leaning, Memory, and Cognition, 23*, 54−70.

Marmel, F., & Tillmann, B. (2009). Tonal priming beyond tonics. *Music Perception, 26*, 211−221.

Marmel, F., Tillmann, B., & Dowling, W. J. (2008). Tonal expectations influence pitch perception. *Perception & Psychophysics, 70*, 841−852.

Marvin, E. W., & Brinkman, A. (1999). The effect of modulation and formal manipulation on perception of tonic closure by expert listeners. *Music Perception, 16*, 389−407.

Mattheson, J. (1981). *Der vollkommene Capellmeister.* (E. C. Harriss, Trans., and Ed.). Ann Arbor: UMI Research Press. (Original work published 1739).

McAdams, S., Vines, B. W., Vieillard, S., Smith, B. K., & Reynolds, R. (2004). Influences of large-scale form on continuous ratings in response to a contemporary piece in a live concert setting. *Music Perception, 22*, 297−350.

McCreless, P. (2002). Music and rhetoric. In T. Christensen (Ed.). *The Cambridge history of Western music theory* (pp. 847-879). Cambridge: Cambridge University Press.

Meyer, L. B. (1973). *Explaining music: Essays and explorations*. Berkeley: University of California Press.

Meyer, L. B. (1989). *Style and music: Theory, history, and Ideology*. Philadelphia: University of Pennsylvania Press.

Palmer, C., & Krumhansl, C. (1987a). Independent temporal and pitch structures in determination of musical phrases. *Journal of Experimental Psychology: Human Perception and Performance, 13*, 116−126.

Palmer, C., & Krumhansl, C. (1987b). Pitch and temporal contributions to musical phrase perception: Effects of harmony, performance timing, and familiarity. *Perception & Psychophysics, 41*, 505−518.

Poulin-Charronnat, B., Bigand, E., Madurell, F. (2005). The influence of voice leading on harmonic priming. *Music Perception, 22*, 613−627.

Ratz, E. (1973). *Einführung in die musikalische Formenlehre: Über Formprinzipien in den Inventionen und Fugen J. S. Bachs und ihre Bedeutung für die Kompositionstechnik Beethovens*. (3rd ed.). Vienna: Universal.

Rosch, E. (1978). Principles of categorization. In E. Rosch & B. Lloyd (Eds.), *Cognition and Categorization* (pp. 27−48). London: Erlbaum.

Rosen, C. (1988). *Sonata forms*. New York: W. W. Norton.

Rosen, C. (1997). *The classical style: Haydn, Mozart, Beethoven*. New York: W. W. Norton.

Rosner, B. S., & Narmour, E. (1992). Harmonic closure: Music theory and perception. *Music Perception, 9*, 383−412.

Schellenberg, G. E., Bigand, E., Poulin-Charronnat, B., Garnier, C., Stevens, C. (2005). Children's implicit knowledge of harmony in Western music. *Developmental Science, 8*, 551−566.

Schmuckler, M. A., Boltz, M. G. (1994). Harmonic and rhythmic influences on musical expectancy. *Perception & Psychophysics, 56*, 313–325.

Schoenberg, A. (1967). *Fundamentals of musical composition*. G. Strang and L. Stein (Eds.). London: Faber and Faber.

Sisman, E. (1982). Small and expanded forms: Koch's model and Haydn's music. *The Musical Quarterly, 68*, 444−475.

Spitzer, M. (1996). The retransition as sign: Listener-oriented approaches to tonal closure in Haydn sonata-form movements. *Journal of the Royal Musical Association, 121*, 11−45.

Stoïanova, I. (1978). *Geste, texte, musique*. Paris: Union Générale d'édition.

Tafuri, J., Baldi, G., & Caterina, R. (2003/2004). Beginnings, and endings in the musical improvisations of children aged 7 to 10 years. In *Musicae Scientiae,* Special issue on musical creativity, 157–174.

Tillmann, B., & Bigand, E. (1996). Does formal musical structure affect perception of musical expressiveness? *Psychology of Music, 24*, 3−17.

Tillmann, B., Bigand, E., Escoffier, N., & Lalitte, P. (2006). The influence of musical relatedness on timbre discrimination. *European Psychology: Human Perception and Performance, 34*, 1031−1043.

Tillmann, B., Bigand, E., & Madurell, F. (1998). Local versus global processing of harmonic cadences in the solution of musical puzzles. *Psychological Research, 61,* 157−174.

Tillmann, B., Bigand, E., & Pineau, M. (1998). Effects of global and local contexts on harmonic expectancy. *Music Perception, 16*, 99−117.

Tillmann, B. Bharucha, J. J., & Bigand, E. (2000). Implicit learning of tonality: A serf-organizing approach. *Psychological Review, 107*, 885−913.

Tillmann, B., & Bigand, E. (2001). Global context effect in normal and scrambled musical sequences. *Journal of Experimental Psychology: Human Perception and Performance, 27*, 1185−1196.

Tillmann, B., & Bigand, E. (2002). A comparative review of priming effects in language and music. In P. McKevitt and S. O. Nuallain (Eds.), *Language, vision, and music*. Amsterdam, Netherlands: John Benjamins.

Tillmann, B., & Bigand, E. (2004). The Relative Importance of Local and Global Structures in Music Perception. *The Journal of Aesthetics and Art Criticism, 62*, 211–222.

Tillmann, B., Peretz, I., Bigand, E., & Gosselin, N. (2007). Harmonic priming in an amusic patient: The power of implicit tasks. *Cognitive Neuropsychology, 24*, 603−622.

Vickers, B. (1984). Figures of rhetoric/figures of music? *Rhetorica: A Journal of the History of Rhetoric, 2*, 1−44.

Zbikowski, L. M. (2002). *Conceptualizing music: Cognitive structure, theory, and analysis*. New York: Oxford University Press.

Chapter 2. The perceptibility of intrinsic formal functionality

This chapter examines the perception of beginnings, middles, and ends of musical themes in the instrumental style of the high classical period. We pose three main questions: (1) can musicians and non-musicians correctly identify the formal function of short, out-of-context, intra-thematic musical units? and (2) is there an effect of musicianship on response accuracy? and (3) are there musical properties that musicians and non-musicians tend to associate with beginnings, middles, and ends?[1]

To address the first two questions, we conducted experiments in which participants heard short, out-of-context excerpts taken from the beginning, middle, or end of themes composed by W. A. Mozart. For each excerpt, participants completed four tasks: they (i) identified the formal function; (ii) rated, on a continuous scale, how strongly this function was conveyed; (iii) verbalized their form-functional decisions; and (iv) judged whether they had heard the excerpt prior to the experiment (familiarity rating). The last task was used to determine whether participants, in their response, were relying on the materials presented in the experiment or on their memory of the excerpt from some earlier hearing.

[1] The term "non-musician" designates participants without extensive formal musical training. At the same time, we accept the notion that all members of a culture possess a certain degree of implicit musical expertise.

To address the third question, we collated the experimental results with the excerpts' musical properties. In many cases, we observed that certain musical features seemed to influence the functional identifications of musicians and non-musicians. We thereby formulated hypotheses about the impact of these musical elements on the perception of formal functions with respect to both expertise groups.

Prior to the experiment, we predicted that all participants would be able to perform better than chance on the functional-identification task, but that musicians would fare better than non-musicians. We predicted that, due to their formulaic nature, ends would be identified with the highest accuracy, whereas middles, due to their context-dependent properties, would be identified with the lowest accuracy. Likewise, we expected participants to rate ends as strongly conveyed, middles as weakly conveyed, with beginnings rated somewhere in-between. Finally, we expected the familiarity ratings to be higher for musicians than for non-musicians.

METHOD

Participants

Twenty participants with musical training equivalent or superior to third-year-university level formed what will be henceforth referred to as the *musicians* group. On average, these participants had 14.8 years of training on a musical instrument, 6.3 years of ear training, 5.5 years of instruction in harmony, and 4.9

years of instruction in musical analysis. Twenty participants with less than a year of musical training constituted the *non-musicians* group.

Stimuli

Thirty-six short excerpts (average 3.9 s.) drawn from Mozart's first nine piano sonatas were presented to participants (Mozart, 1977).[2] There were an equal number of beginnings, middles, and ends (12 of each), and all were selected for what we believed to be their form-functional clarity from a music-theoretic standpoint.[3] In extracting the passages from their context, we ensured that the last onset was on a beat. Minor adjustments were sometimes necessary to avoid, for instance, closing on an unresolved appoggiatura or with an octave leap. All excerpts are reproduced in Appendix A. A conditioning phase preceding the experiment proper used the first 40 measures of Mozart's Piano Sonata in F major, K. 332, first movement. For all stimuli, performance variables (such as rubato) were neutralized, and tempi were determined by convention. Scores were created via the computer software Sibelius 4.0 and converted to .wav sound files using the sound sampler Kontakt Silver.

[2] K. 279 (C major), K. 280 (F major), K. 281 (B-flat major), K. 282 (E-flat major), K. 283 (G major), K. 284 (D major), K. 309 (C major), K. 311 (D major), K. 310 (A minor). We selected these sonatas, composed between 1775 and 1778, because they constituted a corpus that was substantial enough for the needs of this project, while evincing a high level of stylistic consistency. Moreover, this repertoire well represents compositional conventions of the classical style.

[3] All of the end excerpts closed with a perfect authentic cadence; passages concluding with an imperfect authentic cadence or a half cadence were not tested in this experiment. As will be discussed later, the results of the experiment showed that some of the excerpts were not as clearly perceived as originally anticipated.

Apparatus

Listeners were seated in a double-walled IAC sound-isolation chamber. The sounds were reproduced on a Macintosh G5 computer, output as S/PDIF using an M-Audio Audiophile 192 sound card, converted to analog using a Grace Design m904 monitor system, and presented stereophonically over Sennheiser HD280 headphones. The stimuli were presented at a comfortable listening level that was kept constant for all participants. The experimental program, sound presentation, subject interface, and data collection were programmed with the PsiExp software environment.

Procedure

In the conditioning phase, participants were asked to segment a musical passage into three themes by positioning two dividers on a visual interface at the boundaries between the end of a theme and the beginning of the subsequent one. The goals of the conditioning phase were twofold. First, it allowed participants to become familiar with the musical style. Second, it drew participants' attention to the presence of multiple beginnings, middles, and ends within a single piece of music, thus introducing them indirectly to the notion of intra-thematic formal functionality.

In the experiment proper, each participant was presented with a randomized set of all 36 excerpts. Participants were instructed to play each excerpt three times and to answer the following questions:

1. *What is the function of this excerpt? Select either 'Beginning', 'Middle', or 'End'.*

2. *How strongly is this function conveyed? Move the slider along the scale between 'very weakly' and 'very strongly'. Position the slider at the point that corresponds to the strength with which the function is conveyed.*

3. *Describe some characteristics of the excerpt that indicated its function.*

4. *Prior to today, have you heard this music before? Select either 'Yes', 'No', or 'Unsure'.*

Participants could perform the seven operations (three playbacks of the excerpt and four questions) in any order.

RESULTS

Form-functional judgments

Musicians' and non-musicians' form-functional judgment distributions are shown in Appendix A, next to each musical excerpt. [4]

Proportion correct

A two-way mixed analysis of variance (ANOVA) was conducted to test the effect of function and musicianship on the accuracy of identification.[5] The

---

[4] 'Judgment distribution' refers to the number of beginning, middle, and end judgments that one group of participants attributed to an excerpt. It always sums to 20.

Greenhouse-Geisser epsilon was used to correct violations of sphericity due to repeated measures. The results revealed main effects of function, $F(2, 76) = 39.1$, $\varepsilon = .907$, $p < .0001$, and musicianship, $F(1, 38) = 32.8$, $p < .0001$, on accuracy. There was no significant interaction between these two factors, $F(2, 76) = 2.7$, $\varepsilon = .907$, $p = .08$. As expected, musicians performed better than non-musicians. Figure 2.1 shows that participants were most accurate in identifying ends, compared to the other two functional categories. Contrary to our predictions, middles exhibited the next highest proportion of correct responses, and beginnings, the lowest. The 95% confidence interval bars show a slight overlap between beginnings and middles. The overall accuracy of function identification was significantly above chance.[6] Table 2.1 further details the results of each expertise group. It illustrates that (1) musicians were significantly better than non-musicians in identifying beginnings and ends, but not middles; and (2) the accuracy of function identification increased, for both expertise groups, from beginning to middle function, and from middle to end function.

---

[5] We determined the excerpts' formal functions according to their evident temporal location within a theme along with a host of supporting music-theoretic criteria. Thus "accuracy" has to be understood as a concordance between our theoretic judgment prior to the experiment and the participant's perceptual judgment during the experiment.

[6] Chance level is 33.3%.

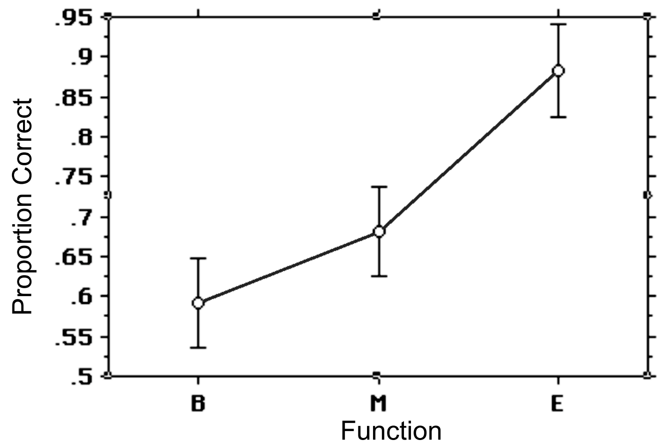


Figure 2.1. Accuracy of function identification for all participants. The overall mean proportion correct identification of the formal functions is shown for each function (B, M, E standing for beginning, middle, and end, respectively). The vertical bars indicate the 95% confidence interval about the mean.

Table 2.1. Accuracy of function identification: total of musicians' and non-musicians' correct and incorrect answers for beginning, middle, and end excerpts.

	MUSICIANS		NON-MUSICIANS		Effect of expertise on accuracy★
	Correct	Incorrect	Correct	Incorrect	
Beginning	169	71	115	125	Yes ($p < .0001$)
Middle	173	67	154	86	Marginal ($p = .06$)
End	236	4	188	52	Yes ($p < .0001$)

★A chi-square test (df = 1) was used in conjunction with a contingency matrix to compare musicians' and non-musicians' correct and incorrect responses.

Consensus

Another way of measuring the strength of an excerpt's form-functional expression within an expertise group was to look at the extent to which listeners of a group agreed on a certain function. In order to determine a threshold for such a consensus, we performed a chi-square test that compared the function that received the highest number of judgments to the sum of the judgments of the other two functions. Out of 20, a minimum of 15 identical form-functional judgments was necessary to achieve significance, $\chi^2(1) = 5.0$, $p < 0.03$. Excerpts that were attributed the same formal function by 15 or more participants from the same expertise group are henceforth qualified as *consensual*.

Table 2.2 shows the number of consensual excerpts for each formal function and expertise group (excerpts' labels are shown between parentheses). Among the set of 36 excerpts presented to participants, 27 were consensual in the musicians group, of which 7, 8, and 12 were categorized as beginning, middle, and end functions, respectively. In the non-musicians group, 15 excerpts were consensual, of which 2, 4, and 9 were categorized as beginning, middle, and end functions, respectively. Overall, consensual ends were the most numerous (21), followed by middles (12), and finally, beginnings (9). Surprisingly, one of the beginning excerpts, B5, was identified as a *middle* by 18 musicians and 15 non-musicians. This special case will be further examined in the discussion section.

Table 2.2. Excerpts that received a minimum of 15 identical functional judgments. The labels of consensual excerpts are shown between parentheses (the excerpts are given in the Appendix). Labels comprise a function letter—B, M, and E, standing for beginning, middle, or end—as well as an excerpt number ranging from 1 to 12 for each functional category.

	Beginning	**Middle**	**End**	**Total**
Mus.	7 (B2−4, B9−12)	8 (M1−4, M8, M9, M11, B5)	12 (E1−12)	27
Non-mus.	2 (B3, B10)	4 (M1, M2, M12, B5)	9 (E2−7, E9−11)	15
Total	9	12	21	42

Confusion matrices

Table 2.3 shows confusion matrices for musicians and non-musicians. The rows correspond to the three categories of stimuli. The values of each row sum to 240 (20 participants per expertise group × 12 excerpts per function). The columns contain participants' responses in the functional-judgment task. Correct responses appear in the cells that intercept rows and columns with identical headings (shaded in the matrices). All other cells represent incorrect responses—i.e., cases where actual beginnings, middles, or ends (row headings) were confused with other formal functions (column headings).

Table 2.3. Musicians' (a) and non-musicians' (b) confusion matrices. Rows correspond to the three types of stimuli and columns, to participants' responses. Correct responses are shown in grey.

(a) Musicians

Stimuli \ Response	Beginning	Middle	End
Beginning	169	57	14
Middle	62	173	5
End	1	3	236
Total	232	233	255

(b) Non-musicians

Stimuli \ Response	Beginning	Middle	End
Beginning	115	99	26
Middle	69	154	17
End	8	44	188
Total	192	297	231

With respect to musicians' and non-musicians' form-functional mistakes, three qualitative observations drawn from Table 2.3 strike us as especially noteworthy. First, for both expertise groups, most confusion occurred between beginning and middle functions: whereas musicians identified beginnings as middles 57 times and middles as beginnings 62 times, non-musicians made the same mistakes 99 and 69 times, respectively. It would thus seem that participants had more difficulty in distinguishing beginnings from middles than either (i) beginnings from ends or (ii) middles from ends. Second, both expertise groups showed similar asymmetrical mistake patterns with respect to beginning and end functions: cases where beginnings were judged as ends (14 and 26 by musicians and non-musicians, respectively) substantially outnumber those where ends were judged as beginnings (1 and 8). As we will explain in the discussion section, this asymmetry is mostly attributable to a single musical excerpt (B1). Third, expertise groups differed strongly as regards the mistake distributions involving the middle function. In the musicians group (Table 2.3a), errors involving beginning and middle functions as well as those for middle and end functions are symmetrically distributed (57 and 62 for the former; and 5 and 3 for the latter).[7] In contrast, the same error types are asymmetrically distributed in the non-musicians group (Table 2.3b); these asymmetries systematically lean towards a substantially higher number of wrong middle-function responses (99 and 69 for errors involving the beginning and middle functions; and 17 and 44 for those for the middle and end functions).

The rows underneath both matrices in Table 2.3 show the total responses per function, and these figures provide a partial explanation for the observation that non-musicians' middle identifications were often erroneous. Whereas musicians' functional judgments were similar for the three formal categories (232 beginning, 233 middle, and 255 end judgments, $\chi^2(2) = 1.41$, $p = .49$), non-musicians' functional judgments differed significantly from a homogenous distribution (192 beginning, 297 middle, and 231 end judgments, $\chi^2(2) = 23.48$,

---

[7] Errors are symmetrically distributed for a given error type when they involve pairs of similar numbers, as in the present case.

$p < .0001$). Therefore, the aforementioned asymmetries emerge as a side effect of the large quantity of middle-function judgments made by participants from the non-musicians group. Moreover, the substantial disparity between the relative scarcity of their beginning responses and the abundance of their middle responses partly accounts for non-musician's weaker accuracy of beginning-function identification over middle-function identification.

Strength-of-function ratings

A two-way mixed ANOVA was used to test the effect of function and musicianship on the average judged strength of each function. The results reveal a significant difference between the average strength ratings of musicians and non-musicians, $F(1, 38) = 16.6$, $p < .0001$, the ratings for the former group being systematically higher than those of the latter. As shown below in Figure 2.2, there was a significant difference in the average strength ratings of all participants among the three functional categories, $F(2, 76) = 25.6$, $\varepsilon = .954$, $p < .0001$. As predicted, ends were conveyed the strongest overall, followed by beginnings and lastly middles. The 95% confidence interval bars show an overlap between beginnings and middles. No interaction was found between function and musicianship, $F(2, 76) = 2.1$, $\varepsilon = .954$, $p = .13$, demonstrating that the relative pattern of results is the same for both groups.

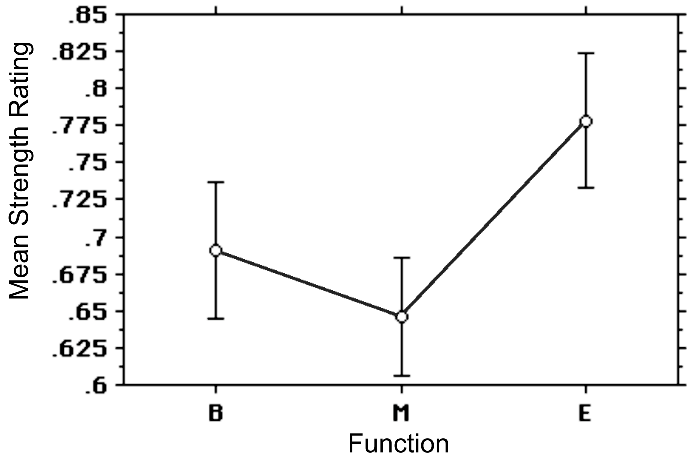


Figure 2.2. Mean rated strength of function (all participants). The mean strength-of-function conveyed is shown for each formal function. The vertical bars indicate the 95% confidence interval about the mean.

Verbalization

The results of the verbalization task reflect perceived information listeners believed to be influential on their decisions. The main goal of this task was to collect new insights into the form-functional impact of various musical parameters. Among the comments involving such parameters, however, none provided supplementary information about perceptually salient musical features. Thus we will not discuss the verbalization task any further in this chapter.

Familiarity

Prior familiarity with the excerpts was rated on a 3-point scale. In response to the question "Have you heard this excerpt before?" participants answered "yes," "unsure," or "no," and these were coded as 0, 1, and 2, respectively. For musicians, proportion correct was correlated very weakly and negatively with mean familiarity ratings, $r(34) = -.29$, $p = .08$, and for non-musicians, the correlation was negligible, $r(34) = -.10$, $p = .56$. Contrary to our predictions, the average familiarity rating for musicians over all of the excerpts was only marginally lower than that for non-musicians (musicians = 1.38, non-musicians = 1.68).[8] The average familiarity ratings of all participants broken down by function were very close: beginning = 1.48, middle = 1.55, end = 1.57. Seeing as beginning functions tend to contain musical materials that are more 'original' or 'individualistic' than the other two functions, it is not surprising that listeners deemed beginnings as most memorable. Overall across participant groups, the correlation between mean familiarity ratings and accuracy was very weak, $r(70) = -.35$, $p = .002$. Although statistically significant, familiarity explains less than 13% of the variation in accuracy in all cases and thus can be considered to have had a negligible influence on the results. It would thus appear that, for the most part, listeners were not reliant on their conscious memory of the excerpt, but rather made decisions based on the musical materials they heard during the experiment.

DISCUSSION

Perception of intrinsic formal functionality

One of the three main goals of this project was to investigate listeners' capacity to correctly identify the formal function of excerpts taken from the beginning, middle, and end of musical themes. The above-average accuracy of

[8] Since the level of familiarity and the rating values are inversely proportional, a lower numerical score indicates a higher degree of familiarity.

both expertise groups in the function identification task indicates that listeners can correctly perceive an excerpt's intrinsic formal functionality in the majority of cases. As concerns the second goal, that is, to assess the effect of musicianship on response accuracy, we have seen that musicians' form-functional evaluations were significantly more accurate than non-musicians'.

Form-defining musical properties

The third goal of this project was to investigate the various musical properties that musicians and non-musicians associated with beginnings, middles, and ends. Such features were determined by collating the excerpts' properties with the results of the functional-identification task. These observations form a corpus of preliminary hypotheses that are tested in subsequent experiments (see Chapters 3 and 4). In most cases, it was nearly impossible to determine a direct relationship between a specific musical characteristic and a particular formal function—i.e., almost no characteristic acted as a necessary or sufficient condition to convey a particular function. We therefore defined a handful of overlapping musical attributes that best accounted for musicians' and non-musicians' perception of formal functions.[9] Thus, excerpts featuring several properties that we defined as appropriate to a given function were likely to generate functional

[9] Such attributes constitute a cognitive category that displays typicality or prototype effects, i.e., some configurations of attributes will generate membership profiles that are more representative than others of a certain category. Such a category is labelled as a "Type 1" cognitive category in Zbikowski (2002), as opposed to a "Type 2" category defined through necessary and sufficient conditions. This issue will be addressed in Chapter 6.

consensus (within a given group of listeners), while excerpts that presented competing properties (i.e., proper to different functions) were more likely to generate disagreement.[10]

We based our hypotheses on three types of observations (expertise groups always being considered separately): (1) the properties of excerpts that gathered the highest response rates in a given functional category (many of them being consensual); (2) the properties of excerpts that gathered the lowest response rates in a given functional category; and (3) the properties of excerpts that were incorrectly identified (the confusion matrices of Table 3 show the across-function distribution of incorrect answers). The following discussion considers the most salient tendencies that we observed.

Beginnings: musicians

Among the features shared by musicians' consensual beginnings, the predominance of tonic harmony is the most salient one. Indeed, of the seven beginning excerpts that emphasize the tonic harmony to the greatest extent (B1−4, B9, B11, B12),[11] six were identified as beginnings by 15 or more musicians—

---

[10] Disagreement has to be distinguished from confusion: whereas the former refers to the extent to which participants of a group ascribed different formal functions to a given excerpt, the latter relates to accuracy. For instance, excerpt B5 showed a low level of disagreement (i.e., participants reached consensus on its conveyed formal function) while causing a high level of confusion (i.e. most participants mistakenly categorized this beginning excerpt as a middle excerpt).

[11] The extent to which an excerpt emphasized the tonic harmony was measured by counting the proportion of beats displaying that harmony. Internal rests (those of excerpts B4 and B12) were counted as extensions of the previous harmony. Although slightly oversimplified from a purely

excerpt B1 was the only exception to that rule. Likewise, the two middle excerpts that most emphasize the tonic harmony (M7 and M5) garnered the greatest number of beginning responses.[12] Of all musicians' consensual beginnings (see Table 2), only B10 showed a relatively low emphasis on tonic harmony. Our data further suggest that the *initial* harmony of an excerpt helped musicians to distinguish between beginning and middle functions: the six middle excerpts that had their initial downbeat "off tonic" counted among the eight consensual middles (see excerpts M1−4, M8, M9).[13]

Rhythmic variety was also likely to affect musicians' perception of beginning function, whereas rhythmic uniformity tended to prompt the identification of a middle function.[14] On the one hand, the middle excerpts that were the most frequently interpreted as beginnings had a high level of rhythmic variety (excerpts M5, M7, and M12).[15] On the other hand, four of the five

music-theoretic perspective (e.g., important information such as the chord's metrical position or its inversion is not taken into account), this measurement helped to systematize our analytical approach and to uncover salient tendencies.

[12] M7 and M5 were identified as beginnings by 14 and 13 musicians, respectively; therefore these middle excerpts almost made it into the category of consensual beginnings.

[13] Excerpt M11 was the only consensual middle that opened with a tonic harmony.

[14] An excerpt is rhythmically uniform when its successive inter-onset intervals (i.e. the time spans between consecutive attacks) are equal. For instance, of the 36 experimental stimuli, excerpt B1 displays the highest level of rhythmic uniformity. Conversely, excerpts that show the greatest diversity of inter-onset intervals are considered as rhythmically varied.

[15] Overall, the fact that excerpts M7 and M5 combined the two most perceptually salient beginning characteristics—tonic emphasis and rhythmic variety—seems to justify the high number of musician's beginning judgments that these excerpts gathered. Note also that only the right hand of excerpt M12 displays rhythmic variety. Excerpt M3 was clearly considered a middle by

beginnings that were not consensual (and thus absent from the 'Beginning' column of Table 2.2) exhibited a low or relatively low level of rhythmic variety (excerpts B1, B5, B6, and B7).[16]

Beginnings: non-musicians

Our data indicate that rhythmic variety also played a relatively important role in non-musicians' perception of the beginning function. Indeed, three of the five middle excerpts that were most often erroneously identified as beginnings display the highest levels of rhythmic variety (excerpts M5, M7, and M3).[17] Unlike musicians, however, it seems that non-musicians relied primarily on the unaccompanied anacrusis ("pick-up") to identify beginnings. The three beginnings that contain the longest unaccompanied anacruses—B3, B10, and B9—were in fact classified among the four clearest beginnings (B3 and B10 were consensual).[18] Likewise, three of the five middles in which the right hand enters

---

musicians, despite its high level of rhythmic variety. That a non-tonic, harmony (i.e., subdominant) appears on its first downbeat may account for the low number of musicians that categorized this excerpt as a beginning.

[16] B8, which many musicians considered a middle, is an exception to this tendency in that it shows a high level of rhythmic variety without clearly conveying a sense of beginning to musicians. In excerpt B6, note that the grace notes provide a minimal sense of rhythmic variety.

[17] Excerpts M4 and M6 are exceptions to this tendency.

[18] Although these three excerpts were clearly identified as beginnings by musicians, the extent to which the unaccompanied anacrusis played a role in their form-functional judgments is difficult to evaluate from the available data.

before the left hand—M3, M5,[19] and M6—were categorized the most often as beginnings.[20]

Middles: musicians

Our analyses indicate that the tonic harmony had a complementary role in musicians' perception of beginnings and middles. Whereas a stronger emphasis on the tonic chord generally corresponded with a high number of beginning judgments, a lack of emphasis on this harmony reciprocally entailed a high number of middle judgments. The consensual middles were in fact those that exhibited the lowest emphasis on the tonic harmony (see Table 2.2).[21] Similarly, the role played by rhythmic uniformity in the perception of the middle function was comparable to the role played by rhythmic variety in the perception of the beginning function.

---

[19] Excerpt M5 does not open with a proper unaccompanied anacrusis since the right hand enters on the downbeat. It nevertheless exhibits the contrasting texture typical of the unaccompanied anacrusis.

[20] Excerpts M8 and M9, although identified as beginnings by 5 and 6 non-musicians, respectively, are exceptions to this tendency.

[21] M12 is an exception to that rule. This excerpt was not a consensual middle despite its lesser emphasis on the tonic harmony than some of the consensual middles (such as M6 and M10). The tonic-prolongational progression underscoring the repeated units—tonic, first-inversion dominant, tonic—is found in "statement-response" beginnings of many themes (Caplin, 1998), and this harmonic-formal configuration may explain why several musicians perceived this excerpt as a beginning.

Middles: non-musicians

Rhythmic uniformity also influenced non-musicians' perception of middles. It seems, however, that non-musicians alone associated two specific properties with the middle function. First, several beginning excerpts that were mistakenly identified as middles by non-musicians displayed a high onset density—that is, a high rate of attack per time unit.[22] Indeed, three of the four beginnings that accumulated the highest number of middle judgments (B2, B4, B5) display the highest levels of onset density.[23] Second, the absence of textural differentiation between a melodic right hand and an accompanimental left hand seemed also to influence non-musicians' perception of middle function. Such a hypothesis follows from the relatively high rate of middle identifications for B4 and B11, in which both hands play the same musical idea one and two octaves apart, respectively.

Some of the musical excerpts that were incorrectly interpreted as middles deserve further analytical attention. First, as mentioned above, excerpt B5 was the only beginning that was erroneously judged as a consensual middle by both groups of expertise. We propose that such an unexpected outcome exemplifies the perceptual influence of rhythmic uniformity—a middle feature.[24] The

---

[22] Because the unit of time being measured is absolute, the perceived onset density depends on the tempo of the performance.

[23] B6 is an exception to this tendency.

[24] We originally thought that the ascending stepwise gesture—a typically beginning-like contour—by the upper voice of the right hand's composite melody (F-G-A, in bar 2) would prevail over the excerpt's middle-like characteristics.

combination of this feature with a highly disjunctive melodic line, rather than a stepwise line, may also account for the frequency with which participants perceived this excerpt as a middle function.[25] Second, excerpts E1, E8, and E12 were the only non-consensual ends in the non-musicians group; rather, many participants from that group judged these three excerpts as middles (10, 7, and 5 respectively) despite their ending with a perfect authentic cadence. We propose that the middle-like quality that non-musicians perceived in E8 may be due to its exceptionally prevalent, uninterrupted rhythmic density. Indeed, both hands play a continuously active rhythmic pattern, and the long trill of the excerpt's penultimate measure—although a fairly obvious sign of end function for a musically trained participant—considerably increases the overall onset density.[26] Similarly, the appreciable number of non-musicians' middle judgments attributed to excerpts E1 and E12 may be explained by their high onset density, as they show the two highest density rates among end excerpts. Excerpt E1 was the only end stimulus that did not gather a *majority* of end judgments; instead, it received more middle judgments than end judgments from non-musicians. Apart from its high onset density, this excerpt exhibits another characteristic that non-musicians

---

[25] This excerpt was taken from the beginning of a transition, whereas the other eleven beginning excerpts were taken from the opening of movements. From a contextual point of view, B5 is the beginning of a higher-level "middle," the transition functioning as the middle of a sonata exposition (Caplin 1998, 2009). In this light, it is less surprising that this excerpt would convey a greater sense of middle than the other beginning excerpts.

[26] Like E8, excerpt E11 also contains a trill over a highly active bass pattern. But E8 has a higher onset density and a longer trill, which may explain why it gathered more of non-musicians' middle judgments than E11.

tended to associate with middle functions: the absence of a clear melody-plus-accompaniment texture, due to the ascending arpeggiations found in both hands of bar one.

Ends: musicians and non-musicians

The significantly high level of accuracy for end identifications suggests that both expertise groups perceived the perfect authentic cadence—a feature that is primarily harmonic—as the strongest functional marker. These results further support the findings of priming studies (e.g., Bharucha & Stoeckig, 1986; Tillmann, Bigand, & Pineau, 1998). The above discussion hints, however, at one difference between musicians and non-musicians. For musicians, a perfect authentic cadence guaranteed a consensual end, and therefore constituted a sufficient condition to the perception of an end function. For non-musicians, rhythmic markers belonging to another formal function (the middle function) could, in extreme cases, appreciably weaken the form-functional effect of the perfect authentic cadence, showing that the presence of a cadence was not sufficient to clearly convey an end function. These latter two observations therefore suggest that, even for the end function, musicians weighted harmony to a greater extent than non-musicians, who were seemingly more influenced by rhythmic features.

As mentioned in the results section, one excerpt was responsible for a large part of the confusion between beginning and end functions. Excerpt B1 was perceived as an end by a high proportion of participants (9 musicians and 10 non-musicians). This is puzzling from a purely music-theoretic standpoint, as B1 does not close with a cadential progression, authentic or otherwise. Instead, it consists harmonically of a two-measure tonic prolongation. The downward arpeggiation of the tonic chord in the left hand, however, could have been perceived as an end gesture by several participants, for the bass not only descends, but ends on the very low F_1.[27] The rhythmically undifferentiated chordal texture in the right hand and the absence of melodic motion in general also compromises the sense of beginning in this excerpt. Indeed, tonic prolongation coupled with non-lyrical repeated chords led some musicians to interpret this excerpt as a *post-cadential* gesture.[28] In other words, they may have sensed that this excerpt came "after the end," but in the absence of such a form-functional category in the function identification task, these musicians identified this excerpt as an end. Finally, this excerpt illustrates well the idea that a statement such as "This is an unusual beginning" clearly implicates the notion of intrinsic formal functionality.

Some generalizations

The foregoing observations suggest that musicians were especially attuned to the harmonic content of excerpts while non-musicians were chiefly influenced by textural and rhythmic features. This difference was especially pronounced when participants had to distinguish between beginnings and middles. Our results show that whereas musicians seem to have based their decisions on the level of prevalence of tonic harmony, non-musicians privileged textural attributes (the

[27] Bass arpeggiation will be further discussed in Chapters 3 and 6.

[28] As confirmed in the verbalization task, in which three musicians mentioned explicitly the possibility of interpreting this passage as post-cadential.

unaccompanied entrance of the right hand and the textural differentiation between both hands) and rhythmic ones (onset density). The perfect authentic cadence as a strong determinant of end function nevertheless highlights the perceptual influence of harmony for both expertise groups.[29] Likewise, the level of rhythmic variety was an attribute used by both groups to discriminate between beginning and middle functions.

Our original prediction that participants' accuracy would be the lowest for middle-function identifications was derived from the dependent status that music theorists generally ascribe to this function. Our findings suggest, however, that musicians and non-musicians were able to identify middles based on several of their internal properties. That our original expectations were wrong, and that middles were identified with a greater accuracy than beginnings, suggest that we underestimated the perceptual weight of middles' intrinsic attributes.

Although many of the musical features that music theorists consider as form-functionally defining seemed to influence the participants' decisions, others appeared to be less relevant perceptually. For instance, most of the middle excerpts consist of repeated 1-bar units. Within their placement in the original themes, these units follow directly upon a passage containing 2-bar units and thus give rise to phrase-structural *fragmentation* (Caplin, 1998). In the out-of-context situation of the experiment, listeners' would not be in a position to perceive the process of fragmentation and thus this major criterion of middle functionality was

[29] We nevertheless proposed above that although both groups were highly responsive to harmony for the end function, musicians weighted this parameter to a greater extent than non-musicians.

not available to them. Likewise, the process of *harmonic acceleration,* another characteristic that theorists have used to identify middle functions, is not immediately perceivable in an out-of-context experimental environment, since it is not possible to compare the rate of harmonic change within the given excerpt to the passage that precedes it in the actual theme. As a result, excerpts exhibiting a relatively fast harmonic rhythm were not judged as middles to a greater extent than those possessing slow or a moderate harmonic rhythm. Thus the theorized link between middle function and the processes of fragmentation and harmonic acceleration—both of which require comparison to previously heard material—seems not to participate in the perception of *intrinsic* formal functionality.

Another criterion that theorists have posed for identifying formal functionality—contour directionality—was not supported by our data. Thus we could discern no direct link between an ascending ("opening-up") melodic contour and beginning function or between a descending ("closing-down") melodic contour and end function. Although all ends closed with a descending melodic contour, many excerpts showing the same property were consensual beginnings or middles (e.g., B3, B9, B10, B11, M3). It seems that by itself—i.e., without a perfect authentic cadence—a descending contour is not a sufficient condition to convey a sense of end.[30]

---

[30] The parameter of melodic contour will be further discussed in Chapter 6 (p. 217).

A sequential decision-making process

When considered together, the results of the function-identification task and those of the strength-of-function rating task induce us to hypothesize that participants identified the formal function of each excerpt through a sequence of three stages.[31] First, on hearing a perfect authentic cadence, participants were most likely to identify an excerpt as an end, whatever competing form-functional cues the excerpt may have contained.[32] This hypothesis is based on three observations: (1) participants' higher accuracy in identifying ends (Figure 1); (2) their higher strength-of-function ratings of this function (Figure 2); and (3) their lower level of confusion involving the end function (Table 3). In a second stage, the absence of a closing perfect authentic cadence led participants to evaluate the excerpt's likelihood of being a beginning. This hypothesis follows from the higher confidence ratings attributed to beginning judgments over middle ones. As a third, final stage, the relative weakness of functional-expression ratings for middles (Figure 2) suggests that excerpts may have been judged as middles as a "fall-back" option in the absence of any better alternative. Such a view would account for the overwhelming quantity of excerpts incorrectly identified as middles by

[31] Further testing is necessary to confirm or reject our hypotheses about participants' decision-making processes. This issue will be addressed in Chapter 5.

[32] We have already discussed that conflicting cues prompted several non-musicians to identify as a middle function some excerpts containing a perfect authentic cadence (E1, E8, and E12); however, these cases were exceptional and in none was the contradictory information strong enough to completely override the effect of the cadence for the group as a whole. In other words, no excerpt closing with a perfect authentic cadence reached the consensus threshold with respect to another formal function than the end.

non-musicians: the status of middle was possibly granted to several excerpts whose formal function could not be easily identified. That most unidentifiable excerpts were classified as middles does not necessarily mean, however, that all middles were unidentifiable. Indeed, our data indicate that some middles clearly conveyed their formal function.[33] Excerpt M1, for instance, constitutes an excellent representative of such a category, for it was the only excerpt in the entire set of experimental stimuli that was judged identically—moreover, correctly—by all 40 participants.[34]

Conclusion

In this study, we investigated the potential for perceiving formal functionality in a musical style governed by well-known conventions. Music theorists have long held that in Western art music of the classical period, the temporal placement of a musical idea and its functional expression can be, and are often, at odds with one another (Agawu, 1991; Caplin, 1998; Kramer, 1988; Lochhead, 1979). We tested the intrinsic perceptibility of the formal functions of beginning, middle, and end. In accordance with established music-theoretic views, we focused on the basic building blocks of musical structure, that is, formal functions contained within a theme (Caplin, 1998; Ratz, 1973; Schoenberg, 1967).

---

[33] The evaluation of middles will be further addressed in Chapter 6.

[34] Excerpts B5 and M2 may be considered as other representatives from this category, since they were both consensual middles for both expertise groups.

Participants, as predicted, performed above chance when asked to identify the intrinsic formal functions conveyed by excerpts from Mozart's piano sonatas. A significant difference was found in the proportion correct identification of the three functions. Both groups of participants identified ends with the greatest accuracy and the strongest level of confidence. Contrary to our initial prediction, middles were identified correctly more often than beginnings. The mean rating strength for middles, however, was lower than that for beginnings. Confusion matrices suggest that participants had difficulty in distinguishing between beginning and middle functions. Overall, our findings indicate that (1) formal functions can be identified out of context; and (2) the perfect authentic cadence—a feature that closed all end excerpts—was by far the strongest functional marker. The accuracy results also showed that many of our theory-based predictions relative to the form-functional clarity of the stimuli were wrong and therefore need to be re-examined. Furthermore, we hypothesized that the functional identification process may be sequential: an excerpt closing with a perfect authentic cadence would most likely be identified as an end; without such a feature, the beginning option would then be considered; and finally, in the absence of clear beginning features, the middle option would be chosen. Finally, our results have shown that musical training played a major role in participants' responses in the function-identification and strength-of-function rating tasks: musicians exhibited a higher accuracy of identification and higher strength-of-function ratings than non-musicians. That musicians were overall more responsive to harmony than non-musicians may partly account for these differences between the groups (especially in the function-identification task), for this parameter plays a fundamental function-defining role in the music of the high classical style. We have seen, nevertheless, that the results of these two tasks were qualitatively similar for both expertise groups—i.e., although the global values were different between the two groups, the *relative patterns* of results were analogous.[35]

In the discussion section, we put forward preliminary hypotheses about which musical features seemed to be most salient for perceiving intrinsic formal functionality. We proposed that (1) generally speaking, musicians tended to rely on harmony to distinguish between beginnings and middles, whereas non-musicians were especially attuned to textural and rhythmic cues; (2) musicians would occasionally use rhythmic information—especially degrees of uniformity or diversity—to differentiate these two functions; (3) both groups were sensitive to harmony (as projected by the perfect authentic cadence) in identifying ends.

In the subsequent phase of this project, we will focus on the form-functional impact of various musical parameters by recomposing alternative versions of our musical excerpts in which we will isolate and modify one musical parameter at a time (to the extent possible). This research is presented in the following chapters.

[35] In other words, there was no significant interaction between musicianship and accuracy of identification, and between musicianship and strength-of-function rating.

References

Bharucha, J., & Stoeckig, K. (1986). Reaction time and musical expectancy: Priming of chords. *Journal of Experimental Psychology: Human Perception and Performance, 12*, 403–410.

Agawu, K. (1991). *Playing with signs*. Princeton: Princeton University Press.

Caplin, W. E. (1998). *Classical form: A theory of formal functions for the instrumental music of Haydn, Mozart, and Beethoven.* New York: Oxford University Press.

Jusczyk, P. W., & Krumhansl, C. L. (1993). Pitch and rhythmic patterns affecting infants' sensitivity to musical phrase structure. *Journal of Experimental Psychology: Human Perception and Performance, 19*, 627−640.

Krumhansl, C., & Jusczyk, P. W. (1990). Infants' perception of phrase structure in music. *Psychological Science, 1*, 70−73.

Kramer, J. D. (1988). *The time of music*. New York: Schirmer Books.

Lochhead, J. (1979). The temporal in Beethoven's opus 135: When are ends beginnings? *In Theory Only, 4*(7), 3−30.

Mozart, W. A. (1977). *Klaviersonaten, Band I* [Score]. E. Herttrich (Ed.). München: G. Henle Verlag.

Ratz, E. (1973). *Einführung in die musikalische Formenlehre: Über Formprinzipien in den Inventionen und Fugen J. S. Bachs und ihre Bedeutung für die Kompositionstechnik Beethovens*. (3rd ed.). Vienna: Universal.

Schoenberg, A. (1967). *Fundamentals of musical composition*. G. Strang and L. Stein (Eds.). London: Faber and Faber.

Tillmann, B., Bigand, E., & Pineau, M. (1998). Effects of global and local contexts on harmonic expectancy. *Music Perception, 16*, 99−117.

Chapter 3. Associational analyses: The links between musical properties and form-functional consensus

In the previous chapter, we discussed musicians' and non-musicians' capacity to ascribe a formal function (beginning, middle, or end) to an out-of-context short musical passage and we proposed hypotheses regarding the musical properties that may contribute to the expression of these functions for each expertise group. Overall, the results showed (1) that both musicians and non-musicians identified beginnings, middles, and ends of musical themes taken from Mozart's piano sonatas comfortably above chance levels, although for both groups, the functions that were the hardest to distinguish from one another were beginnings and middles; (2) that musicians identified beginnings, middles, and ends more accurately than non-musicians; and (3) that musicians seemed to use harmonic information to a greater extent than non-musicians when identifying formal functions; conversely, non-musicians seem to use texture and rhythmic information to a greater extent than musicians. This chapter and the following one present the results of two experiments—referred to as Experiments 2 and 3—that tested the validity of the hypotheses presented in Chapter 2 as well as several others.

AIMS OF EXPERIMENTS 2 AND 3

We investigated further the perception of the intra-thematic formal functions of beginning, middle, and end in the instrumental style of the high classical period by means of two experiments. We posed the following two main questions: (1) what is the role of specific musical properties in the expression of intrinsic formal functionality? (2) how does the level of musical training influence the perception of intrinsic formal functionality? To answer these questions, we composed a set of *modified excerpts*, those which alter specific properties of Mozart's original excerpts. By having a large pool of both original and modified excerpts, we were able to conduct statistical analyses that measured the strength of the association between specific musical properties and the groups of excerpts that best projected the functions of beginning, middle, and end for musicians and non-musicians (the object of the present chapter), and to test the form-functional effect of a specific modification type on several excerpts (as discussed in the following chapter). Since participants of Experiment 1 were the least accurate in distinguishing beginnings from middles, a substantial part of the following two experiments was dedicated to these two functions, although end functions were explored as well.

Alteration of musical properties

In Experiments 2 and 3, musical *properties* comprise two types of characteristics. First, we call musical *parameters* those characteristics that are necessarily present in all musical excerpts, such as melodic contour, rhythmic relationships (for instance, onset density, levels of rhythmic uniformity, etc.), and, since this project involves tonal music, scale degree and harmonic function.[1] Parameters apply throughout musical excerpts—to their entire time-span—and are quantifiable as continuous data. For instance, we will use continuous measurements

[1] To be sure, a single melodic line contains a range of more or less probable implied harmonies.

such as an excerpt's average onset density (attacks per time unit) and coefficients that measure an excerpts' overall level of rhythmic variety, etc. (these will be examined in the results section).[2]

Second, we call musical *specificities* some pre-defined configurations of musical parameters that are either present or absent in an excerpt, such as a cadential formula, an unaccompanied anacrusis, an opening with tonic harmony, etc. In this project, specificities have a determinate temporal location within excerpts—to oversimplify slightly, they can be said to arise at specific time-points—and are quantifiable on a binary scale (present/absent).[3]

While creating the modifications, every attempt was made to isolate variables (i.e., musical properties) while maintaining, to the fullest extent possible, stylistically acceptable stimuli. Such a combination of constraints—an extremely important one in this project—is, however, fairly difficult to satisfy. On the one hand, musical properties are not necessarily independent, discrete entities. As a result, modifying one property may have an impact on another one. For instance,

---

[2] For the purpose of this project, 'parameter' has a more specific and restricted meaning than in traditional music-theoretical discourse, in which it designates music's fundamental elements or resources, such as pitch, rhythm, tempo, dynamics, etc. In this project, 'parameters' represent specific, quantifiable configurations of those resources.

[3] The two types of oppositions that distinguish parameters from properties—continuous vs. binary and time-span vs. time-point—do *not* necessarily have to overlap. Indeed, one could think of a musical property that applies to a specific time-point and that is quantifiable as continuous data (say, a coefficient that represents the amount of sensory dissonance of an excerpt's initial harmonic event), or a property that operates over an entire time-span and that is quantifiable on a binary scale (for instance, complete vs. partial rhythmic uniformity, a property that we will discuss later). However, these oppositions *did* overlap for most of the musical properties studied in the current project. We therefore used these two categories of properties for sake of simplicity.

changing the harmonic inversion of a given chord will often (although not always) affect the contour of the bass line, or changing the harmony will have an impact on the scale degrees used in the melody, etc. When modifying the excerpts, we tried to limit such side effects as much as possible. On the other hand, the stylistic constraints that were imposed to maximize the stimuli's ecological validity caused substantial limitations to our experimental design. Since a specific modification type (e.g., harmonic change) does not necessarily yield musically satisfactory results when applied to different excerpts, we therefore restrained the quantity and the type of parametric modifications that would otherwise have strengthened our design and given us further statistical power. For instance, creating more modifications that augmented the proportion of tonic harmony may have led to stronger statistical results as regards this property. However, it was impossible to apply this modification to many excerpts without transgressing our stylistic boundaries or minimizing side effects on other properties. Overall, we tried to ensure that all of the modified excerpts were, to the best of our knowledge, consistent with Mozart's style.

Figure 3.1 provides a schematic representation of the two types of modification networks that were used in both experiments 2 and 3. In *circumpolar* modifications (Figure 3.1a), modified excerpts (labeled 'Xa,' 'Xb,' and 'Xc') are each one modification apart from a central excerpt (labeled 'X'). *Incremental* modifications consist in a cumulative process for which an excerpt (called Y in Figure 3.1b) is the starting point of a series of modifications in which each subsequent member of the series keeps the previous member's modified elements (labeled Ya, Yab, Yabc, etc.). Figures 3.2 and 3.3 show examples of musical excerpts belonging to a circumpolar and incremental network, respectively.

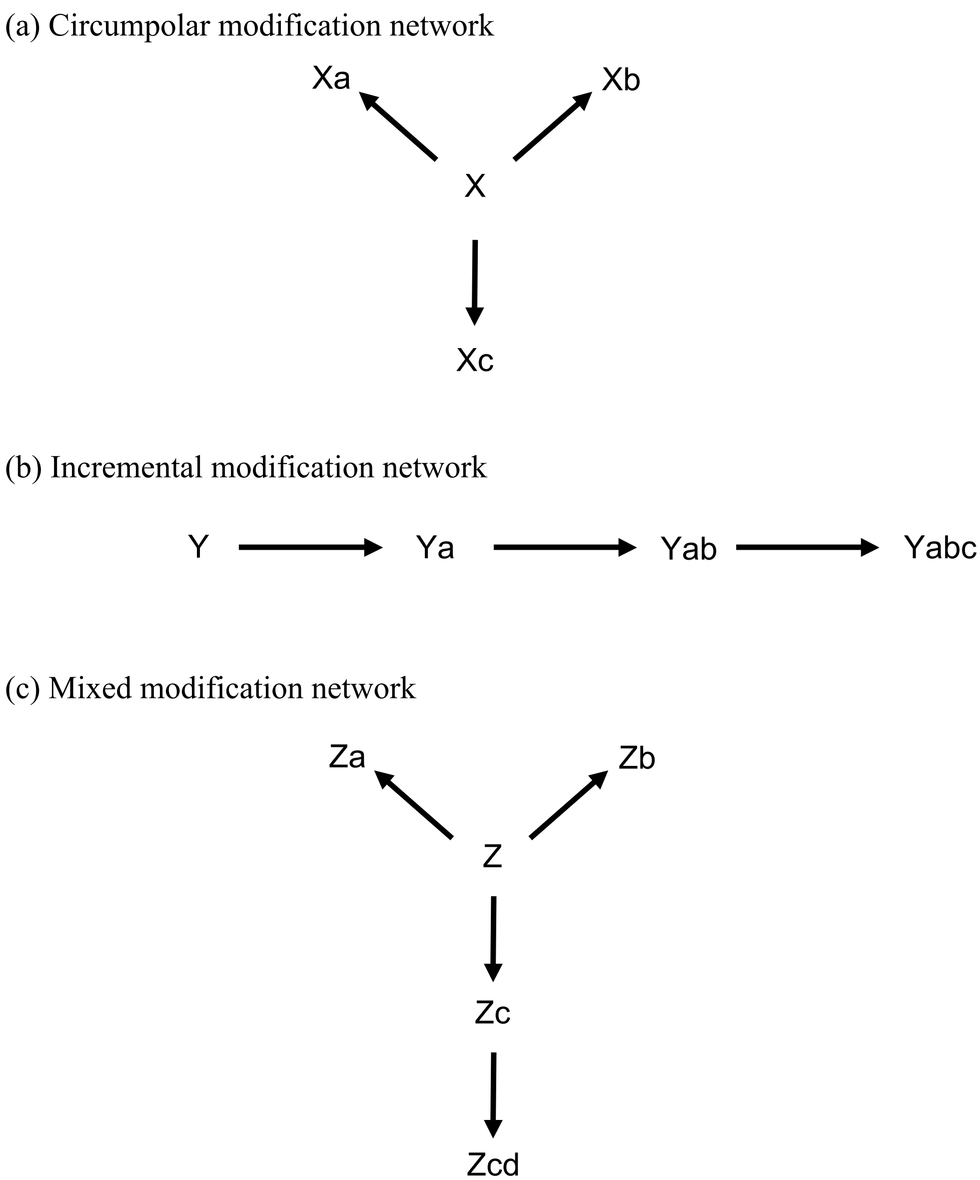


Figure 3.1. Modification networks used in Experiments 2 and 3.

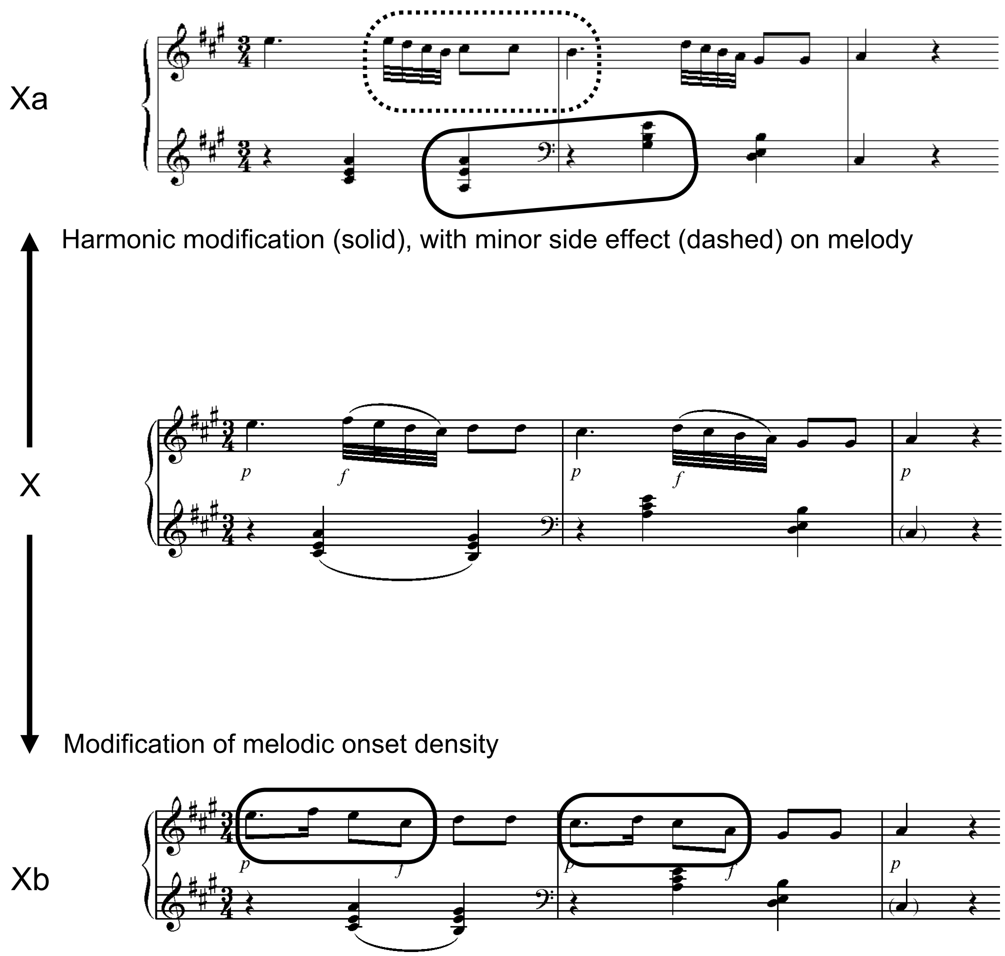


Figure 3.2. Mozart, Piano Sonata in D major, K. 284, ii, 5−7 (excerpt 'X') and two modifications ('Xa' and 'Xb') in a circumpolar network (see excerpts M5, M5-1, and M5-4 in Appendix B).

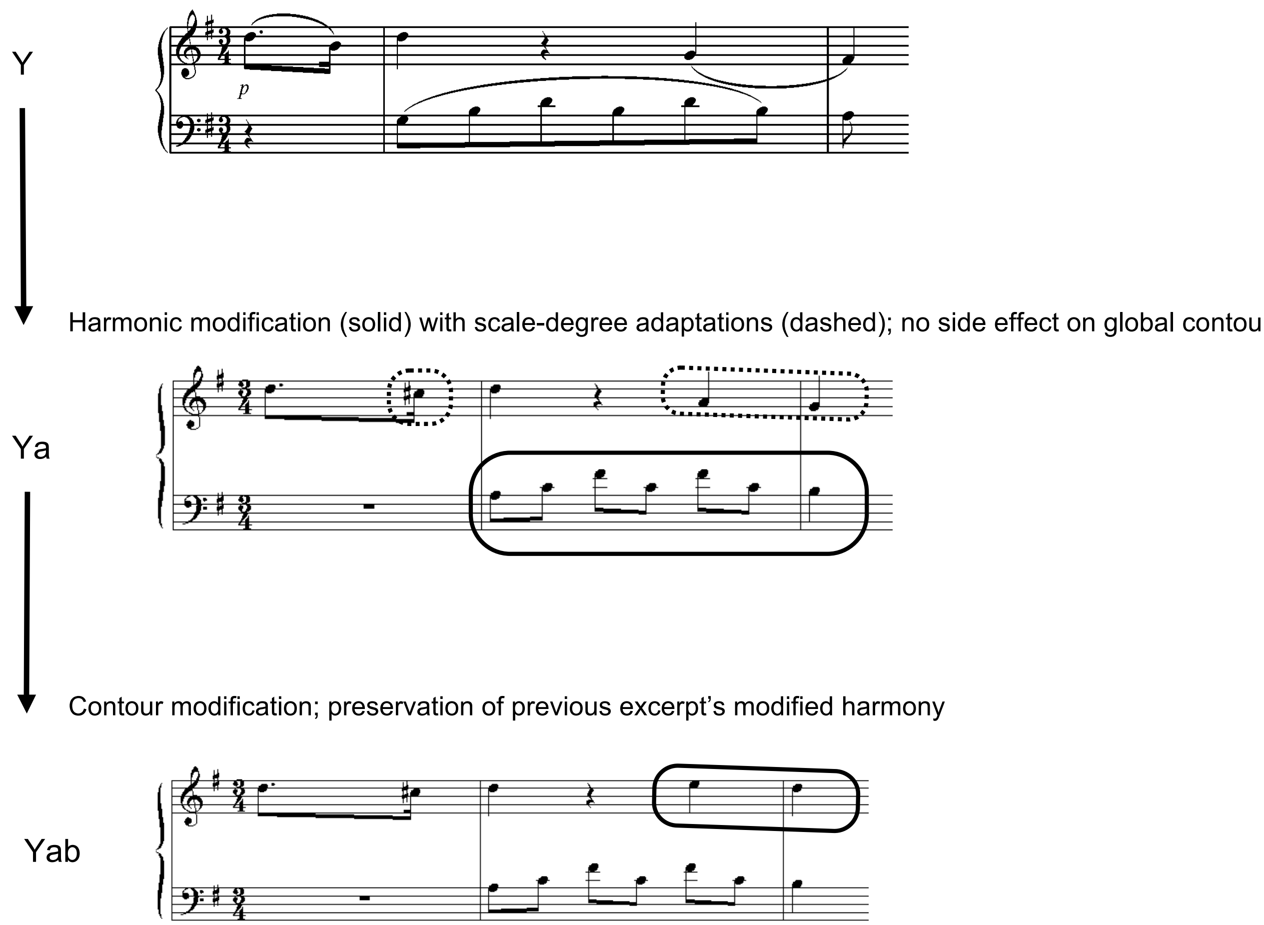


Figure 3.3. Mozart, Piano Sonata in G major, K. 283, i, 1−3 (excerpt 'Y') and two modifications ('Ya' and 'Yab') in an incremental network (see excerpt B3 in Appendix A and excerpts B3-1 and B3-2 in Appendix B).

When using incremental modifications, our intent, in general, was to alter an excerpt's expressed formal function in a unidirectional way, such as moving from its originally being a beginning function to its becoming a middle function. From the point of departure, each subsequent step in the series had to be closer to the formal function expressed by the last excerpt of the chain. Broadly speaking, we used incremental modifications for two main purposes. In some circumstances, we initiated the series of modifications with excerpts that were form-functionally ambiguous—either for musicians, non-musicians, or both groups—according to the results of Experiment 1. In such cases, our aim was to clarify, one parameter at the time, the expressed formal function of such excerpts in such a way that the last member of the chain would express unambiguously one function. In other circumstances, the first member of the series of incremental modifications was an excerpt that had a clear or relatively clear form-functional expression according to previous experimental results.[4] We then altered this function, one parameter at the time, with the goal of having the excerpts at both ends of the chain express completely different formal functions. Note that circumpolar and incremental modification networks were sometimes interconnected to create a "mixed" single original excerpt will be henceforth referred to as a *family* of excerpts, as shown in Figure 3.1c. We restricted to eight the number of excerpts from the same family in our pool of stimuli to avoid presenting participants with too many modifications derived from the same original excerpt.[5]

General hypotheses: form-functional role of musical properties

Due to the large number of hypotheses that we examined in Experiments 2 and 3, it will not be practical to describe all of them thoroughly. For our purpose, it suffices to state our major hypotheses—all based on the observations made in Chapter 2—that motivated the specific modifications of the musical properties of

---

[4] That is, there was a high or relatively high level of consensus across participants on these excerpts' expressed formal function. Measurements for the level of agreement within an expertise group were proposed in Chapter 2 and will be discussed in the results section of the current chapter.

[5] This methodological concern will be discussed in Chapter 6 (p. 245) with respect to carry-over effects.

the excerpts (the specific modifications will be further explained in the result section). First, we hypothesized that the form-functional implications of harmony would differ between expertise groups with respect to the beginning and middle functions, but would be similar as regards the end function. We particularly anticipated a strong association by musicians (only) between an opening tonic and the beginning function and, conversely, between an "off tonic" opening and the middle function. We also anticipated a strong association by both musicians and non-musicians between a closing tonic harmony, especially when preceded by a cadential dominant, and an end function. Second, we hypothesized that rhythmic properties—especially rhythmic uniformity and onset density—would entail similar form-functional responses across expertise groups, although we expected non-musicians to rely on rhythm to a greater extent than musicians to distinguish beginnings from middles. Specifically, we believed that participants would associate a high level of rhythmic variety and a low onset density with the beginning function as well as a low level of rhythmic variety (otherwise said, a high level of rhythmic uniformity) and a high onset density with the middle function. Third, we hypothesized that the unaccompanied anacrusis—a specificity associated with beginnings—would strongly influence non-musicians' capacity to differentiate beginnings from middles while having a lesser impact on musicians' form-functional identifications.

We also examined the effect of other musical properties based on their importance in traditional music-theoretic discourse even though the first experiment's data did not suggest that they had substantial form-functional implications. We focused mainly on three types of such properties: (1) harmonic inversion—root-position tonic harmony being theoretically associated with a beginning function; (2) grouping structure—shorter units being theoretically associated with a middle function; (3) melodic contour—an "opening" (i.e., ascending) melodic contour being theoretically typical of a beginning function.[6]

As noted earlier, our statistical analyses were twofold. First, we analyzed our data on an associational basis, that is, the extent to which specific properties associate with consensual beginnings, middles, or ends (further explanations are given in the results section below). As a reminder, no causal relationship can be drawn from associational analyses.[7] As in Chapter 2, we posited that an excerpt is more likely to be clearly identified as a representative of a specific formal function when (1) this excerpt features several properties that strongly represent one formal

[6] As will be discussed in Chapter 6, contour is a property that poses difficult problems as regards its description and its quantification. As far as associational analyses are concerned, it is the only property that we treated qualitatively.

[7] The following fictitious study illustrates that important point. Let us consider, for instance, a civil engineering company that carries a study on, say, 20 cities in a given district. The results of the study show a strong positive correlation between the number of primary schools and the number of breweries in a city: cities with a large number of primary schools also tend to have a large number of breweries while those with few primary schools also tend to have few breweries. From those results, it would be fallacious to draw any conclusions involving causal relationships between the number of primary schools and breweries. In other words, we can't conclude that variations in the number of primary school *cause* variations in the number of breweries, or vice-versa. In this case, one should rather consider the possibility that the fluctuations in the numbers of primary schools and breweries across cities are caused by a third variable, most likely the overall population of cities (larger cities count more school-age children and beer consumers than smaller cities, which in turn, creates a need for more primary schools and breweries). It must therefore be kept in mind that strong results in associational analyses do not necessarily entail causal relationships.

function;[8] (2) the parameters associated with this function are strongly expressed (e.g., a *high* onset density, a *low* rhythmic variety, etc.); and (3) there are few or no properties representing *different* formal functions within the excerpt. This chapter will explore the results of associational analyses only. Second, as part of the experimental design of this study, we posited that an *alteration* to an important form-functional property would have a substantial impact on participants' functional judgments. For instance, participants' form-functional evaluation of an excerpt opening *with* an unaccompanied anacrusis should be different than their evaluation of the same excerpt *without* its unaccompanied anacrusis. The analyses that are used to measure the form-functional impact of such alterations are based on comparisons of excerpts' judgment distributions with and without the modification. Such comparative analyses, from which causal relationships can be inferred, constitute the main topic of Chapter 4.

METHOD

Experiment 2

Participants

Forty musicians with musical training equivalent or superior to 3rd-year-university level (mean age = 23.2; S.D. = 2.8) and forty non-musicians with less than a year of musical training (mean age = 21.6; S.D. = 3.8) participated in this

[8] Those properties come from both music-theoretical predictions and our own observations from the first Experiment.

study. On average, musicians had 14.9 years of training on an instrument, 6.0 years of ear training, 5.0 years of instruction in harmony, and 4.0 years of instruction in music analysis.

Stimuli

The set of stimuli comprised a total of 150 musical excerpts, including 143 modified excerpts and 7 unmodified (original) excerpts. The average playing time was 3.2 s (S.D. = 0.76). We divided the entire set of excerpts into two equal subsets of 75 excerpts, each subset being presented to 20 musicians and 20 non-musicians. We used two subgroups of participants of each type in order to minimize their level of fatigue. The procedure, however, was faster and less demanding than anticipated and, as a result, we abandoned the two-subgroup design in the subsequent experiment (described below).

The same conditioning phase as in Experiment 1 (see Chapter 2) preceded the experiment proper. For all stimuli, performance variables such as rubato were neutralized. Scores were created via the computer software Sibelius 4.0 and converted to .aiff sound files using the sound sampler Kontakt Silver.

Apparatus

The apparatus was the same as in Experiment 1.

Procedure

The conditioning phase was the same as in Experiment 1. The experiment proper started with five practice trials to ensure that participants were comfortable with the visual interface and the procedure. Then, each participant heard one of the two subsets of 75 excerpts (i.e., one subset being presented to the first subgroup of participants and the other subset to the second subgroup). To minimize close repetition of similar excerpts, an algorithm was used to ensure a minimum of four intervening stimuli between occurrences of excerpts from the same family. Since this algorithm rejected the randomized drawings in which such a restriction was not satisfied, the overall process that determined the order of the excerpts was not, technically speaking, *fully* randomized.

For each excerpt, the subjects performed three tasks. The first was a timed functional identification task (i.e., a 'speeded-judgment' task). At the first hearing of each excerpt, participants activated the excerpt by holding down the mouse button and released it as soon as they had enough musical information to make a functional judgment. Upon release of the mouse button, the music stopped and participants answered the question "*What is the function of this excerpt*?" by selecting either "beginning," "middle," or "end" on a visual interface. The second task—the main task of the experiment—was a second form-functional judgment that subjects made after hearing the same excerpt for a second time, now in its entirety. The third one was a rating task in which participants answered the following question: "*How strongly is this function conveyed? Move the slider along the scale between 'very weakly' and 'very strongly'. Position the slider at the point that corresponds to the strength with which the function is conveyed."* The three tasks had to be performed in that specific order. For all excerpts, participants were asked to judge the formal function independently, that is, regardless of their form-functional judgments on excerpts that were heard in previous trials.

Experiment 3

Participants

Twenty musicians with musical training equivalent or superior to 3rd-year-university level (mean age = 27.1; S.D. = 9.0) and twenty non-musicians with no musical training (mean age = 23.6; S.D. = 6.5) participated in this study.

Stimuli

A total of 148 stimuli were used, including 90 modified and 58 unmodified excerpts. 9 pairs of identical excerpts were introduced to verify the reliability of our measurements.[9] Several "new" originals (i.e., originals that were not used in Experiment 1) were added and some of them were also modified. All of the excerpts' final duration was set to an eighth-note value.[10] The average playing time was 3.5 s (S.D. = 0.7). Stimuli were produced under the same conditions and with the same computer software as in Experiments 1 and 2.

[9] Participants' judgments on identical excerpts were strongly correlated, $r(25) = .98$, $p < .001$ (musicians) and $r(25) = .92$, $p < .001$ (non-musicians), which indicates that our measurements were reliable.

[10] Excerpts in the Appendix may not have been adjusted accordingly.

Procedure

The same conditioning phase as in Experiments 1 and 2 was used. The experiment proper started with nine practice trials. We used a greater number of practice trials than in Experiment 2 since the procedure was slightly more complex. Then, each participant went through 148 trials. After the 74^{th} trial—halfway through the experiment—subjects were prompted to leave the experimental booth and to take a short break during which they filled out a questionnaire about their listening habits. As in Experiment 2, stimuli were presented in a randomized order. However, because participants were exposed to a greater number of excerpts from the same family than in Experiment 2, we augmented from four to nine the minimum number of intervening stimuli between excerpts from the same family.

Among the three tasks that participants performed for each stimulus, only the first one was slightly different from those performed in Experiment 2. As in Experiment 2, the first task was a timed response. In Experiment 3, however, participants heard the excerpt in its entirety before making their first form-functional judgment. They were instructed to respond as fast as possible as soon as the excerpt ended. To minimize the response time, subjects selected their answer by pressing the keys “1” (beginning), “2” (middle), or “3” (end) on the numerical keypad of the keyboard. Feedback about their timing was provided. Whereas in Experiment 2, the time results provided information about the amount of music that was heard prior to the first form-functional identification, in Experiment 3, the time results corresponded to the delay between the end of an excerpt and the form-functional judgment. The three tasks were performed in that specific order, and the wording of the instructions and questions was exactly the same as in Experiment 1.

RESULTS – ASSOCIATIONAL ANALYSES

Since the main task of Experiments 2 and 3 was virtually identical, the results of both experiments will be presented together to facilitate their comparison.[11] Only the salient results will be discussed at length.

Unlike functional identifications of original excerpts, identifications of modified excerpts cannot be evaluated in terms of accuracy since they don't belong to an actual temporal location in an actual musical composition. As we did for the first experiment, we measured the clarity of excerpts' form-functional expression through the level of consensus within subject groups (see Chapter 2, p. 35 for further details). For the current purpose, it suffices to recall that excerpts that prompted 15 or more judgments (out of 20) for one function within an expertise group are referred to as *consensual* within that group.[12]

We classified the consensual excerpts according to the subject group and the expressed formal function (e.g., musicians' consensual beginnings, non-musicians' consensual beginnings, musicians' consensual middles, etc.). We were then able to determine the musical properties that were more characteristic of a

---

[11] Two of the 150 excerpts from Experiment 2 were discarded in the data analysis as they were judged to be at the edge of stylistic acceptability. It must be emphasized, though, that the data relative to these excerpts did not contradict any of the conclusions that were drawn from the results.

[12] Mastunada & Abe's (2005) coefficient of concentration of selection (CCS) was not appropriate for purposes of these analyses since it does not provide a significance threshold for consensual results.

group of consensual excerpts than other groups of consensual excerpts. We must emphasize, however, that a property that is more typically found in a certain group of consensual excerpts does not necessarily have a strong perceptual impact. For instance, if property A is much more likely to be found in musicians' consensual beginnings then musicians' consensual middles, it does not follow that property A has a strong impact on musicians' perception of the beginning function; property A may rather tend to occur coincidentally with property B, which itself has a much stronger form-functional impact. The only way to verify if property A has an impact on beginning judgments is to "remove" it from a series of excerpts and measure the impact of these manipulations on participants' responses, as will be discussed in Chapter 4.

As mentioned above, one of the main concerns in this study was to determine the musical characteristics that help musicians and non-musicians distinguish beginnings from middles. Most analyses on consensual excerpts therefore focus on those two formal functions. Unless otherwise specified, excerpts that closed with a perfect authentic cadence are excluded from these analyses. The numbers of consensual beginnings, middles, and ends by musicians and non-musicians in Experiments 2 and 3 appear in Table 2.3.

Table 3.1. Number of excerpts that received a minimum of 15 judgments for either beginning (B), middle (M), or end (E) function for both subject groups in Experiments 2 and 3.

	Experiment 2			Experiment 3		
	B	M	E	B	M	E
Musicians	30	25	20	17	22	35
Non-musicians	11	20	18	14	19	15

Methodological issues

One of the greatest challenges in this project was to determine the musical properties that would serve as a basis for our statistical analyses. To the extent possible, we chose properties that applied to as many excerpts as possible within our pool of excerpts from Experiments 2 and 3 and that were relevant from a traditional music-theoretical standpoint. Consequently, some properties—including psychoacoustical ones such as sensory dissonance—with potentially important form-functional effects may have been overlooked. We are fully aware that our choice of musical properties and coefficients to quantify certain parameters (such as the level of emphasis on tonic harmony, the level of rhythmic unity/diversity or rhythmic density, etc.) can be debated and eventually substantially improved.

Emphasis on tonic harmony

Emphasis on tonic harmony is a parameter that was computed as the temporal proportion spent on the tonic harmony for a given excerpt. Such a measurement is obviously oversimplified from a purely music-theoretical standpoint as it does not account for important characteristics such as chordal inversion, temporal placement of the tonic harmony, bass motion, etc. The tendencies found in Experiment 1 are nevertheless clear: musicians are much more likely than non-musicians to identify as beginnings excerpts with a larger temporal proportion of tonic harmony, and to identify as middles those that spent more time on non-tonic harmonies. Figure 3.4 illustrates the average temporal proportion spent on tonic harmony in consensual beginnings and middles by both subject groups for Experiments 2 and 3. Significance levels for this property, as well as all the ones discussed in this section, were computed with a permutation test with 50,000 bootstrapped replications.[13]

[13] Bootstrapping is a resampling method for deriving estimates of confidence intervals for various statistics. The permutation test used here computes a statistic 50,000 times by randomly redistributing the combined values from both sets (the consensual beginnings and middles, respectively) every time it computes the statistics. This process creates a normal distribution of results that are generated by chance. The position of the observed statistics (i.e., the statistics that corresponds to our actual results) on this distribution corresponds to its (one-tailed) probability to be generated by chance.

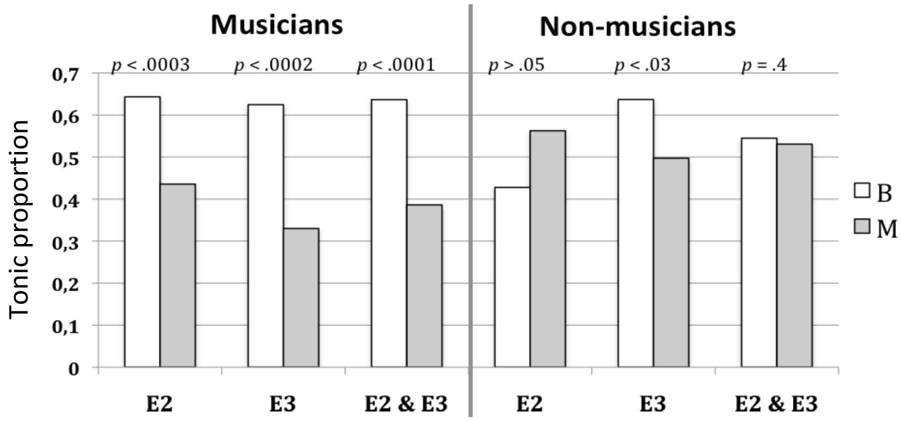


Figure 3.4. Average temporal proportion of tonic harmony in consensual beginnings and endings by musicians and non-musicians in Experiments 2 (E2) and 3 (E3) as well as both experiments combined (E2 & E3), for consensual beginnings (B) and middles (M).

As shown in the figure, there is a statistically significant tendency for musicians' consensual beginnings to temporally emphasize tonic harmony to a greater extent than consensual middles. This tendency was slightly stronger in Experiment 3, but overall, the results are highly consistent across the two experiments. The effect is significant on non-musicians only in Experiment 3. Across experiments, this parameter explains non-musicians' data very poorly. In sum, the prevalence of tonic harmony is a property that may help musicians discriminate between the functions of beginning and middle. (We will develop this point further on.)

Opening tonic harmony

Whereas 'tonic proportion' is a parameter that does not take into account the temporal position of harmonies, the specificity called *opening tonic harmony* does include temporal position. In Chapter 2, we saw that the results of the first experiment suggested that musicians (only) tended to identify excerpts opening with a tonic harmony as a beginning function, and those starting "off tonic," as a middle function.

Figure 3.5 shows the proportion of musicians' and non-musicians' consensual beginnings and middles that displayed the feature of an opening tonic harmony in Experiments 2 and 3. The graph shows a marked difference between musicians' consensual beginnings and middles: whereas, in both experiments, less than the half of the consensual middles opened with a tonic harmony, *all* of the consensual beginnings did. On the one hand, this finding indicates that, for participants of the musicians group, opening with tonic harmony is a necessary condition for a consensual beginning identification. Moreover, although musicians

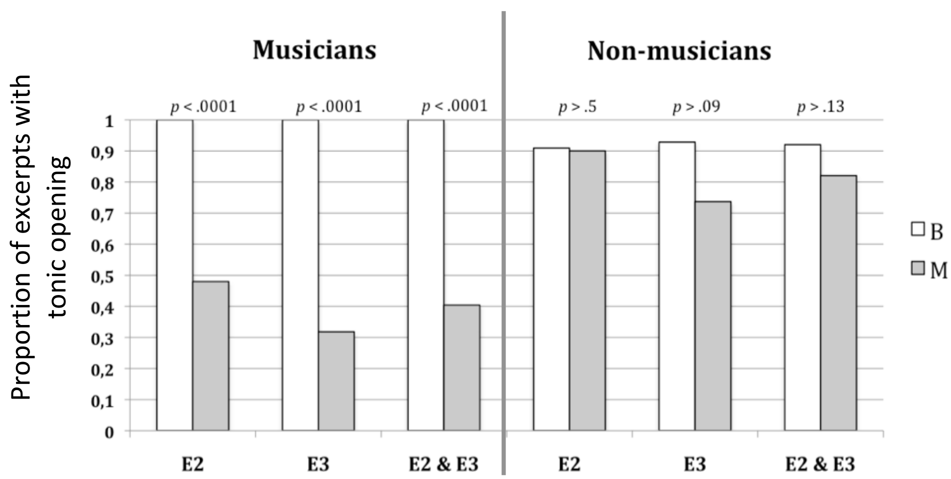


Figure 3.5. Proportion of musicians' and non-musicians' consensual beginnings (B) and middles (M) opening with tonic harmony in Experiments 2 (E2) and 3 (E3) and both experiments (E2 & E3).

did not perceive a tonic opening as completely incompatible with the expression of a middle function, the presence of this specificity considerably reduced the chances of an excerpt being perceived as such. On the other hand, opening an excerpt "off tonic" augmented the chances of obtaining a consensual middle. For non-musicians, no significant trend in their data was observable. Overall, these results suggest that (1) the opening harmony is a much stronger form-functional cue for musicians than mere tonic emphasis; and (2) similar to the tonic proportion property, tonic as an opening harmony is much more important for musicians than for non-musicians in differentiating beginnings from middles. As will become apparent later on, an opening tonic is the one property that yielded the strongest differences in results between musicians and non-musicians.

We ran a series of binomial tests to determine the probability of obtaining the results shown in Figure 3.5, given that the musical property investigated here—opening tonic harmony—is encountered in much more than 50% of the experimental excerpts (see Table 3.2 below). Indeed, the uneven distribution of this property within our pool of stimuli could minimize the strength of the statistical findings presented above. To properly circumscribe the current issue—that is, the distinction between beginning and middle functions based on the excerpts' opening harmony—we excluded all consensual ends by musicians and non-musicians from the calculations. To illustrate what this statistical test shows, let us take a specific example, say, non-musicians' consensual beginnings in Experiment 3 (thus the first five rows of the next-to-last column of the table). The binomial test answered the

Table 3.2. Results of a binomial test measuring the effect of excerpts' opening harmony on beginning and middle function identifications.

		Musicians			Non-musicians		
		E2	**E3**	**Both**	**E2**	**E3**	**Both**
Global percentage of excerpts with tonic opening (%)*		83.6	76.1	80.1	83.9	70.7	77.2
Consens. beginnings	**Tonic opening**	30	17	47	10	13	23
	Total agreed upon	30	17	47	11	14	25
	% tonic opening	100	100	100	90.9	92.9	92.0
	***p* (beginning)**	< .005	< .01	< .001	> .3	< .05	< .05
Consens. middles	**Tonic opening**	12	7	19	18	14	32
	Total agreed upon	25	22	47	20	19	39
	% tonic opening	48	31.8	40.4	90	73.7	82.1
	***p* (middle)**	< .001	< .001	< .001	> .21	> .2	> .1

* Includes all experimental stimuli except consensual ends

following question: given that 70.7% of the excerpts (excluding non-musicians' consensual ends) open with tonic harmony, what is the probability that 13 of the 14 consensual beginnings (thus, 92.9% of them) will open with tonic harmony?[14] The following row shows that the probability is smaller than .05.

---

[14] The probability of success on a single trial (π) was given by the percentage of excerpts that open with tonic harmony—which excluded, as mentioned above, the consensual ends—and we defined a "successful" trial as an consensual excerpt that opened with tonic harmony.

The musicians' results show that, given the distribution of this specificity, it is very unlikely that such a high proportion of consensual beginnings and such a low proportion of consensual middles would open with tonic harmony by chance; non-musicians' results show that it is unlikely that such a high proportion of consensual beginnings open with tonic harmony, but the proportion of middles containing this specificity could easily occur by chance. This suggests that, for non-musicians, the opening tonic specificity may augment the probability of beginning responses but not diminish the probability of middle responses. Overall, these results show that whereas musicians' responses are markedly independent from the distribution of the opening tonic specificity within the pool of stimuli, non-musicians' responses depend to a much greater extent on this distribution.

For musicians, however, this statistical test does not allow quantitative comparisons between the probability of an association between tonic opening and beginning function and that of an association between an off-tonic opening and a middle function. This is mostly due to the ceiling effect as regards musicians' beginning function: even though 100% of musicians' consensual beginnings open with tonic harmony, this feature is so frequently encountered that it is impossible to obtain a probability that would be as low as the one that relates to the middle function. To eliminate this ceiling effect, a pool of stimuli in which half of the excerpts opened with tonic harmony would be required, therefore making an association between a tonic opening and beginning function as likely as an association between an off-tonic opening and a middle function. It must be noted that the ceiling effect also influenced non-musicians' results, especially with respect to the beginning function. Indeed, had all of non-musicians' consensual beginnings opened with tonic harmony, the sample (n = 11) would not have been large enough to make the results of the binomial test statistically significant (a minimum sample of n = 17 would be necessary to reach statistical significance). All in all, the results of the binomial test must be taken cautiously, and further testing on that specific musical feature should be made in order to compare quantitatively the impact of that property on both groups' perception of beginnings and middles.

Unaccompanied melodic opening

Among the musical specificities that we thought were mostly influential on non-musicians' functional judgments, the unaccompanied melodic opening is the strongest one. The results from Experiment 1 showed that many non-musicians interpreted such an opening as a cue for beginning function identifications. From these results, however, it was impossible to determine whether or not musicians were influenced by that specificity.

Figure 3.6 shows the proportion of consensual beginnings and middles that opened with an unaccompanied melody. Most of these excerpts opened with an unaccompanied anacrusis, generally defined as a short unaccompanied melodic fragment located on a weak beat and leading to the subsequent downbeat, at which point the accompaniment appears. In three consensual beginnings, however, this unaccompanied opening was located on the downbeat and therefore did not constitute a proper anacrusis. Moreover, several excerpts from Experiment 3 opened with a *lead-in*, that is, a short melodic passage that (as placed in its original

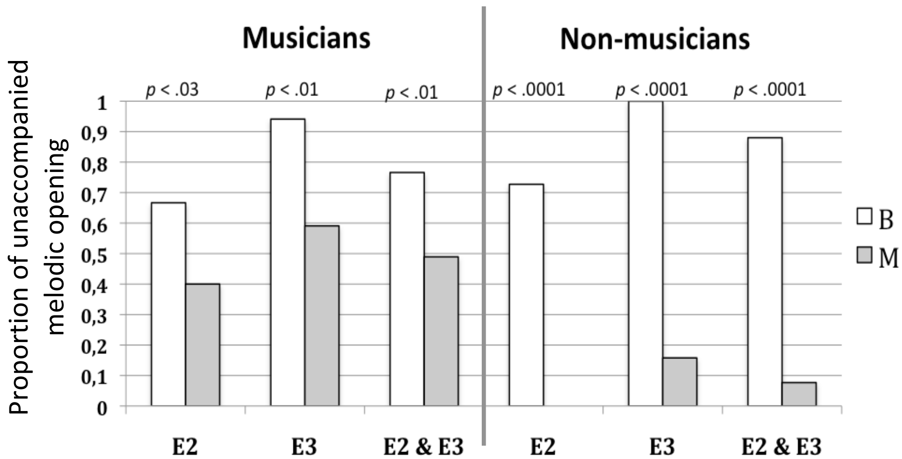


Figure 3.6. Proportion of musicians' and non-musicians' consensual beginnings and middles with an unaccompanied melodic opening in Experiments 2 and 3.

context) links the last melodic note of a phrase to the first melodic note of the following phrase (see excerpts from the 'B17' family in Appendix C). We therefore adopted the term *unaccompanied melodic opening* to characterize all of the above cases. (The separate form-functional influences of the anacrusic and textural components of the unaccompanied anacrusis will be briefly addressed later.)

As shown in the figure, this feature seems to play a major role in non-musicians' judgments of beginnings and middles. On the one hand, non-musicians associate the unaccompanied melodic opening with the expression of a beginning function and, on the other hand, strongly—and completely in Experiment 2—dissociate this feature from the expression of a middle function. Although, qualitatively speaking, musicians tend to behave somewhat similarly, they seem to rely on this feature to a lesser extent than non-musicians, as we anticipated earlier.

As with the opening harmony, we ran a series of binomial tests to determine the probability of obtaining such results based on the distribution of unaccompanied melodic openings in the pool of stimuli (see Table 3.3). The results of these tests

Table 3.3. Results of a binomial test measuring the effect of the unaccompanied melodic opening (UMO) on beginning and middle function identifications.

		Musicians			Non-musicians		
		E2	**E3**	**Both**	**E2**	**E3**	**Both**
Global percentage of excerpts with an UMO*		46.9	64.6	54.4	46.2	62.8	50.6
Consens. beginnings	**Total UMO**	20	16	36	8	14	22
	Total agreed upon	30	17	47	11	14	25
	% UMO	66.7	94.1	76.6	72.7	100	88.0
	***p* (beginning)**	< .02	< .004	< .001	= .053	< .001	< .001
Consens. middles	**UMO**	10	13	23	0	3	3
	Total agreed upon	25	22	47	20	19	39
	% UMO	40	59.1	48.9	0	15.8	7.7
	***p* (middle)**	> .12	> .16	> .08	< .001	< .001	< .001

* Includes all experimental stimuli except consensual ends

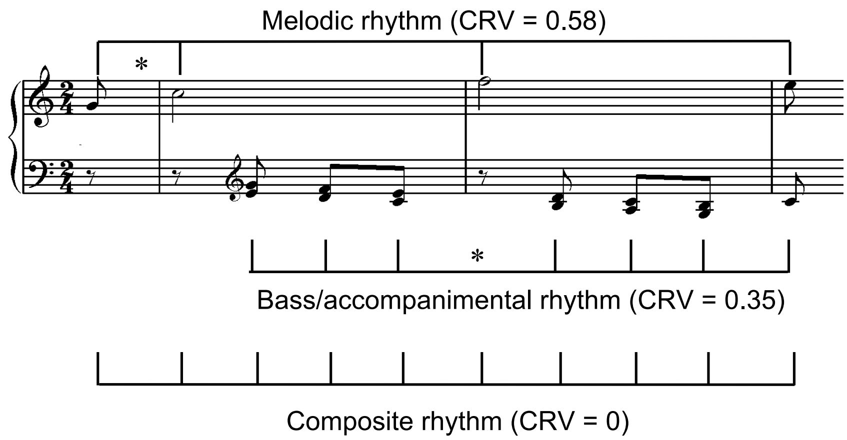
show some relationships between groups and functions that cannot be seen on Figure 3.6 alone. On the one hand, there is a significant positive association between unaccompanied melodic openings and beginning function for both subject groups. (Significance is barely reached for non-musicians in Experiment 1, partly due to the scarcity of consensual beginnings, which weakens the statistical power of the binomial test.) On the other hand, musicians and non-musicians behave quite differently with respect to the middle function: whereas for the latter group, we observe a very strong dissociation of the unaccompanied melodic opening from middle-function identification, for the former group, the feature barely seems to influence the expression of the middle function. In other words, for non-musicians, an unaccompanied melodic opening is virtually incompatible with the expression of a middle function while for musicians, the presence or absence of this feature does not affect the expression of that function. Overall, both expertise groups rely on this feature to differentiate beginnings from middles, but non-musicians seem to do so to a much greater extent.

Rhythmic variety

The results of Experiment 1 strongly suggested that the degree of rhythmic variety contained within excerpts influenced the functional judgments of both musician and non-musician participants. Rhythmically uniform excerpts were associated with the middle function while rhythmically varied excerpts yielded a greater number of beginning identifications. For all excerpts from Experiments 2 and 3, three types of rhythmic relationships were analyzed: (1) *composite rhythm*, relative to all consecutive onsets (in the melody or the accompaniment); (2) *melodic rhythm*, relative to consecutive onsets belonging to the melody; and (3) *bass/accompaniment rhythm*, relative to consecutive onsets belonging to the accompanimental pattern (e.g., Alberti bass, drum bass, etc.) or the bass voice, in excerpts without an accompanimental pattern. For each of these three types, a *coefficient of rhythmic variety* (CRV) was calculated in such a way that (1) each *inter-onset interval* (IOI) was represented by a value that was proportional to its duration (for instance, "2" for half notes, "1" for quarter notes, etc.); and (2) the values were standardized so that their average was equal to 1, in order to ensure that the tempo and choice of metrical unit had no influence on the coefficient. The CRV was finally obtained by computing the standard deviation of these normalized values. A CRV value of zero therefore represents complete rhythmic uniformity (i.e., all durations are equal) and larger values represent higher levels of rhythmic variety (i.e., some, several, or most durations are not equal). Figure 3.7 illustrates the composite, melodic, and bass/accompanimental rhythmic layers on two musical excerpts and shows the computed CRV values for these layers.

Figure 3.8 compares the average values of the CRV for musicians' and non-musicians' consensual beginnings and middles for the two aforementioned types of rhythmic relationships that gave consistent results, that is, composite rhythm and melodic rhythm. The figure shows clear differences in average CRV between both groups' consensual beginning and middle excerpts. In both experiments, beginnings display a significantly higher level of rhythmic diversity than middles. This observation applies to both composite and melodic rhythmic settings. It suffices here to mention that, with respect to rhythmic uniformity, both participant groups seem to pay a similar amount of attention to the composite rhythm and melodic rhythm in order to distinguish between beginning and middle functions. There was indeed no effect of expertise on the difference of CRV values between beginning and middle functions.

(a) Mozart, Piano Sonata in C major, K. 279, iii, 1−3



(b) Modification of Mozart, Piano Sonata in D major, K. 284, i, 5−6

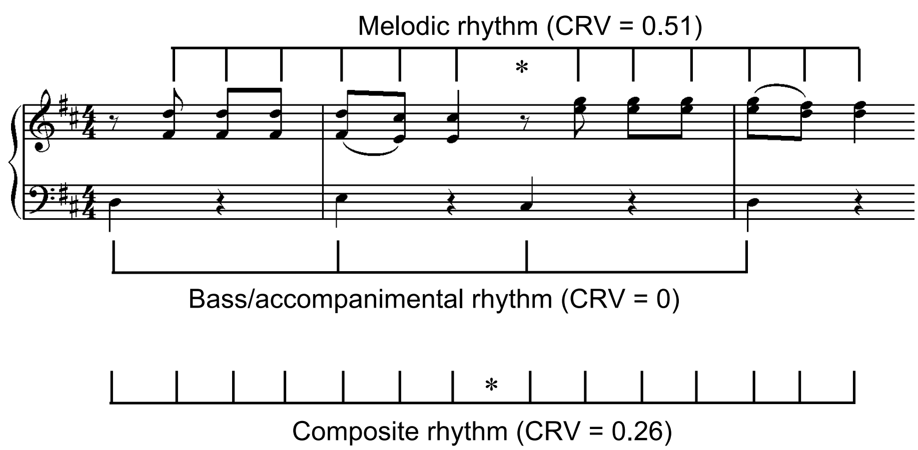
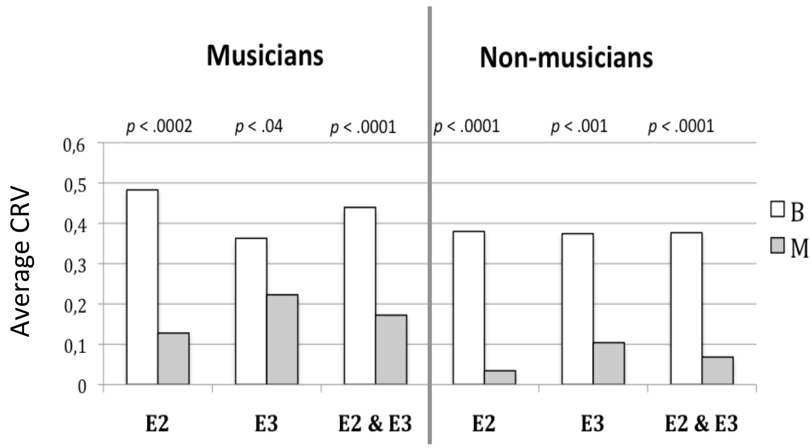


Figure 3.7. CRV values of composite, melodic, and bass/accompanimental rhythmic layers of two musical excerpts. Asterisks (*) indicate inter-onset intervals (IOI) that differ from the other ones within the same layer.

(a) Composite rhythm



(b) Melodic rhythm

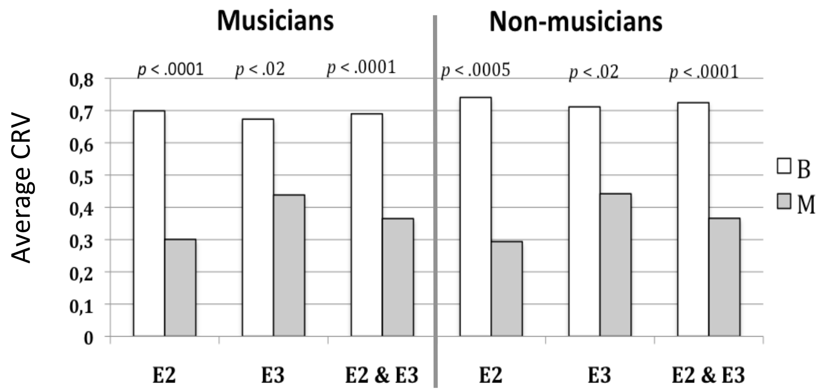
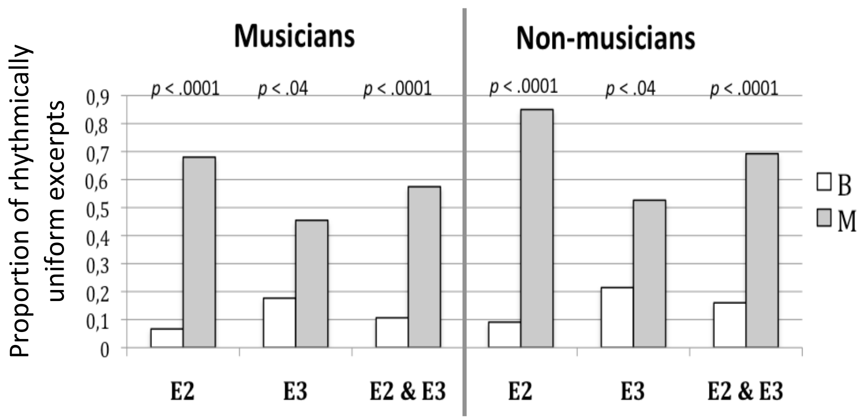


Figure 3.8. Average values of the coefficient of rhythmic variety (CRV) for musicians' and non-musicians' consensual beginnings and middles. Higher values represent a higher level of rhythmic variety, and a value of zero stands for complete rhythmic uniformity.

Another way to assess the form-functional impact of proportional relationships between rhythmic values is by simply computing the proportion of consensual beginnings and middles that show a complete rhythmic uniformity, that is, excerpts having a CRV value of zero. The results of this binary relationship for composite and melodic rhythmic settings are shown in Figure 3.9. As could have been predicted from the CRV values shown above, consensual middles have significantly higher level of rhythmic uniformity than beginnings. (Once again, no consistent tendencies were observed with the bass/accompanimental rhythm.) Also noteworthy is the absence of consensual beginnings with completely uniform rhythmic settings of the melody for both musicians and non-musicians. This shows that, within the context of these experiments, rhythmic variety in the melody is a necessary condition for an excerpt to be identified as a beginning.

(a) Composite rhythm



(b) Melodic rhythm

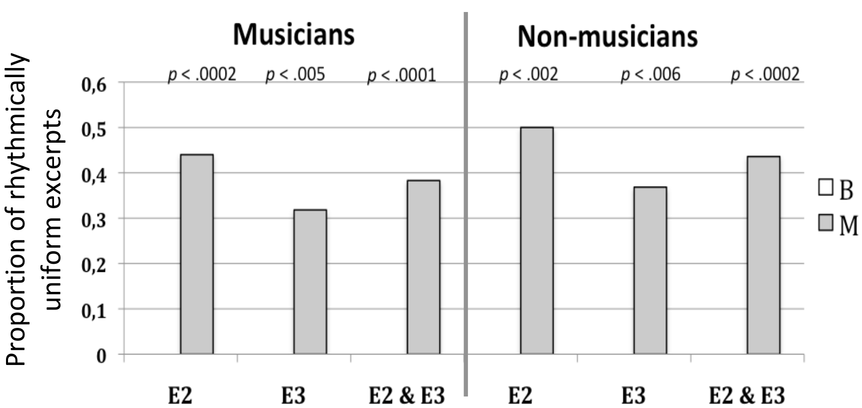


Figure 3.9. Proportion of consensual beginnings and middles with complete rhythmic uniformity.

Onset density

Contrary to the parameter of rhythmic variety, which concerns only the *proportional* relationships between successive IOIs, the parameter of onset density refers to the actual size of IOIs. Therefore, onset density is influenced by the choice of tempo and the rate of onsets per unit of time given by the rhythmic figures. In Experiment 1, we hypothesized that a higher onset density would be more likely to convey a middle function, and a lower one, a beginning function. We originally thought that this feature affected only non-musicians' form-functional judgments.

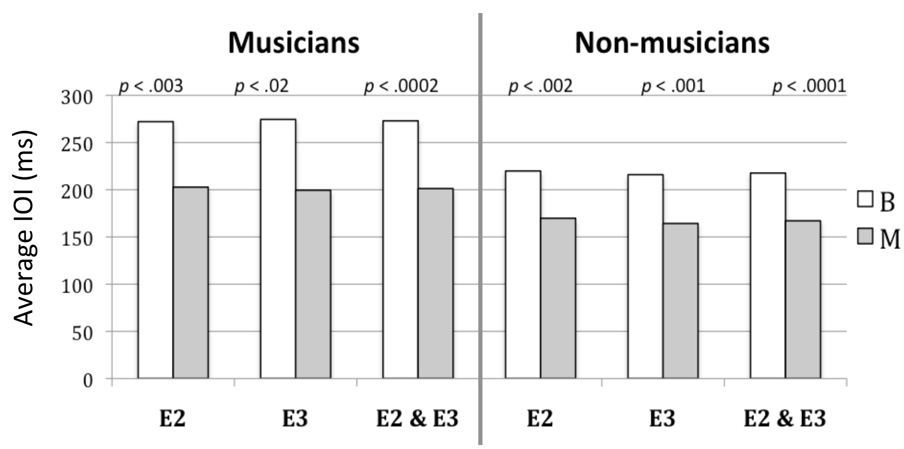
As with the parameter of rhythmic uniformity, composite, melodic rhythm, and bass/accompanimental rhythms were analyzed. For each excerpt and rhythm type, we computed the mean value of the excerpts' IOIs, in milliseconds. Since IOIs and density are inversely proportional, a higher average IOI signifies a lower onset density, and vice-versa.[15] Figure 3.10 compares the average IOIs for musicians' and non-musicians' consensual beginnings and middles for the two types of rhythmic relationships discussed above that gave consistent results, namely, composite and melodic rhythms. Across-group, within-group, and between-group tendencies are remarkably consistent as regards composite rhythm. Across participant groups, consensual beginnings have significantly lower onset

[15] Such a measurement is, obviously, oversimplified from a music-theoretical standpoint as it ignores the actual rhythmic configurations that characterize the musical surface as well as their temporal location. This measurement allowed us, however, to find quite strong tendencies with regards to participants' discrimination between beginnings and middles, and it helped to circumscribe the effect of density of attacks while minimizing the overlaps with the technical definition of the coefficient of rhythmic variety. Moreover, since the excerpts are fairly short, working with average IOIs is less problematic than if our analyses were aimed at entire themes, sections, or pieces.

densities than consensual middles (the difference is marginally significant in the case of musicians in Experiment 2). Within groups, the average onset density is extremely consistent between experiments (i.e., there is no effect of experiment on the average density). Between groups, we consistently observe that musicians' consensual beginnings and middles have lower onset densities than those of non-musicians. We have not been able so far to account for such an outcome.

For the most part, the results of the melodic rhythm are consistent with those of the composite rhythm, although they are less salient. While the overall tendency is the same (lower average onset density for beginnings than for middles), statistical significance is not obtained for musicians in Experiment 2. As with rhythmic uniformity, no consistent and statistically significant tendency emerges from the rhythmic analysis of the bass and the accompaniment. As a whole, the two rhythmic properties of onset density and rhythmic uniformity gave consistent results for both expertise groups and seem to constitute a property that helps all participants making the distinction between beginning and middle functions.

(a) Composite rhythm



(b) Melodic rhythm

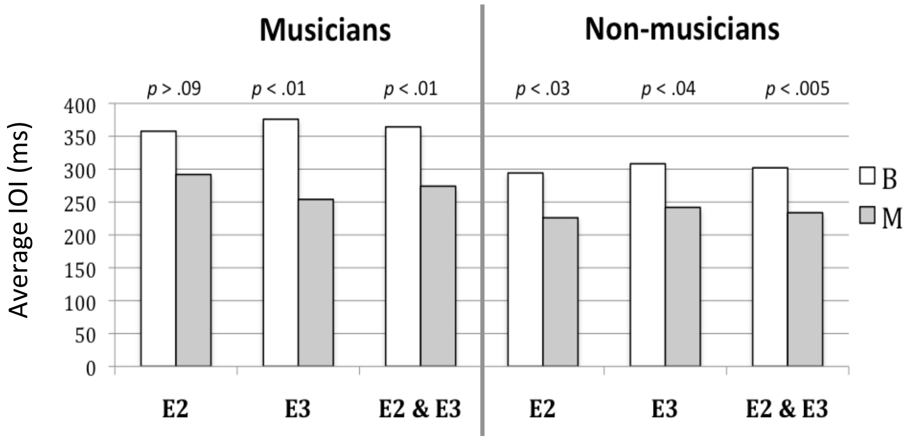


Figure 3.10 (previous and current pages). Average inter-onset intervals (IOI) for musicians' and non-musicians' consensual beginnings and middles, measured in milliseconds. Lower values represent a higher average onset density and vice-versa.

Grouping structure (as defined by repetition)

Theoretically speaking, middle functions—especially continuations (Caplin 1998)—tend to consist of shorter subunits than the beginning functions that they follow. Typically, a two-bar unit expressing a continuation function is made of two single-bar subunits. Many cues, such as repetition, temporal and registral proximity, dynamic and instrumentation contrasts, etc., help segment a musical passage into subunits. Of these cues, repetition is, by far, the most frequently encountered within our experimental stimuli. We thereby classified all excerpts on a 3-step scale according to their level of internal grouping as articulated by repetition.[16] We gave a score of "0" to excerpts that did not contain subunits, a

[16] Theoretically speaking, the level of internal grouping could be quantified on a continuous scale as the weighted sum of the individual contributions from all the musical parameters at play (see, for instance, Hanninen (2001) for a model that could serve as a basis for such an eventual quantification). In practice, however, the weighting of the various parametric contributions would

score of "2" to excerpts in which internal repetition led to a strong sense of internal sub-grouping, and a score of "1" to intermediate cases. We based our subjective analytical judgments on the level of repetition in the melody and in the accompaniment. We interpreted as "strongly subdivided" (score of "2") excerpts where repetition in one textural layer, say, the melody, created a segmental structure that was either re-emphasized in the other layer (the accompaniment, as seen in Figure 3.11), or at least, not contradicted by it (as in Figure 3.12). And we interpreted as "moderately subdivided" (score of "1") cases where the repetition was more ambiguous (see Figure 3.13) or where the two textural layers were not synchronized with respect to their segmental structure (see Figure 3.14).

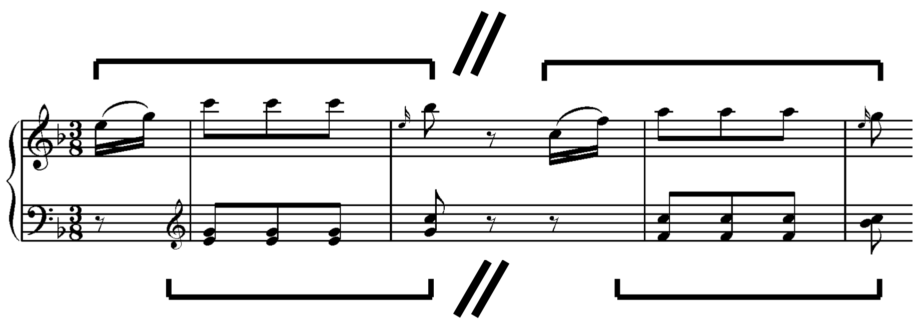


Figure 3.11. Excerpt with strong internal repetition created by both melodic and accompanimental patterns. Brackets illustrate the grouping structure and oblique dashes show the segmental structure.

be contingent upon several subjective factors and, overall, such a task would be overly complicated for the current purpose. We therefore opted for using a discrete 3-category scale based on a series of pre-established criteria.

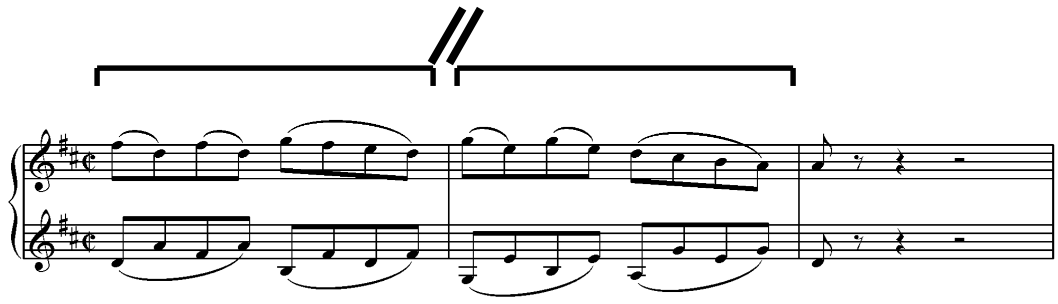


Figure 3.12. Excerpt in which the strong melodic repetition is not reinforced nor contradicted by the accompanimental pattern (i.e., the lower voice's one-beat pattern fits within the grouping structure imposed by the melody's two-beat repeated pattern).

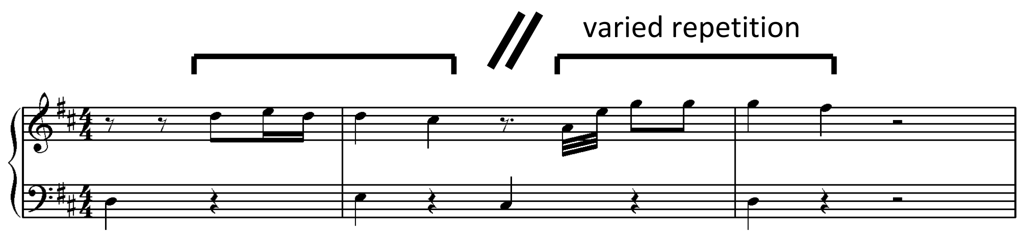


Figure 3.13. Excerpt in which the repetition of first melodic motive is varied, thus, relatively ambiguous compared to the above cases.

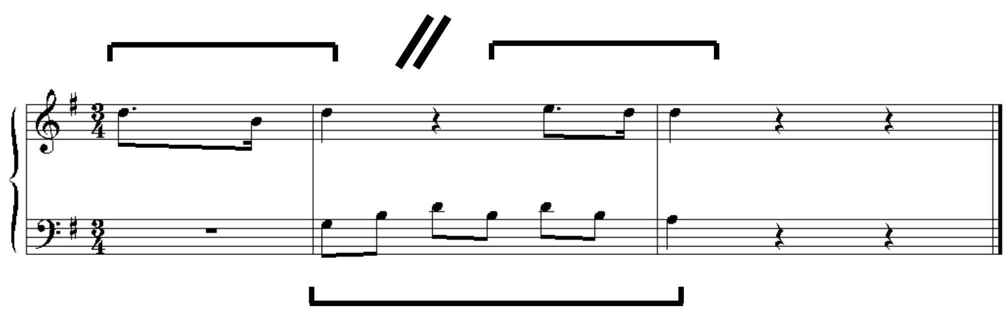


Figure 3.14. Excerpt in which the segmental structure of the melody does not correspond to that of the accompaniment.

Figure 3.15 shows the effect of grouping structure on the identifications of beginnings and middles by the two expertise groups. For musician participants, middles show a greater level of internal subdivision than beginnings, as expected from our theoretical hypotheses. For non-musician participants, this effect was only significant in Experiment 3 and should be considered overall as very weak.

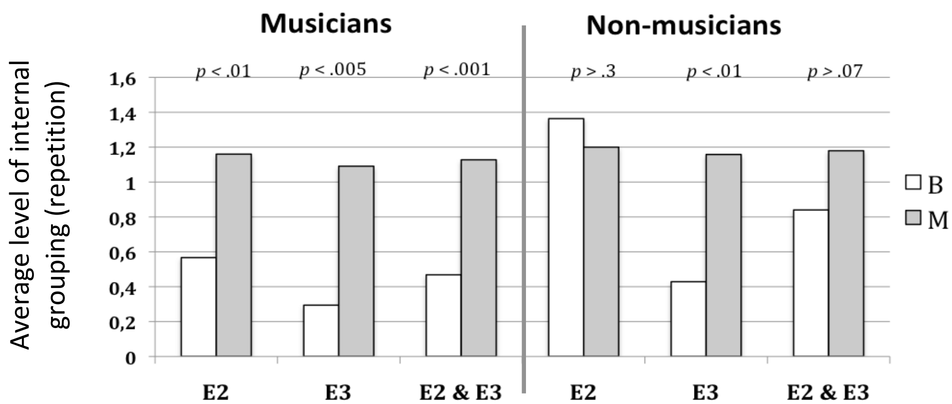


Figure 3.15. Average levels of internal sub-grouping in musicians' and non-musicians' consensual beginnings and middles (3-level scale). Higher values indicate higher levels of internal sub-grouping through repetition.

Other properties

The properties discussed thus far are those that best explained participants' distinctions between consensual beginnings and middles. Other properties, however, did not entail significant results, which suggests that their explanatory power with respect to those two formal functions is minimal.

Among those properties, let us focus on the three most important ones, beginning first with the parameter of melodic contour. Despite the frequent association in conventional music-theoretical discourse between an "opening up" melodic contour and beginning function, we found no configuration of melodic contour that was specific to (or more likely to be associated with) the sense of formal beginning. Concerning the parameter of harmonic rhythm—that is, the rate of chord change per time unit, we expected middles, as opposed to beginnings, to be associated with a faster harmonic rhythm, a common compositional strategy used in the medial function of continuation (Caplin, 1998). But our data did not confirm those predictions; that is, the rate of chord change per time unit was not significantly different in consensual middles than beginnings. Harmonic inversion also yielded weak results. Music-theoretical accounts of form generally associate a higher level of stability with root-position tonic harmony, especially at the opening of an excerpt. Excerpts opening with a root-position tonic were therefore expected to convey a stronger sense of beginning than those opening with an inversion of that harmony. This specificity, however, was not found to be more frequent in consensual beginnings than in middles.

Multiple regression and the weighted influence of individual properties

The above analyses allow for comparing the importance of a specific musical property *between* expertise groups (e.g., a link between property X and formal function A that is stronger for musicians than non-musicians), but not the relative importance of several properties *within* a single expertise group (e.g., for musicians, the link between property X and formal function A is stronger than that between property Y and formal function A). We therefore used multiple regression analyses, which consist in elaborating a model that aims at maximizing the proportion of the behavioral data that is explained (accounted for) based on individual contributions of several properties (predictors). The following analyses show the relative weights supplied to all musical properties described above in order to explain both groups' variations in beginning and middle judgments (see

Figure 3.16). In order to have enough statistical power to assess the impact of a relatively large number of descriptors, all non-consensual ends were included in these analyses and therefore, the pool of excerpts ($113 < n < 130$) was larger than in the analyses on consensual excerpts shown above. The weights are provided as standardized beta values whereby the influence of a property is proportional to the magnitude of the weight ascribed to a property, regardless of the direction. Negative values refer to properties that have a negative contribution to the expression of a given formal function. (For instance, we observe more middle-function identifications when there is *no* unaccompanied melodic opening; therefore the middle function and the property of unaccompanied melodic opening correlate negatively.) We used stepwise backwards settings, that is, the model begins with all predictors and gradually removes those that do not contribute significantly to the overall accountability of the behavioral data. Values of '0' (or predictors not represented on a graph) correspond to the predictors removed during the test. For all analyses, r- and r^2-values for the entire model are provided.[17]

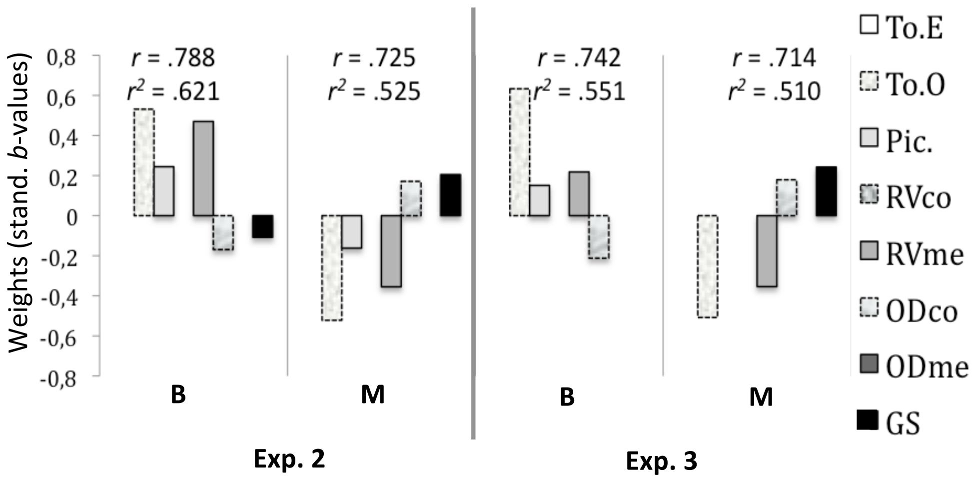
The following tendencies are particularly noteworthy:

- The most determinant musical property for musicians is the opening tonic and for non-musicians, the unaccompanied melodic opening; the latter property also contributes substantially to explaining musicians' data, but to a much lesser extent than non-musicians' data;

[17] The r-value represents the multiple correlation coefficient—that is, the correlation between the observed (actual) values and the values predicted by the model—and the r^2-value shows the total amount of variation that is accounted for by the model. Both values are in-between 0 (random) and 1 (perfect correspondence).

- Melodic rhythmic variety has a much stronger explanatory power with respect to musicians' data than its composite component, which has been systematically removed in all conditions; on the contrary, the onset density of the composite rhythm better explains musicians' data than does that of the melodic rhythm, which has also been removed from the model in all conditions;
- For musicians, grouping structure plays a stronger role in the expression of middles than beginnings;
- Broadly speaking, for non-musicians, the properties of rhythmic variety and onset density have stronger weights with respect to middle functions than beginning functions;
- Musicians' data is better explained with a smaller and more consistent set of properties than non-musicians' data. All properties' contributions for beginnings and middles are in opposite directions, except for non-musicians as regards tonic emphasis (positive for middles in Experiment 2, and also positive for beginnings in Experiment 3); this suggests that, overall, properties' contributions are fairly stable with respect to these functions across experiments, and that the property of tonic emphasis makes inconsistent predictions with respect to non-musicians' form-functional decisions and should therefore be considered as a poor predictor.

(a) Musicians



(b) Non-musicians

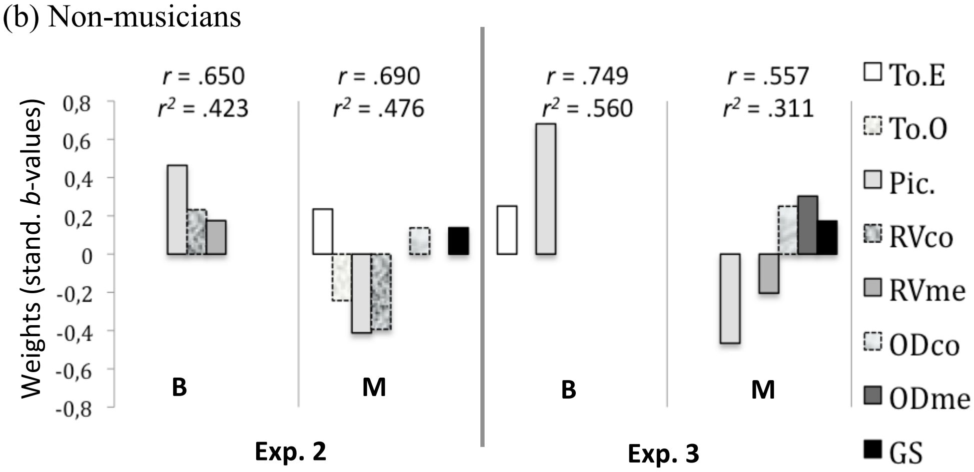


Figure 3.16. Results of multiple regression analyses showing the weighted influence of musical properties of tonic emphasis (To.E), tonic opening (To.O.), unaccompanied melodic opening (Pic.), composite rhythmic variety (RVco), melodic rhythmic variety (RVme), onset density on composite rhythm (ODco), onset density on melodic rhythm (ODme), and grouping structure (GS) on musicians' and non-musicians' beginning (B) and middle (M) judgments in Experiments 2 (Exp. 2) and 3 (Exp. 3).

From these results, it is possible to hypothesize that some properties are form-functionally stronger then others. Indeed, such an outcome is highly probable in cases where (1) pairs of properties are highly correlated across excerpts—for instance, the likelihood that an excerpt starts with tonic harmony increases as its tonic proportion increases—*and* (2) one of these two properties was given stronger weights in the multiple regression analyses than the other. Three pairs of properties were moderately correlated across excerpts: (i) tonic emphasis and opening tonic ($.622 < r < .753$, $p < .001$); (ii) composite and melodic rhythmic variety ($.437 < r < .649$, $p < .001$); and (iii) composite and melodic onset density ($.562 < r < .608$, $p < .001$). As shown in Figure 3.16a, musicians' data were best explained with only one member of each of these three pairs of properties: the opening tonic in the first pair, melodic rhythmic variety in the second pair, and composite onset density in the third pair. Although we can't infer causality based on this test alone, the results suggest that for musicians, tonic emphasis, composite rhythmic variety and melodic onset density may be artifacts of their form-functionally stronger, highly-correlated counterparts (opening tonic, melodic rhythmic activity, composite onset density, respectively). Further analyses are nevertheless required to sustain this proposition (see Chapter 4). For non-musicians, however, it is impossible to assess whether any properties were similarly prioritized over others.

Although the r- and r^2-values of our tests are overall relatively satisfactory (if we exclude non-musicians' middles in Experiment 3), it is important to try to pinpoint some of the model's deficiencies. First, it is very likely that some form-functionally efficient properties were left out of the calculation, either because they are less relevant to a traditional music-theoretical investigation, or because they are simply unknown yet. Second, it is possible that the efficiency of some parameters—tonic emphasis, rhythmic variety, and onset density—is not linear and only affects listeners' form-functional identifications past a certain threshold. Third, it is likely that the form-functional impact of a property is constrained by the musical context. For instance, the form-functional impact of an unaccompanied melodic opening may vary according to the level of rhythmic variety, onset density, etc. The latter two observations will be substantiated in Chapter 6.

A few words about ends

Although we dedicated most of our attention to beginnings and middles, we found a few salient tendencies as regards the end function. From the information available in Experiment 1, we concluded that the perfect authentic cadence (PAC) was the strongest form-functional indicator for all formal functions and subject groups. We observed, however, that this feature had a stronger impact on musicians than on non-musicians. The results of Experiment 3, in which several new original end excerpts were included, tend to support this observation. On the one hand, our data indicate that the mere presence of a PAC is virtually a sufficient condition to obtain a consensual end function in the musicians group (that is, 32 out of 34 such excerpts yielded 15 or more end judgments).[18] On the other hand, for non-

[18] Among the two exceptions to this rule, one excerpt received 14 functional end judgments and was therefore on the edge of being consensual (excerpt E19, in Appendix C), and the other (B10-13, in Appendix C) was a modified beginning at the end of which the first scale degree replaced the fifth degree. This latter excerpt will be discussed in Chapter 6 (pp. 228–230).

musicians, the rate of end-function agreement among excerpts featuring a PAC dropped to about 35%. Such a low proportion suggests that one or several properties other than the melodic/harmonic PAC affect non-musicians' perception of ends.

To address this issue, we examined the pool of excerpts closing with a PAC and compared the distribution of several properties across non-musicians' consensual and non-consensual end excerpts. The five properties we examined were those that we deemed to have the greatest potential to explain non-musicians' data: (1) the presence/absence of a rhetorical closure on the weak beat following the ultimate tonic harmony, most often featuring a leap in the bass (see Figure 3.17) and/or the resolution of suspension(s)—this property will be henceforth termed *weak-beat closure*;[19] (2) the presence/absence of a marked decrease in onset

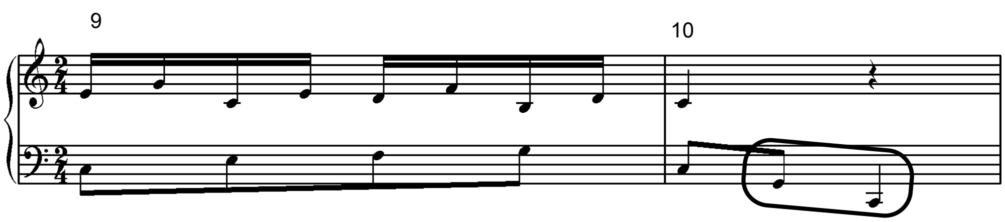


Figure 3.17. Weak-beat closure; Mozart, Piano Sonata in C major, K. 279, iii, m. 10.

density towards the closure of the excerpt, henceforth referred to as *final onset density decrease* (see Figure 3.18);[20] (3) the presence/absence of a trill in the upper voice of the penultimate harmony (see Figure 3.19); (4) the level of rhythmic

---

[19] The effect of the descending bass arpeggiation was discussed in Chapter 2 (pp. 50–51) with respect to excerpt B1.

[20] Note that the onset density decrease takes sometimes place in the weak-beat closure.

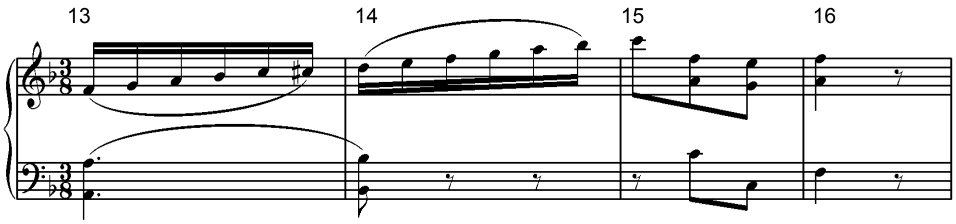


Figure 3.18. Final onset density decrease (from 16th- to 8th-notes); Mozart, Piano Sonata in B-flat, K. 280, iii, m. 15.

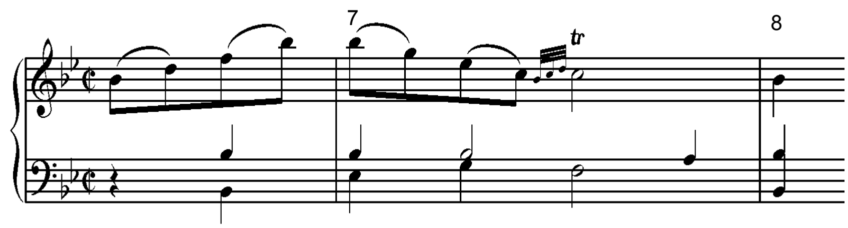


Figure 3.19. A typical use of a trill over the cadential dominant; Mozart, Piano Sonata in B-flat, K. 281, iii, m. 7.

variety, measured on composite, melodic, and bass/accompanimental rhythm (see Figure 3.7 above); and (5) the average onset density, also measured on composite, melodic, and bass/accompanimental rhythm. We predicted that a larger proportion of consensual end excerpts would feature a weak-beat closure and a final onset density decrease than non-consensual excerpts.[21] Conversely, we expected fewer consensual ends with trills than non-consensual ends. Although trills—especially when involving scale degrees 2 and 3—often act as indicators of a forthcoming cadence, they also tend to increase the onset density. We supposed that non-musicians would be less familiar with such a specific musical convention and consequently more inclined to follow their form-functional intuitions based on

---

[21] The latter prediction is based on the findings of Jusczyk & Krumhansl (1993), Krumhansl & Jusczyk (1990), and Palmer & Krumhansl (1987a, 1987b).

the level of onset density exclusively. We therefore hypothesized that trills would yield an augmentation of middle judgments and a diminution of beginning judgments. Finally, we predicted a higher level of rhythmic variety and a lower average onset density for consensual ends than for non-consensual excerpts. Those five properties were selected from our own music-theoretical knowledge and intuitions, and we acknowledge that we may have overlooked other musical properties that may convey a strong sense of end to non-musicians.

As shown on Figure 3.20, only three of those properties led to statistically significant results. First, as predicted, a higher proportion of non-consensual excerpts closing with a PAC featured a final onset density decrease than the consensual ones (Figure 3.20a). Second, contrary to our predictions, non-consensual excerpts showed a higher level of rhythmic variety (thus a higher coefficient of rhythmic variety, or 'CRV') than the consensual ones, but only in the composite rhythm (Figure 3.20b). Third, also contrary to our expectations, consensual excerpts showed a statistically significant *higher* level of onset density than non-consensual ones, and only in the bass/accompanimental rhythm (Figure 3.20c). The latter two properties—rhythmic variety and onset density—suggest that non-musicians' consensual ends are somewhat closer to middles than beginnings (we have already seen that middles have a lower coefficient of rhythmic variety and a higher average onset density). The former property—the final onset density decrease—gives a special clue as to how these excerpts may be rhythmically distinguishable from middles, that is, through rhythmic information located at their closing part. This issue will be discussed further in Chapter 6.

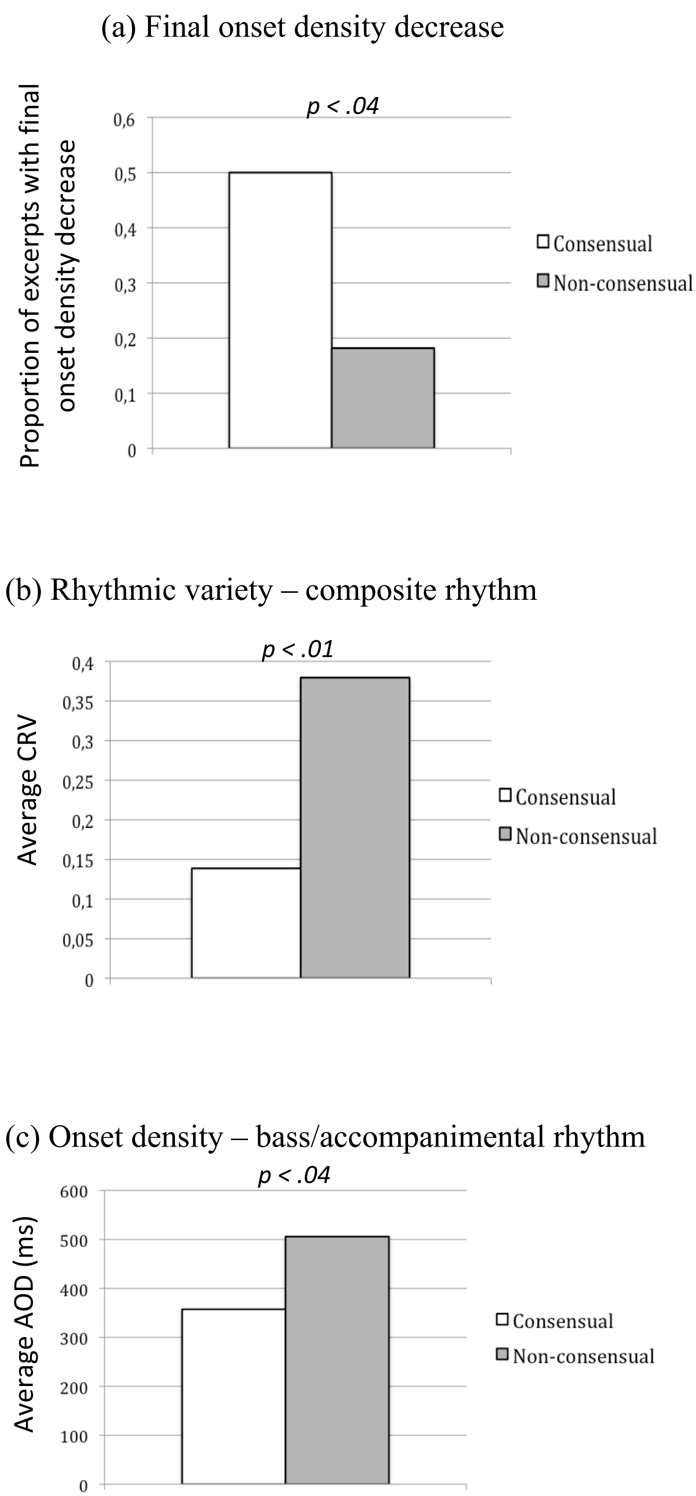


Figure 3.20. Statistically significant differences in properties measured in non-musicians consensual and non-consensual ends closing with a PAC.

The above analyses were directed exclusively at non-musicians' responses to excerpts ending with a PAC in Experiment 3. Now let us turn to general observations concerning both groups' consensual ends in Experiments 2 and 3 together. First, *all* consensual endings closed on tonic harmony and a large majority featured a melodic closure on the first scale degree. Second, several consensual endings by both musicians and non-musicians (6 excerpts in each expertise group, all in Experiment 2) did not close with a genuine perfect authentic cadence, as their penultimate dominant chord was inverted (which contravenes the traditional definition of the PAC). Although excerpts with genuine perfect authentic cadences were relatively scarce in Experiment 2 and thus the results concerning the end function in that experiment must be interpreted cautiously, these observations indicate that the perception of the end function depends to a greater extent on the final chord—necessarily a tonic—than on the penultimate chord.

Associational analyses: a summary

In sum, as far as associational analyses are concerned (i.e., analyses on consensual excerpts and multiple regression), there is sufficient evidence to lay down the following principles as regards musicians' and non-musicians' perception of beginnings and middles:

- Opening with tonic harmony is a necessary condition for musicians' consensual perception of the beginning function;
- The opening harmony is a crucial criterion for musicians' distinction between beginnings and middles;

- Non-musicians rely strongly on an unaccompanied melodic opening to distinguish between beginnings and middles while musicians rely on this property to a lesser extent, but for the same purpose;
- Both groups associate a greater rhythmic variety with beginnings, and a greater rhythmic uniformity with middles; for musicians, this property applies mostly to melodic rhythm;
- Both groups associate a lower onset density with beginnings, and a higher one with middles; for musicians, this property applies mostly to composite rhythm;
- Musicians weakly associate internal sub-grouping (through repetition) with middles.

As regards the perception of the end function, we can summarize our findings as follows:

- For both subject groups, closing on a tonic harmony is a necessary condition for the consensual perception of an end function;
- For both subject groups, closing with a PAC is *not* a necessary condition for a consensual perception of an end function, but it is virtually a sufficient one for musicians;
- Melodies closing on the first scale degree are by far the most conclusive for both musicians and non-musicians;

- Rhythmic properties—especially a final decrease in onset density—have a tangible impact on non-musicians' perception of ends.[22]

The conclusive quality of these properties had already been addressed in the literature (e.g., Bharucha & Stoeckig, 1986; Boltz, 1989a, 1989b; Marmel, Tillman, & Dowling, 2008; Marmel & Tillmann, 2009; Palmer & Krumhansl, 1987a, 1987b; Krumhansl & Jusczyk, 1990) and as such, our results are consistent with those of previous studies.

In this chapter, we discussed a portion of the results of Experiments 2 and 3. We were able to make associational links between musicians' and non-musicians' consensual beginnings, middles, and ends and the musical properties that are more likely to characterize them. In the following chapter, we will discuss the impact of our experimental manipulations on the stimuli used in those two experiments. Contrary to associational analyses, the analyses based on these manipulations will allow us to posit a causal relationship between a property and its impact on musicians' and non-musicians' perception of formal functions.

References

Bharucha, J., & Stoeckig, K. (1986). Reaction time and musical expectancy: Priming of chords. *Journal of Experimental Psychology: Human Perception and Performance, 12*, 403–410.

---

[22] Notice that our results do *not* show that this property has no influence musicians' perception of the end function.

Boltz, M. (1989a). Perceiving the end: Effects of tonal relationships on melodic completion. *Journal of Experimental Psychology: Human Perception and Performance, 15*, 749–761.

Boltz, M. (1989b). Rhythm and “good endings”: Effects of temporal structure on tonality judgments. *Perception & Psychophysics, 46*, 9–17.

Caplin, W. E. (1998). *Classical form: A theory of formal functions for the instrumental music of Haydn, Mozart, and Beethoven.* New York: Oxford University Press.

Hanninen, D. A. (2001). Orientations, criteria, segments: A general theory of segmentation for music analysis. *Journal of Music Theory, 45*, 345–433.

Krumhansl, C., & Jusczyk, P. W. (1990). Infants’ perception of phrase structure in music. *Psychological Science, 1*, 70−73.

Marmel, F., & Tillmann, B. (2009). Tonal priming beyond tonics. *Music Perception, 26*, 211−221.

Marmel, F., Tillmann, B., & Dowling, W. J. (2008). Tonal expectations influence pitch perception. *Perception & Psychophysics, 70*, 841−852.

Palmer, C., & Krumhansl, C. (1987a). Independent temporal and pitch structures in determination of musical phrases. *Journal of Experimental Psychology: Human Perception and Performance, 13*, 116−126.

Palmer, C., & Krumhansl, C. (1987b). Pitch and temporal contributions to musical phrase perception: Effects of harmony, performance timing, and familiarity. *Perception & Psychophysics, 41*, 505−518.

Chapter 4. Comparative analyses: The effect of musical modifications on participants' form-functional judgments

---

The results discussed in Chapters 2 and 3 provided evidence for strong associations between excerpts that clearly project a specific formal function—according to either musicians or non-musicians—and the musical properties that are most likely to be found in those functionally unequivocal excerpts. Since associational analyses cannot, by definition, allow us to infer causal relationships between a parameter and a perceptual effect, several ambiguities remain as concern the relative perceptual strength of the properties analyzed thus far. For instance, risks of false positive errors—that is, claiming that a property has a perceptual impact when, in reality, it does not—are particularly important (1) when the musical properties are not evenly distributed within the global pool of stimuli, a condition that applies to our own pool; and (2) when some properties have a stronger form-functional impact than others, which the results from Chapter 3 strongly suggest. Indeed, on the basis of associational analyses alone, any given property may be interpreted as form-functionally efficient while, in fact, it may merely co-occur with one or more other properties that have a stronger form-functional impact. This chapter exposes the results of *comparative analyses*, which consist in comparing the perceptual effect of carefully manipulated experimental materials, namely, the recompositional *modifications* discussed in the first part of Chapter 3. Contrary to associational analyses, comparative analyses allow us to infer causal relationships and, therefore, to circumscribe the perceptual effect of individual properties.

COMPARATIVE ANALYSES OF MANIPULATED VARIABLES

The associational analyses presented in the previous chapters were based on the excerpts' *absolute* number of form-functional identifications. The comparative analyses discussed in the current chapter consist of comparing the *relative* judgment distributions of pairs of excerpts (from the same family) that are one modification apart. Each pair of compared excerpts contains a *referential* excerpt—the control excerpt relative to which the effect of a modification is measured—and a *comparative* excerpt—the excerpt that is one modification apart from the referential excerpt.[1]

As discussed above, however, modified excerpts can sometimes serve as the point of departure for other parametric modifications. Consequently, the same excerpt can be, in principle, referential in some circumstances and comparative in others. As a matter of fact, our methodology assumes that there are no definite criteria to attribute the referential or comparative role to a specific excerpt involved in such a comparison; either excerpt of the pair can theoretically play either role. The form-functional impact is thus assumed to be reversible (a detailed example is provided below).

---

[1] As mentioned in Chapter 3, some excerpts were duplicated in Experiment 3. In these cases, we used for our analyses the judgment distribution of the first excerpt that was heard.

The quantified comparison involved in these analyses will henceforth be referred to as a *modification vector*. It consists of a three-entry array that shows the impact of a parametric modification on all three formal functions, that is, where given functional judgments (of beginning, middle, or end) augment or diminish. The modification vector's three values always sum to zero,[2] and no entry in the vector can have an absolute value greater than 20.

Figure 4.1. An example of a pair of excerpts that are one modification apart.

Figure 4.1 exemplifies two excerpts whose respective judgment distributions were compared. In this comparison, Excerpt 1 is referential, and Excerpt 2 is comparative. These excerpts are one modification apart, the modification being a reduction in the length of the unaccompanied anacrusis (indicated with circles). Because the excerpts were presented to participants in a

[2] This property is due to the constant number of judgments, i.e., 20.

randomized order, it was equally probable for them to hear Excerpt 1 before or after Excerpt 2.

Table 4.1 shows the two excerpts' respective functional judgment distributions for both expertise groups. We obtained the modification vector, shown in both Figure 4.2 and the last row of Table 4.1, by subtracting the three entries for the referential excerpt from those for the comparative excerpt. The effect of a modification on the judgments within a functional category is significant if the error bar does not touch the abscissa axis. The 95% confidence interval (one-tailed) for changes in functional judgment distributions was obtained by performing a bootstrap analysis with 20,000 replicates on the modification vectors. In the example illustrated in Figure 4.2, the diminution of beginning judgments and the augmentation of middle judgments are significant only for non-musicians, i.e., the 95% confidence interval includes zero for musicians and cannot therefore be considered significantly different from zero. If the referential and comparative functions of these two excerpts were interchanged, that is, if we measured the impact of an *augmentation* of the unaccompanied anacrusis' length, the impact on judgments would have the same magnitude, but the opposite direction. This illustrates how the form-functional impact is assumed to be reversible.

As a mere comparative measure of two excerpts' judgment distributions, the modification vector does not contain any information about ceiling or floor effects. Those effects occur when the number of judgments for a certain functional category is already at (or close to) the maximal or minimal attainable value (i.e., 20 and 0, respectively). Consequently, the number of judgments in that category cannot (or can hardly) increase or decrease further, regardless of the form-functional efficiency of the modified musical property in the comparative excerpt. Such cases will be identified in the following analyses and will be corrected for, as they impair our capacity to draw fair conclusions on the actual form-functional impact of properties.

Table 4.1. Musicians' and non-musicians' judgment distributions and modification vectors for the two excerpts illustrated in Figure 4.1. Letters B, M, and E stand for beginning, middle, and end, respectively.

Excerpts	Musicians			Non-musicians		
	B	M	E	B	M	E
1 (referential)	13	5	2	17	2	1
2 (comparative)	11	7	2	12	7	1
Modification Vector	-2	(+)2	0	-5	(+)5	0

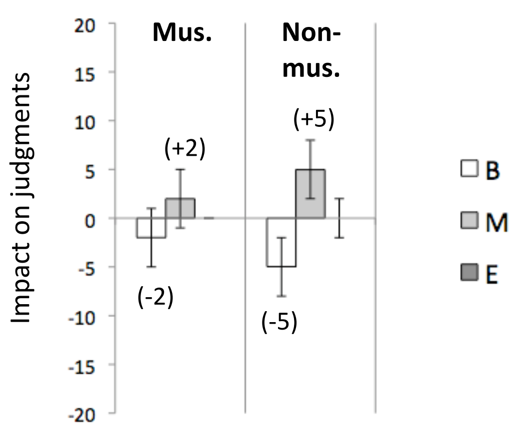


Figure 4.2. Musicians' (Mus.) and non-musicians' (Non-mus.) modification vectors for beginning (B), middle (M), and end (E) functions, relative to the excerpts shown in Figure 4.1.

Tables A to K in Appendix D show the functional distributions of all the referential and comparative excerpts that were involved in each modification type—that is, a series of modifications involving a specific property—presented in this study. We sorted the data in such a way that cases involving floor or ceiling effects appear towards the end of the table. As a convention, a referential excerpt in which a functional category is 3 or less judgments away from the maximal or minimal value (that is, 17−20 or 0−3 judgments) is identified as a case of floor/ceiling effect; however, this applies only in cases where a change in that category is impaired or limited by the lack of room for variation in the *expected* (i.e., hypothesized) direction. The size of this buffer-value (i.e., three judgments) corresponds to the minimal vector entry that was necessary, in all our data, to obtain a statistically significant judgment variation. Due to the different ordering used for musicians' and non-musicians' referential and comparative excerpts, vector numbers in the forthcoming graphs do not necessarily correspond to the same pairs of stimuli between groups. Since the results were highly consistent across experiments, the data from both Experiments 2 and 3 have occasionally been interleaved.[3] For each modification type, we will present, along with the individual vectors, the average variation values (magnitude and direction) of all the vectors representing that modification. We computed the significance levels of

[3] Although most compared excerpts were part of the same experiment, we occasionally compared excerpts of Experiment 2 with those of Experiment 3 (as long as they were from the same family and one modification apart). Since the procedure was very similar in both experiments, we deemed such comparisons methodologically acceptable. All such cases will nevertheless be clearly identified in the analyses below.

each averaged value with a one-tailed bootstrapped permutation test with 20,000 replications. Corrected values excluding the entries affected by floor/ceiling effects are provided for both average and *p*-values, when applicable.[4]

As previously mentioned, both experiments described here comprised an exploratory component. Indeed, we did not confine ourselves to the verification of the hypotheses from Experiment 1, but also tried out several other experimental manipulations that, according to our own music-theoretical intuitions, were likely to have a tangible form-functional impact. Due to the large number of modification types, we will describe only those that yielded clear and consistent tendencies.

RESULTS – COMPARATIVE ANALYSES

Opening tonic harmony

As shown in the results of Experiment 1 (Chapter 2) and associational analyses (Chapter 3), there is a strong link between musicians' categorization of beginning and middle functions and an excerpt's opening harmony: a tonic-harmony opening was a necessary condition for consensual perception of the beginning function, while an "off-tonic" opening was more likely to entail middle identifications. It was therefore hypothesized that substituting an opening tonic chord with an off-tonic chord would have a strong negative effect on beginning judgments and a positive one on middle judgments.

[4] The *p*-values indicate the probability that a given result may be generated by chance.

The modifications considered in this section are those that affected the opening tonic harmony of excerpts regardless of the impact on subsequent harmonies. This includes two broadly defined sub-groups of modifications: (1) cases where harmonies other than the first one were not affected; (2) cases in which all harmonies were affected (for instance, when switching the respective positions of the excerpts' two chords; or when altering the key signature to operate a key change, thus affecting the excerpt's entire chordal content, etc.). However, we did not observe any effect of sub-groups on the results.

In Experiment 2, we mostly explored the effect of changing an opening tonic to an opening dominant (including diminished seventh chords).[5] In Experiment 3, we explored the effect of other non-tonic opening harmonies by using several subdominant and submediant openings.

Table A (Appendix D) shows the functional distributions of all the referential (opening with tonic) and comparative ("off-tonic" opening) excerpts that represented this modification type. The results of Experiments 2 and 3 are presented separately, due to the large number of vectors. One vector was computed from excerpts belonging to different experiments (vector #8 for musicians and #9 for non-musicians) and is presented with the vectors from Experiment 3.

Figure 4.3 illustrates the modification vectors (one vector per column) for Experiments 2 and 3 calculated from the data of Table A. The number on top of

[5] One modification (vector #7 for musicians and vector #3 for non-musicians in Figure 4.3 below) involved a subdominant rather than dominant harmony.

each column designates the pair number from Table A, and Roman numerals at the bottom of the columns indicate the harmony that substituted for the opening tonic. Table 4.2 shows the average impact on all three functions, including the corrections for floor/ceiling effects, where applicable.

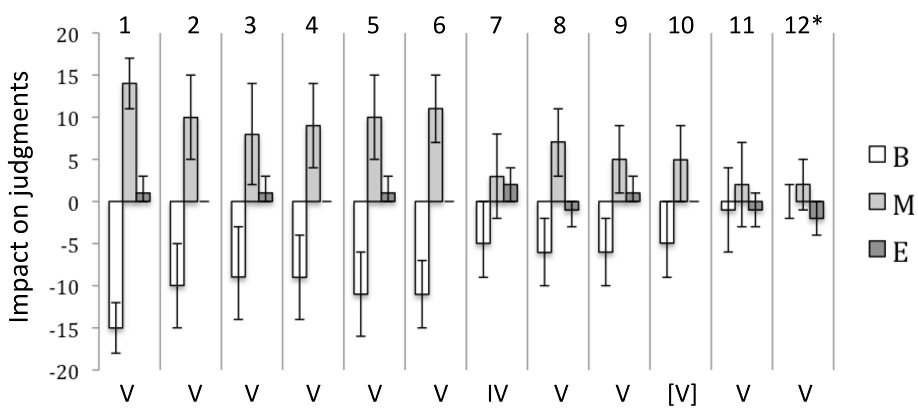
For musicians, results are quite clear. In the overwhelming majority of cases, substituting the opening tonic harmony for another harmony has a strong negative impact on beginning judgments and a strong positive impact on middle judgments. Most results are statistically significant, or close to statistical significance. We observe the same tendency in vectors that are not statistically significant, except for Experiment 3's vector 6. Average vector values (Table 4.2) confirm this tendency while further showing a marginally significant positive variation in end judgments when both experiments' data are considered ($p =$ .069). The magnitude of the average end judgments variation is, however, much weaker than that of beginning and middle judgments, and is most likely a side effect of the occasional positional switch of tonic and dominant harmonies, thereby creating a tonic closure and, concomitantly, a sense of ending (such an example will be presented in Chapter 6; see Figure 6.10). Note also that the magnitude of the impact is slightly higher on beginnings than middles, but not significantly so ($p > .2$), whereas the magnitude differences between beginnings and ends as well as middles and ends are both highly significant ($p < .001$ in both cases).[6]

---

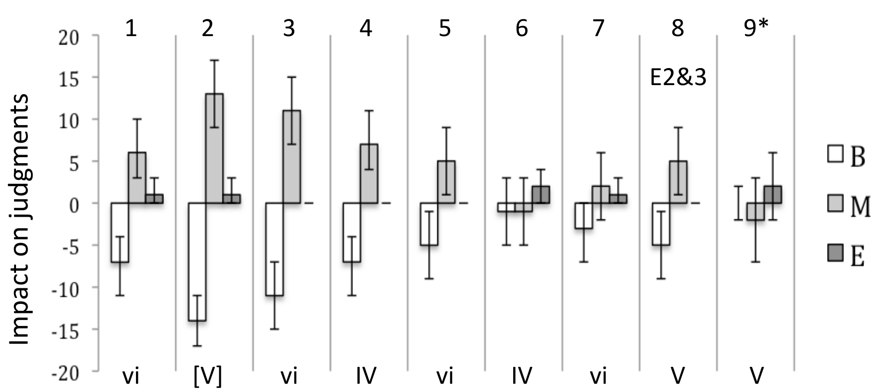
[6] All from bootstrapped permutation tests.

Non-musicians' results are, as originally expected, highly ambiguous. Individual vectors show no clear tendency as variations of beginning and middle judgments are often weak in magnitude, inconsistent in direction, and seldom reach statistical significance. The average vector values shown in Table 4.2 further support this observation, as these values are extremely low and do not reach statistical significance. It seems therefore that the opening harmony has little bearing on non-musicians' beginning and middle identifications.

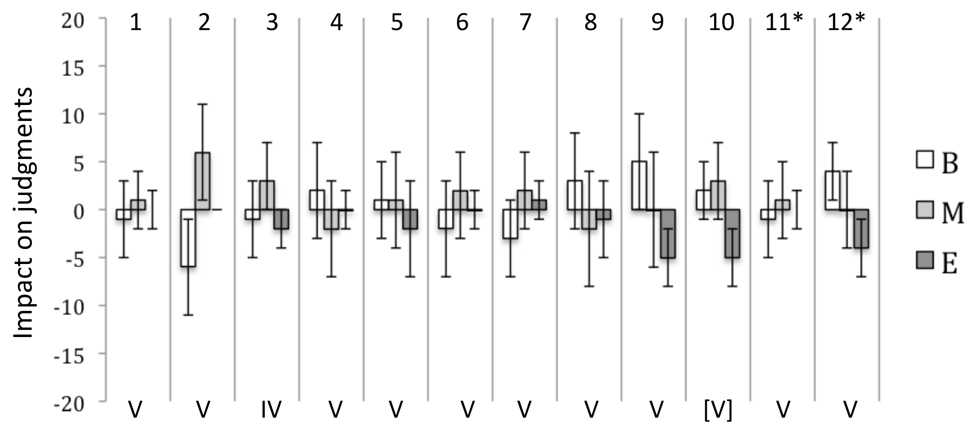
(a) Musicians, Experiment 2.



(b) Musicians, Experiment 3 (except vector 8).



(c) Non-musicians, Experiment 2.



(d) Non-musicians, Experiment 3 (except vector 9).

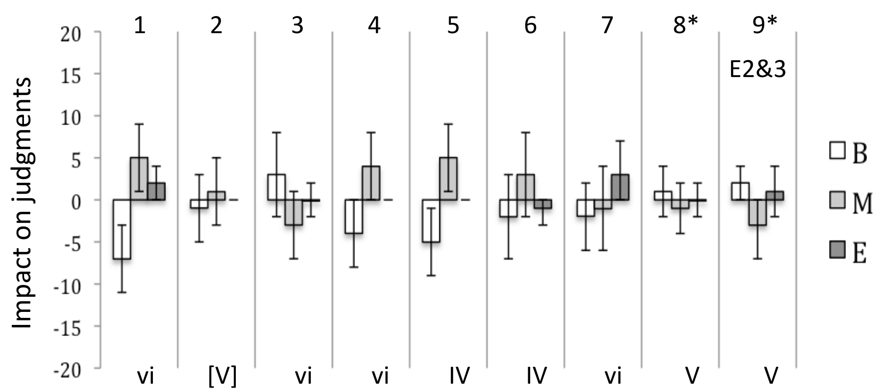


Figure 4.3 (previous and current pages)**.** Modification vectors showing the form-functional impact of substituting an excerpts' opening tonic with either a subdominant (IV), dominant (V), submediant (vi), or secondary dominant ([V]) harmony. Floor/ceiling effects are indicated with an asterisk (*).

Table 4.2. Average form-functional impact of a substitution of an excerpts' opening tonic with an off-tonic harmony for Experiment 2 ('E2'), Experiment 3 ('E3'), and all data combined ('All').

		Musicians			**Non-musicians**		
		B	**M**	**E**	**B**	**M**	**E**
E2	**Avg. vector value**	-7.3	7.2	0.2	0.3	1.3	-1.9
	Cor. floor/ceiling	-8.0	7.6		0.0		
	p	< .001	< .001	> .1	> .3	> .2	> .1
	Cor. floor/ceiling	< .001	< .001				
E3	**Avg. vector value**	-5.9	5.1	0.8	-1.7	1.1	0.6
	Cor. floor/ceiling	-6.6			-2.6	1.6	
	p	< .005	< .01	> .1	> .2	> .3	> .2
	Cor. floor/ceiling	< .005			> .09	> .2	
All	**Avg. vector value**	-6.7	6.3	0.4	-0.6	1.2	-0.6
	Cor. floor/ceiling	-7.4	6.5		-1.1	1.4	
	p	< .001	< .001	> .06	> .3	> .2	> .1
	Cor. floor/ceiling	< .001	< .001		> .2	> .1	

Unaccompanied melodic opening: unaccompanied anacrusis

As observed in Chapters 2 and 3, participants associated unaccompanied melodic openings with formal beginnings. In Experiment 2, we removed the unaccompanied melodic opening of four excerpts in order to compare the judgment distributions of excerpts with and without this feature. Since all of these unaccompanied melodic openings were on upbeats, they constituted genuine unaccompanied anacruses.[7] We hypothesized that the feature's removal would

[7] We discussed the distinction between unaccompanied anacruses and unaccompanied melodic openings on pp. 84-85 of Chapter 3.

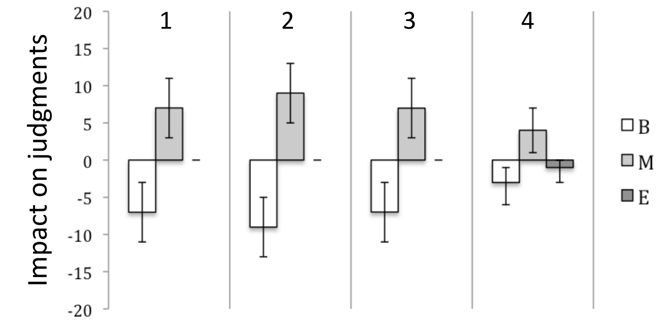
entail a diminution of beginning judgments and an augmentation of middle judgments.

Table B (Appendix D) shows the functional distributions of all the referential and comparative excerpts (i.e., with and without the unaccompanied anacrusis, respectively) related to this modification type. We sorted the data according to the number of participants' beginning judgments attributed to the referential excerpt, in decreasing order. Figure 4.4 illustrates the four modification vectors that resulted from removing the unaccompanied anacrusis and Table 4.3 shows the average vector values and significance levels (there were no floor/ceiling effects for this modification type). The impact of this modification was markedly similar on both subject groups: beginning judgments strongly decreased and middle ones strongly increased, these variations being either significant or close to significance (beginning and middle variations do not reach statistical significance in non-musicians' fourth vector, and similarly, musicians' average beginning variation is marginally significant, $p = .065$; the latter lack of significance with $\alpha = .05$ is partly due to the scarcity of vectors with this modification). Scores in Table 4.3 suggest that the effect was stronger and more consistent on non-musicians, although bootstrapped permutation tests revealed no statistically significant effect of expertise ($p > .1$ and $p > .3$ for beginning and middle functions, respectively). Note also that, for both groups, the magnitude difference[8] between beginning and middle variations was not significant whereas

[8] The magnitude difference corresponds to the difference between absolute values.

those between beginning and end, as well as middle and end, were highly significant ($p \leq .01$).[9]

(a) Musicians, Experiment 2.



(b) Non-musicians, Experiment 2.

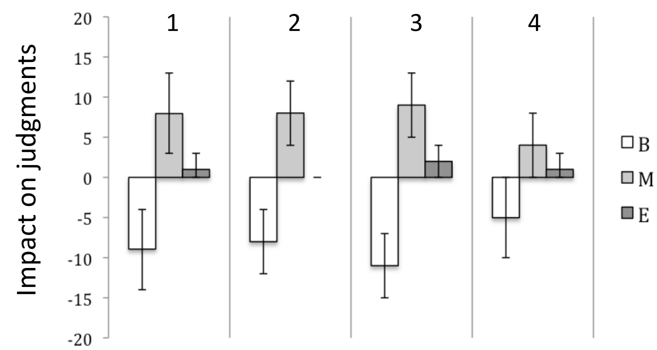


Figure 4.4. Four modification vectors resulting from the removal of the unaccompanied anacrusis.

This modification type was not tested further in Experiment 3. Instead, we focused on a handful of characteristics proper to the unaccompanied anacrusis, notably (1) the specificity's scale degrees; (2) its texture component; (3) its duration (length); (4) its rhythmic component (namely, the use of dotted rhythms versus steady eighth notes); (5) the relationship between the rhythmic

---

[9] From bootstrapped permutation tests.

configuration of the unaccompanied anacrusis and that of the following materials; and (6) anacruses in the bass voice. Among these, only the first three gave consistent results and will be presented here.

Table 4.3. Average form-functional impact of the unaccompanied anacrusis' removal.

	Musicians			**Non-musicians**		
	B	**M**	**E**	**B**	**M**	**E**
Avg. vector value	-6.5	6.75	-0.25	-8.25	7.25	1.0
p	> .06	< .04	> .4	< .01	< .01	= .5

Figure 4.5 shows the three vectors that resulted from changing the opening scale degree of unaccompanied anacruses. Given that the harmonic setting of the excerpts' opening has stronger form-functional implications for musicians than for non-musicians, we hypothesized that unaccompanied anacruses involving scale degrees foreign to the tonic chord would impair the expression of beginning for participants of the musicians' group only. We thus expected the substitution of tonic-chord scale degrees to off-tonic scale degrees at the opening of unaccompanied anacruses to have a negative impact on musicians' beginning judgments and a positive one on their middle judgments.

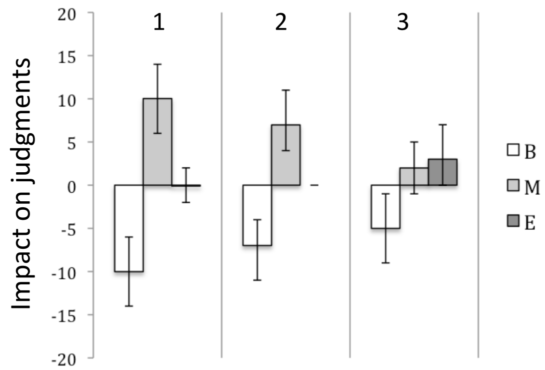
Table C (Appendix D) shows the functional distributions of all the referential and comparative excerpts that correspond to this modification. There were no cases of ceiling/floor effect. In two cases, the fifth scale degree was replaced by the sixth scale degree (vectors 1 and 3 for both groups), and in one case, by the fourth scale degree (vector 2 for both groups).

The effect of this modification was consistent on musicians' individual vectors (Figure 4.5): it yielded a diminution of beginning judgments that was significant in all vectors and an augmentation of middle judgments that was significant in two of the three vectors. The average vector values (Table 4.4) show an overall strong negative impact on beginning functions and a strong positive impact on middle functions, both being statistically significant. Here again, the magnitude difference between beginning and middle variations was not significant, whereas those between beginning and end as well as middle and end were significant ($p < .05$). As expected, there was virtually no effect on non-musicians' judgment distributions. This modification implied a substitution of a scale degree belonging to the tonic harmony (the fifth scale degree[10]) with a scale degree foreign to it (scale degrees 4 and 6) and thus less likely to be perceived as expressing a beginning function by musicians. That musicians reacted in a stronger and more consistent way than non-musicians further sustains the thesis that the opening harmony has much stronger formal implications for the former group than the latter one.

---

[10] Although the fifth scale degree also belongs to dominant harmony, this scale degree is *not* foreign to the tonic chord. To establish that the observed effect is due to the affiliation of the referential excerpt's opening scale degree with the tonic chord would require further investigation through substitutions involving scale degrees that are exclusive to the tonic chord (scale degrees 1 and 3) and those that belong to the dominant (scale degrees 7 and 2). Such an investigation, however, would most probably transgress fairly quickly the boundaries of stylistic acceptability.

(a) Musicians, Experiment 3.



(b) Non-musicians, Experiment 3.

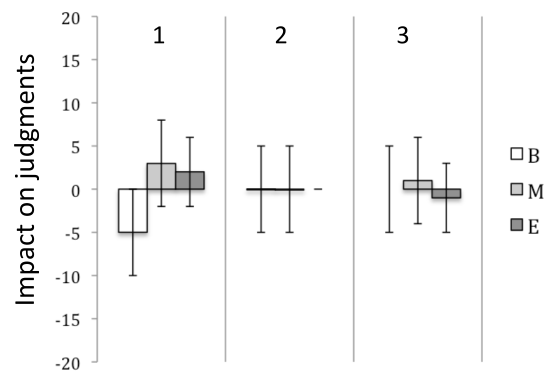


Figure 4.5. Three modification vectors resulting from a substitution of the opening fifth scale degree of unaccompanied anacruses with the sixth (vectors 1 and 3) and the fourth (vector 2) scale degrees.

Table 4.4. Average form-functional impact of modifications made to the unaccompanied anacrusis' scale degrees.

	Musicians			**Non-musicians**		
	B	**M**	**E**	**B**	**M**	**E**
Avg. vector value	-7.3	6.3	1.0	-1.7	1.3	0.3
p	< .03	< .02	> .3	> .2	> .2	> .4

Let us move to the textural aspect of the unaccompanied anacrusis. We hypothesized that creating a texture contrast between the upbeat and the subsequent downbeat at the opening of an excerpt would enhance the expression of the beginning function. Referential excerpts for that modification type thus featured genuine *un*accompanied anacruses in which a reduced texture (the right hand only) entered on the upbeat and the second hand joined in on the subsequent downbeat, whereas comparative excerpts presented the full (2-hand) texture on the upbeat—creating, so to speak, an *accompanied* anacrusis. We expected this modification to yield a diminution of beginning judgments and a concurrent augmentation of middle judgments. We thought that the effect would be stronger on non-musicians than on musicians, the former being generally more responsive to excerpts' textural properties than the latter.

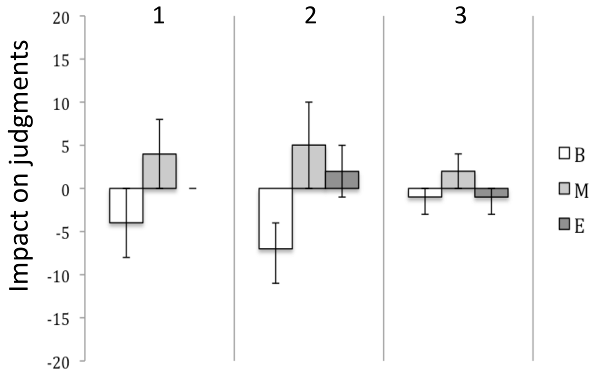
The form-functional judgment distributions of the referential and comparative excerpts are shown in Table D (Appendix D). As shown in Figure 4.6, the effect is similar across subject groups and concurs with our hypotheses. In most cases, we observe an augmentation of middle judgments, with the exception of non-musicians' third vector, and diminutions of beginning judgments. Table 4.5 shows that even though average variations in beginning and middle judgments are moderately strong, they merely approach significance only for non-musicians. The magnitude difference between beginning and middle variations was non-significant for both group, while that between beginning and end was significant for both groups ($p < .05$) and that between middle and end was significant for musicians ($p < .05$) and marginally significant for non-musicians

($p = .07$).[11] Once again, the scarcity of data partly accounts for the lack of clear statistical significance of this property's impact. Even though the effect on non-musicians is stronger, bootstrapped permutation tests show that it is not significantly different than on musicians ($p > .2$). Although these results have to be interpreted cautiously because statistical significance was marginal, they nevertheless suggest that the unaccompanied anacrusis's functional impact may be, at least with respect to non-musicians, partially due to the texture contrast, and not solely to the feature's anacrusic quality. Obviously, further testing would be necessary to draw stronger conclusions.

Duration was the third feature of the unaccompanied anacrusis that was tested in Experiment 3. We hypothesized that a reduction of the unaccompanied anacrusis' duration would impact beginning judgments negatively and middle judgments positively. (An instance of that modification type was illustrated in Figure 4.1 above.) Assuming that longer unaccompanied anacruses direct listeners' attention to the ensuing texture contrast and create expectations of a full melody-plus-accompaniment texture to a greater extent than shorter ones, and taking into account that non-musicians' form-functional judgments tend to rely more heavily on textural features than those of musicians, we expected non-musicians to be especially responsive to this property.

[11] From bootstrapped permutation tests.

(a) Musicians, Experiment 3.



(b) Non-musicians, Experiment 3.

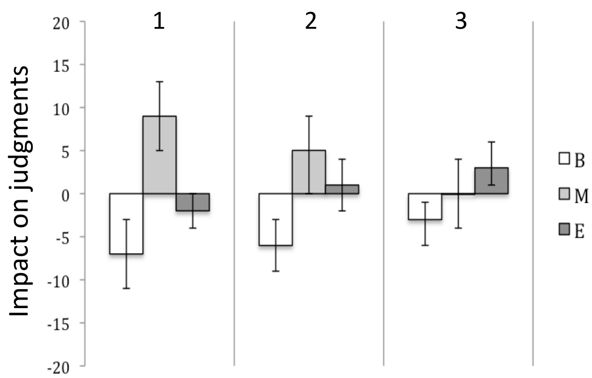


Figure 4.6. Three modification vectors entailed by changing an unaccompanied anacrusis (only the right hand entering on the upbeat) to an accompanied anacrusis (both hands entering simultaneously on the upbeat).

Table 4.5. Average form-functional impact of changing an unaccompanied anacrusis to an accompanied anacrusis.

	Musicians			**Non-musicians**		
	B	**M**	**E**	**B**	**M**	**E**
Avg. vector value **Cor. floor/ceiling**	-4.0 -5.5	3.7	0.3	-5.3	4.7	0.7
p **Cor. floor/ceiling**	> .1 > .1	> .1	> .3	= .056	= .083	> .2

Figure 4.7 illustrates the effect of unaccompanied anacruses' length reduction and Table 4.6 shows the average impact on form-functional judgments and these variations' significance levels. The form-functional judgment distributions of the referential (long unaccompanied anacruses) and comparative (short ones) excerpts are shown in Table E (Appendix D). As can be seen in Figure 4.7, this modification had no consistent impact on musicians. Only the fourth vector, corresponding to the largest change to the feature's length among the four cases displayed in the figure, comprises a significant negative impact on beginnings and a significant positive impact on middles. There were no statistically significant differences between the magnitude of any pairs of formal functions. By contrast, the modification had a much stronger impact on non-musicians' functional judgments: it systematically yielded a diminution of beginning judgments (achieving significance 3 times, otherwise close to significance) and an augmentation of middle judgments (achieving significance twice, otherwise close to significance). Table 4.6 confirms this tendency: non-musicians' average variation values for both beginning and middle functions have a high magnitude and reach statistical significance. Although two vectors contained a significant augmentation of end judgments, one in each subject group (Figure 4.7), the average variation of end judgments was weak and non-significant (Table 4.6). The magnitude difference between beginnings and middles was not significant ($p > .2$), whereas it was significant between the other two pairs of functions ($p < .05$).

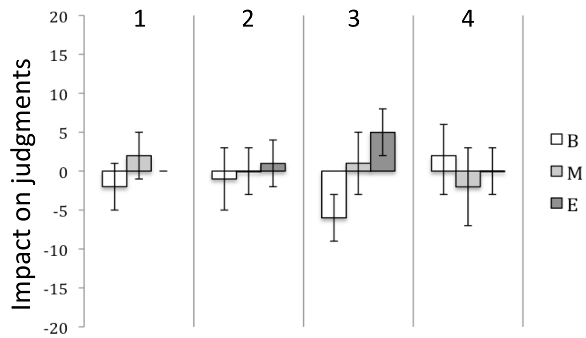
According to our hypotheses, and similarly to texture contrasts, changes in the length of unaccompanied anacruses affected judgment distributions for non-musicians more powerfully than for musicians. The difference between expertise groups was strong and stable enough to reach statistical significance ($p < .03$ and $p < .005$ for beginning and middle judgments, respectively).

It must be emphasized that our decision to test several components of the unaccompanied anacrusis was made at the expense of a large number of modifications representing each component. It is nevertheless encouraging that the effect of the components discussed above reached statistical significance (or marginal significance as regards the texture contrast) with only three or four vectors. Even though we must be cautious about generalizing these results, one might thus anticipate even stronger and more consistent tendencies were a greater number of modifications used.

Rhythmic activity

Although the two properties of rhythmic variety and onset density were treated separately in associational analyses, it was not possible to do so in comparative analyses. Despite these properties' theoretical distinctiveness, our current stimuli were hardly suitable for modifications affecting exclusively one property without affecting the other, all the while remaining stylistically acceptable. Rhythmic modifications were therefore grouped under the generic term *rhythmic activity* and affected either the melody or the bass and accompaniment. (By definition, altering either one of those two rhythmic

(a) Musicians, Experiment 3.



(b) Non-musicians, Experiment 3.

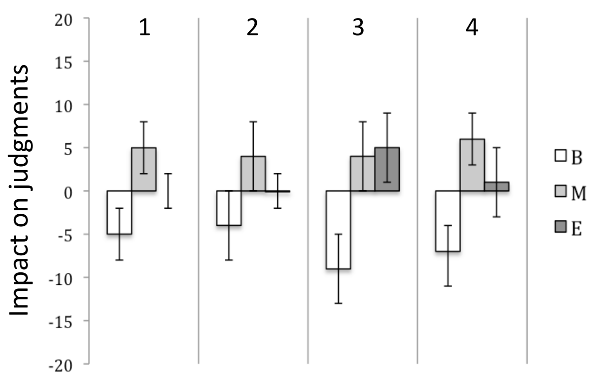


Figure 4.7. Musicians' and non-musicians' four modification vectors showing the impact of the reduction of the unaccompanied anacrusis' length.

Table 4.6. Average form-functional impact of shortened unaccompanied anacruses.

	Musicians			**Non-musicians**		
	B	**M**	**E**	**B**	**M**	**E**
Avg. vector value	-1.8	0.3	1.5	-6.3	4.8	1.5
p	> .1	> .4	> .1	< .005	< .005	> .2

components affected the composite rhythm, although this rhythmic layer will not be discussed in this chapter.)[12] Modifications involving an increase in rhythmic activity correspond simultaneously to an increase in onset density and a decrease in rhythmic variety (or, otherwise stated, an increase in rhythmic uniformity): both of these properties are generally associated with middles, as seen above.

Several modifications involving rhythmic activity produced incongruent and/or weak variations in form-functional judgments. For the sake of statistical analyses, we formed three groups of rhythmic modifications, namely, (1) those affecting the melody, (2) those affecting the bass/accompaniment, and (3) those affecting both categories, referred to as 'melody & bass/accompaniment' in the following analyses. Only the latter two groups gave statistically significant results and therefore the former group will not be discussed further. Our original hypotheses stated that (1) an increase in rhythmic activity should have a negative impact on beginning judgments and a positive one on middle judgments; and (2) the effect should be stronger for non-musicians than for musicians (as suggested by the results of Experiment 1).

Tables F and G (Appendix D) show that the form-functional distributions of referential (lower rhythmic activity) and comparative (higher rhythmic activity) excerpts involved the categories of rhythmic modifications to the bass/accompaniment (Table F) and to the melody & bass/accompaniment (Table G). Figures 4.8 and 4.9 show the effect of this modification on participants' form-

[12] For musical illustrations of composite, melodic, and bass/accompanimental rhythmic layers, see **Figure 3.7** in Chapter 3.

functional judgments, and Tables 4.7 and 4.8 show the average vector values and significance levels. The results are partially consistent with our hypotheses: this modification affected mostly non-musicians and had a positive impact on middle judgments and a negative one on beginning judgments. Two aspects, however, were not faithful to our expectations. The first one was the extent to which the magnitude of beginning-judgment variation is weaker than middle-judgment variation. Indeed, the magnitude difference between beginning and middle variations even reaches marginal significance in one of the conditions (namely, the bass/accompanimental rhythm in the combined data of Experiments 2 & 3); and, the second one was that the impact on end judgments is fairly similar to that on beginning judgments, and the magnitude difference between the variation of those functions is *non*-significant on several occasions (namely in the bass/accompaniment rhythm in the individual and combined data of Experiments 2 & 3, and in the melody and bass/accompaniment rhythm in the data of Experiment 2).[13] Note that, among all the properties aimed at affecting beginning and middle functions for which significant judgment variations were observed, those two situations occurred *only* in the context of rhythmic activity. Overall, average variation values—corrected or not—are fairly modest, except for non-musicians' middle judgments in Experiment 3. Significance is achieved for non-musicians' average beginning- and middle-judgment variations for Experiment 3

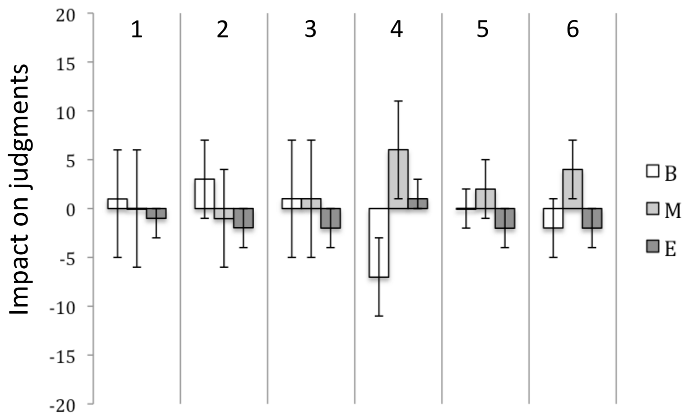
---

[13] As will be discussed further below, those two aspects are strongly interrelated, because in a three-category system, an increased difference in the impact magnitude between two categories (here, beginnings and middles) will necessarily lead to decreased difference in the impact between two other categories (here, beginnings and ends).

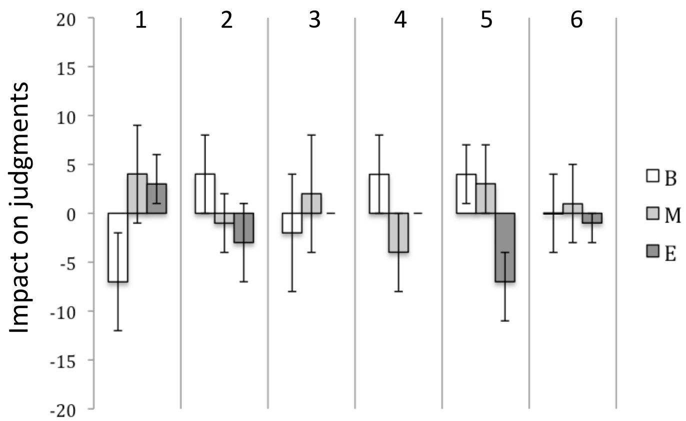
and the combined data of Experiments 2 and 3 (in one case, only the corrected value passes the significance threshold of .05), but also for both groups' end-judgment variations on several occasions. Musicians' average variation values remain, however, quite low, and the impact should be considered as very weak, despite the relative consistency of some of the end-judgment variations.

Although partially faithful to our hypotheses as regards form-functional impact and expertise, those results were much weaker than anticipated. Moreover, they partially contravene the consensus analyses presented in Chapter 4, which showed that, contrary to the composite and melodic rhythmic settings, bass and accompanimental rhythm had little to do with participants' form-functional decisions. To be sure, bass/accompanimental rhythm contributes to the composite rhythmic layer—which was not evaluated in comparative analysis, as mentioned above, for stylistic reasons—so in that respect, the current results are not in complete contradiction with the associational ones presented above. They remain nonetheless more challenging to explain than those of most other properties presented here. For our current purposes, let us keep in mind that the rhythmic property discussed here constitutes a *parameter*—a property that affects an excerpt's entire time span—as opposed to a *specificity*—a property temporally located at a specific time point within an excerpt—and, as I will explain in Chapter 6, there are reasons why modifications to parameters and specificities are likely to have quantitatively different form-functional impacts.

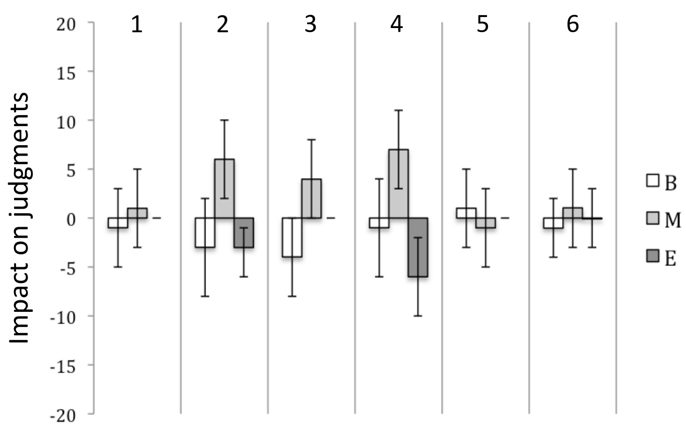
(a) Musicians, Experiment 2.



(b) Musicians, Experiment 3.



(c) Non-musicians, Experiment 2.



(d) Non-musicians, Experiment 3.

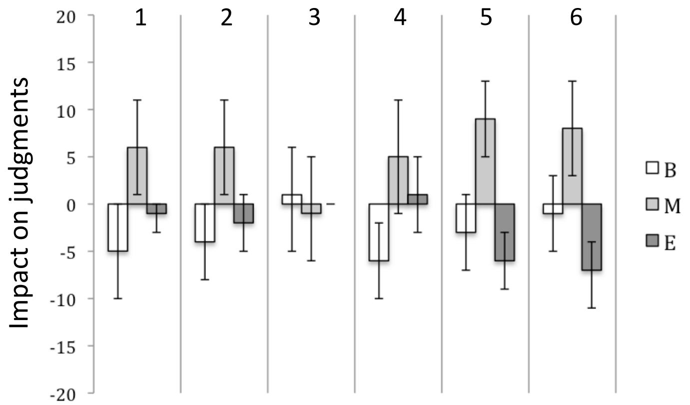
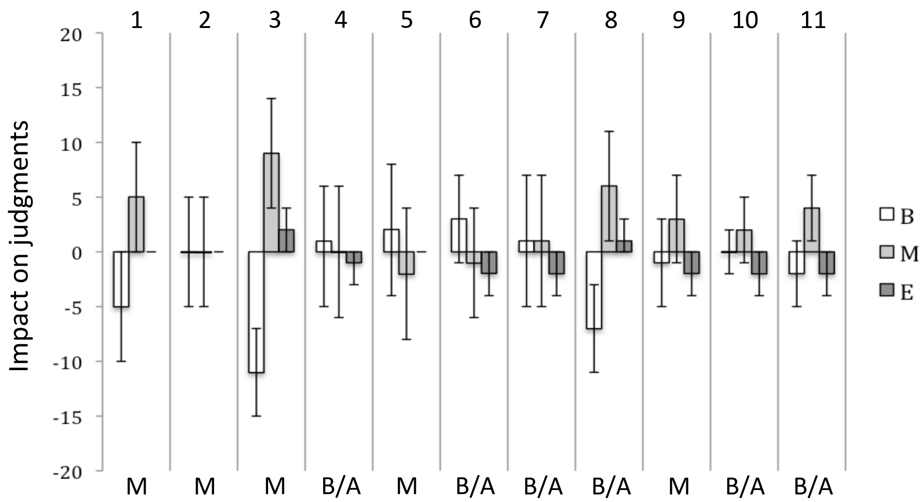


Figure 4.8 (previous and current pages). Musicians' and non-musicians' modification vectors showing the impact of an increase in the bass and accompanimental rhythmic activity.

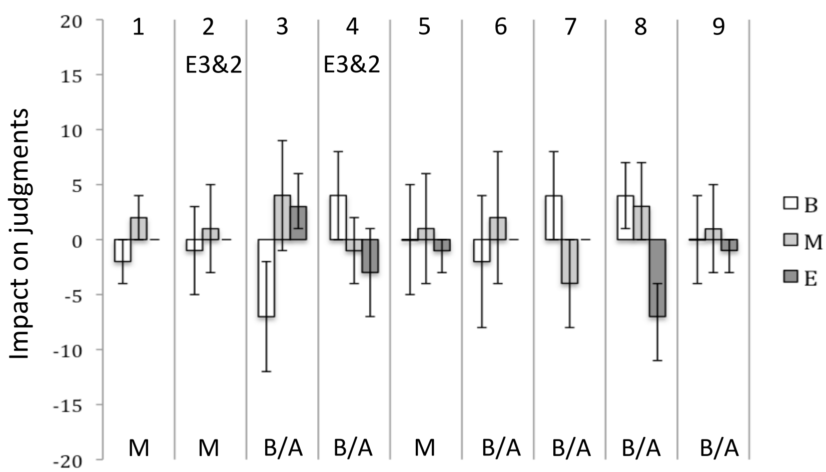
Opening tonic inversion

We already discussed the theoretical claim that a root-position opening tonic harmony, due to its stability, should yield a clearer expression of beginning function than a relatively less stable inverted tonic harmony. As mentioned above, however, the results of the form-functional agreement analyses did not provide evidence to support this theoretical claim. With respect to our parametric modifications, our original hypothesis stated that replacing an opening root-position tonic with a first-inversion tonic would have a negative impact on beginning judgments and a positive one on middle judgments. Since harmonic modifications tend to affect musicians to a much greater extent than non-musicians, we expected this modification to have an effect only on the former's functional decisions.

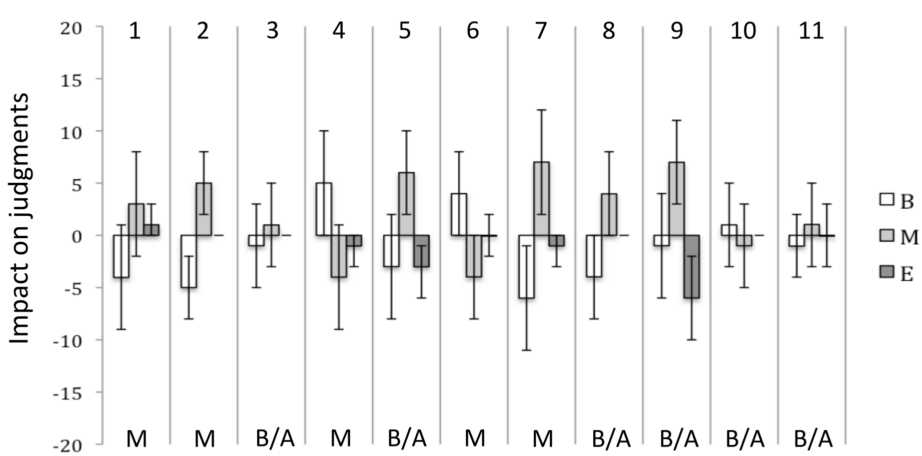
(a) Musicians, Experiment 2



(b) Musicians, Experiment 3 (except vectors 2 and 4)



(c) Non-musicians, Experiment 2



(d) Non-musicians, Experiment 3 (except vectors 2 and 9)

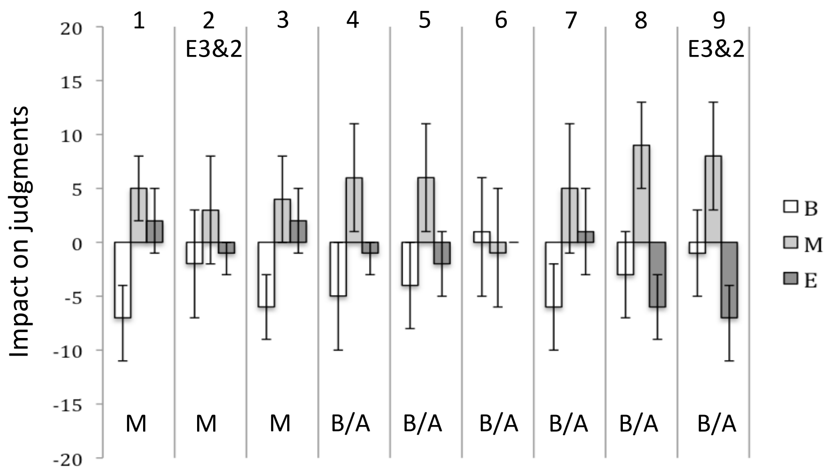


Figure 4.9 (previous and current pages)**.** Musicians' and non-musicians' modification vectors showing the impact of rhythmic activity increase either in the melody (M) or in the bass and accompanimental (B/A) layer.

Table 4.7. Average form-functional impact of an increase of the bass and accompanimental rhythmic activity for Experiment 2 (E2), Experiment 3 (E3), and all data combined (All).

		Musicians			**Non-musicians**		
		B	**M**	**E**	**B**	**M**	**E**
E2	**Avg. vector value**	-0.7	2.0	-1.3	-1.5	3	-1.5
	Cor. floor/ceiling	-0.4			-2.3	3.8	
	p	> .4	> .2	< .01	> .4	> .3	> .1
	Cor. floor/ceiling	> .4					
E3	**Avg. vector value**	0.5	0.8	-1.3	-3.0	5.5	-2.5
	p	> .2	> .1	> .1	< .05	< .005	> .07
All	**Avg. vector value**	-0.1	1.4	-1.3	-2.3	4.3	-2.0
	Cor. floor/ceiling	0.1			-2.7	4.7	
	p	> .4	> .2	< .05	= .06	< .005	< .05
	Cor. floor/ceiling	> .4			< .04	< .001	

Table 4.8. Average form-functional impact of rhythmic activity increase either in the melody or the bass and accompaniment for Experiment 2 (E2), Experiment 3 (E3), and all data combined (All).

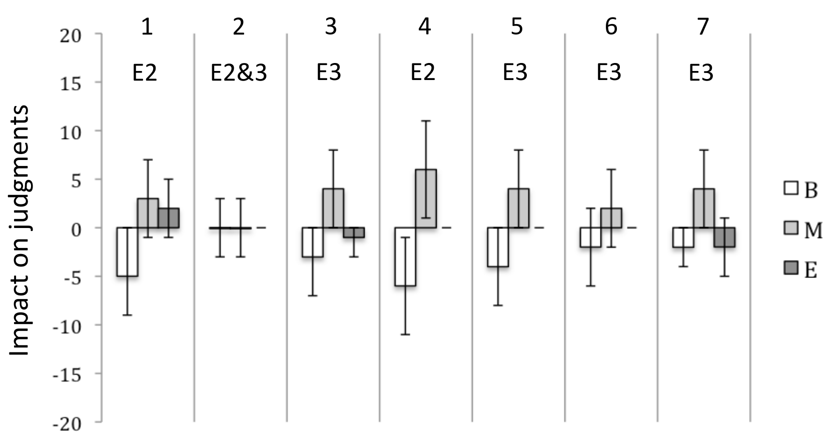
		Musicians			Non-musicians		
		B	**M**	**E**	**B**	**M**	**E**
E2	**Avg. vector value** **Cor. floor/ceiling**	-1.0 -0.9	1.8	-0.9	-2.4 -2.7	3.5 3.7	-1.1
	p **Cor. floor/ceiling**	> .2 > .2	> .12	< .04	> .2 > .1	> .1 > .1	> .1
E3	**Avg. vector value**	0.0	1.0	-1.0	-3.7	5.0	-1.3
	p	= .5	> .3	> .1	< .04	< .005	> .1
All	**Avg. vector value** **Cor. floor/ceiling**	-1.0 -0.9	1.8	-0.9	-2.4 -2.7	3.5 3.7	-1.1
	p **Cor. floor/ceiling**	> .2 > .2	> .1	< .05	< .04	< .005	> .06

Table H (Appendix D) shows the form-functional judgment distributions of the referential (opening root-position tonic) and comparative (opening first-inversion tonic) excerpts. Figure 4.10 illustrates the seven vectors created by this modification type and Table 4.9 shows the average variation values, including corrected values for floor/ceiling effects for non-musicians' beginnings. The general tendency is fairly faithful to our form-functional hypothesis stated above, and, surprisingly, it applies to both expertise groups. Although the variations were stable enough to reach statistical significance (or marginal significance, as in non-musicians' average variation of middle judgments), average variation values for beginnings and middles remain quite modest. Contrary to the above associational analyses, these results suggest nonetheless that harmonic inversion does affect—

although modestly—participants' capacity to distinguish between beginnings and middles. Non-musicians' results are all the more surprising considering that chord type did not influence their form-functional evaluations with that level of consistency (see the section entitled *Opening tonic harmony* above).

Most of these excerpts, however, were characterized by fairly static melodies. Indeed, apart from one pair of excerpts—musicians' vector #2 and non-musicians' vector #1 in Figure 4.10—melodies showed either no pitch variations at the opening or a much lower onset density than the bass/accompanimental pattern. These fairly inactive melodies may have prompted participants to focus their attention on the bass line, thereby exaggerating the form-functional efficiency of this property. Further testing involving more active melodic patterns may be appropriate before being able to generalize our conclusions about the form-functional impact of the opening tonic inversion.

(a) Musicians, Experiments 2 and 3



(b) Non-musicians, Experiments 2 and 3

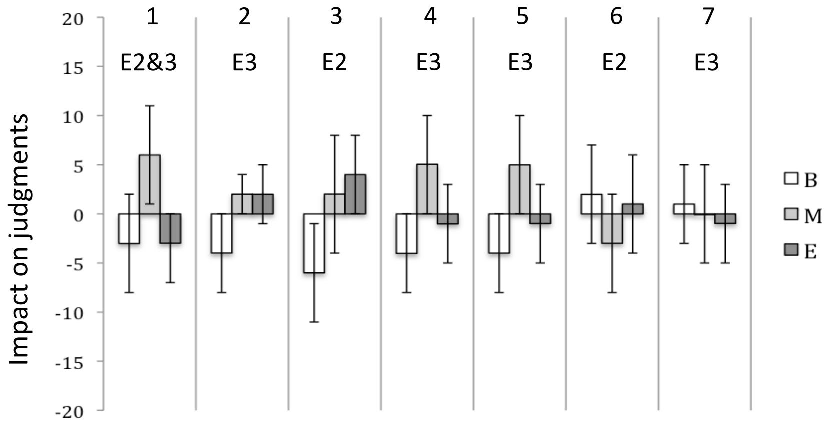


Figure 4.10 (previous and current pages)**.** Musicians' and non-musicians' modification vectors resulting from the substitution of an opening root-position tonic chord with an opening first-inversion tonic chord.

Table 4.9. Average form-functional impact of the substitution of an opening root-position tonic with a first-inversion tonic.

	Musicians			**Non-musicians**		
	B	**M**	**E**	**B**	**M**	**E**
Avg. vector value **Cor. floor/ceiling**	-3.1	3.3	-0.1	-2.6 -3.2	2.4	0.1
p **Cor. floor/ceiling**	< .04	< .04	> .4	< .05 < .03	> .06	> .4

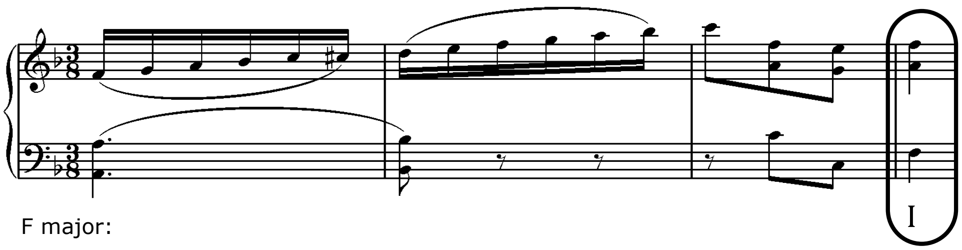
Endings and tonality

As already mentioned in Chapter 1, most of the psychological literature on tonality—especially probe-tone and priming studies—involves end-based judgments from musician and non-musician listeners. In a nutshell, those studies show that both listener types share a similar abstracted tonal framework within which maximal stability—what we interpret here as an intrinsic condition for the sensation of ending—requires a tonic function, either as a chord or a scale-degree, the latter also referred to as 'first scale degree.' Most modifications aimed at affecting end judgments therefore involved tonality, including both harmonic and scale-degree functions. We present below three categories of tonal modifications: (1) modifications in melodic/harmonic settings; (2) scale-degree modifications in melodic/harmonic settings; and (3) scale-degree modifications without explicit harmonic setting. (Musical examples are provided below for these three categories.)

Modifications in melodic/harmonic settings. In Experiment 1 and the above associational analyses, we observed that closing on tonic harmony was a necessary condition for the expression of an end function for both subject groups. We therefore hypothesized that alterations to an excerpt's final tonic would negatively affect participants' end responses, especially if a perfect authentic cadence was involved. An example of referential and comparative excerpts illustrating this modification type is shown in Figure 4.11.

Four vectors resulting from a first type of harmonic modification are illustrated in Figure 4.12. This modification consisted in ruining the cadence's closure effect by either substituting its closing tonic with a submediant harmony, thereby creating a deceptive cadence (vector #1 for musicians and #4 for non-musicians), or by switching the respective positions of the cadential dominant and tonic harmonies (the remaining three vectors). Table I (Appendix D) shows the judgment distributions of referential (with a cadence) and comparative excerpts (with a ruined cadential effect) and Table 4.10 shows the average vector variations. The impact of this modification was similar across subject groups: all ending judgments decreased significantly at the expense of beginning or middle judgments. Both individual and average variations in end judgments are remarkably strong. In fact they are by far the strongest ones in this study. A noteworthy observation concerns the difference in non-musicians' reaction strength between the deceptive cadence (vector #4) and the position switch in cadential harmonies (vectors #1−3), the former being much weaker than the latter. Although more instances of both modification types would be necessary to make appropriate generalizations, our current data suggest that, for non-musicians (only), the cadence's sense of closure is partially preserved when substituting a tonic harmony with a submediant harmony—the latter being indeed characterized in music theoretical discourse as a substitute for the former—while being completely destroyed when the dominant harmony closes a passage. Whether or not this principle is true, our results show that non-musicians are extremely sensitive to harmony when a passage's closing point is concerned, which contrasts sharply with their general indifference to that property for a passage's opening point. This suggests that non-musicians' sensitivity to harmony may depend both on harmonies' location as well as their form-functional role (this discussion will be pursued further in Chapter 6).

Referential excerpt (Mozart, Piano sonata in F major in B-flat major, K. 280, iii, 13−16)



Comparative excerpt (modification of the referential excerpt)

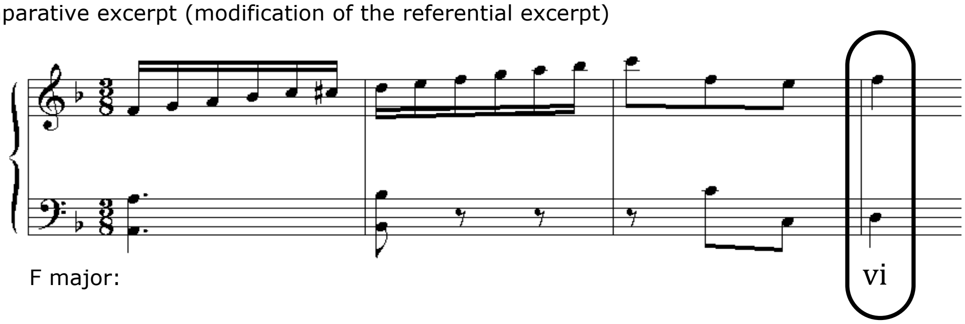
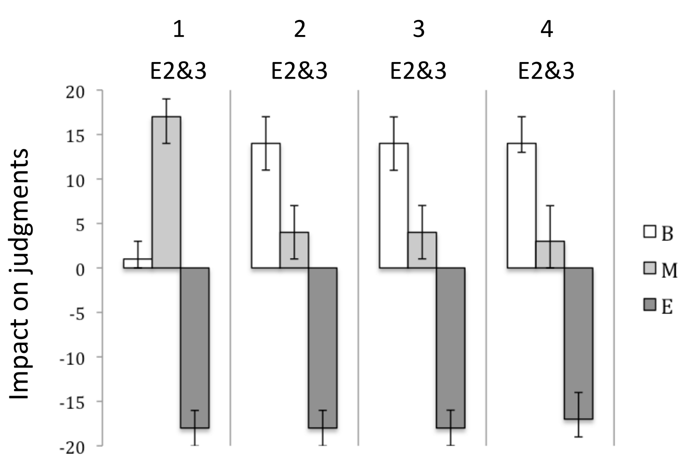


Figure 4.11. A pair of referential and comparative excerpts representing a modification to the final tonic of a cadential progression. Note that the inner voice has been removed in the last two measures of the comparative excerpt to avoid voice-leading problems.

(a) Musicians, Experiments 2 and 3



(b) Non-musicians, Experiments 2 and 3

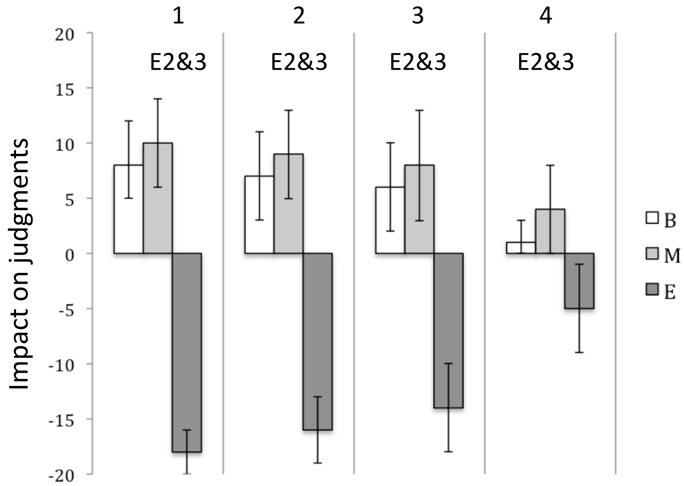


Figure 4.12 (previous and current pages). Four vectors showing the impact of modifications to the referential excerpts' perfect authentic cadence by either creating a deceptive cadence (vector #1) or switching the positions of the cadential dominant and tonic harmonies (vectors #2−4).

Table 4.10. Average variations caused by modifications to the perfect authentic cadence's harmonies.

	Musicians			**Non-musicians**		
	B	**M**	**E**	**B**	**M**	**E**
Avg. vector value	10.8	7	-17.8	5.5	7.8	-13.3
p	< .03	< .04	< .005	< .02	> .005	> .005

A second type of tonality-based modification involved melodic scale degrees. The results from Experiment 1 suggested that, apart from harmony, the final note of the melody also played an important role in expressing an end function for both groups of expertise (see Figure 4.13). We then observed that when a dominant-to-tonic progression closed an excerpt, participants were much more likely to identify the excerpt as an ending if its melody closed on the first scale degree than if it closed on some other degree, especially the fifth, an observation that sustains the theoretical precept that the first scale degree yields the strongest cadential closure possible. We therefore hypothesized that in excerpts closing with a dominant-to-tonic progression, substituting a closing first scale degree with the fifth degree—a theoretically much less stable scale degree—would impair the sensation of ending and thus have a negative impact on end-function judgments. We expected a qualitatively similar effect on both expertise groups, although we anticipated a stronger reaction from musicians, due to their overall tendency to exhibit stronger responses to tonal modifications.

Referential excerpt (Mozart, Piano Sonata in D major,K. 311, iii, 15–16)

Comparative excerpt (modification of Mozart, Piano Sonata in D major,K. 311, iii, 15–16)

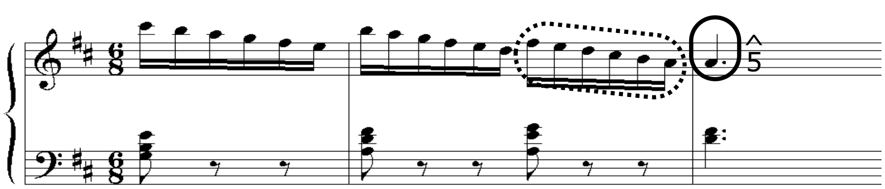
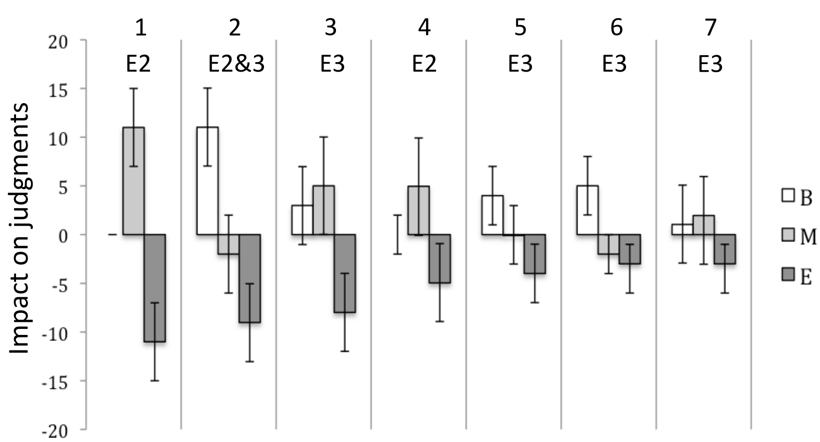


Figure 4.13. A pair of referential and comparative excerpts illustrating a modification to the final scale degree (solid line). Note that the pitch adjustments in the next-to-last bar of the modified excerpt (dashed line) have virtually no effect on the global pitch contour.

Figure 4.14 illustrates the seven modification vectors resulting from substitutions to the final melodic scale degrees (see Table J in Appendix D) and Table 4.11 shows the average variations, including corrected values for both groups' end function. The overall tendency is very clear: substituting the closing first scale degree with another one yields a strong and consistent decrease in end judgments. Note that although the average variations for beginning and middle judgments are moderately strong, they don't reach significance, meaning that they are fairly inconsistent. As expected, the impact was stronger on musicians than on non-musicians, but not significantly so.[14] As predicted on theoretical grounds, melodies ending on the first scale degree were consistently perceived as more conclusive than the ones ending on the fifth degree.[15]

(a) Musicians, Experiments 2 and 3



---

[14] A bootstrapped permutation test gave a non-significant *p*-value.

[15] Although our results suggest that melodic closure on the third scale degree has a level of stability somewhere in-between that of first and fifth scale degrees, we didn't gather enough evidence to generalize our observation.

(b) Non-musicians, Experiments 2 and 3

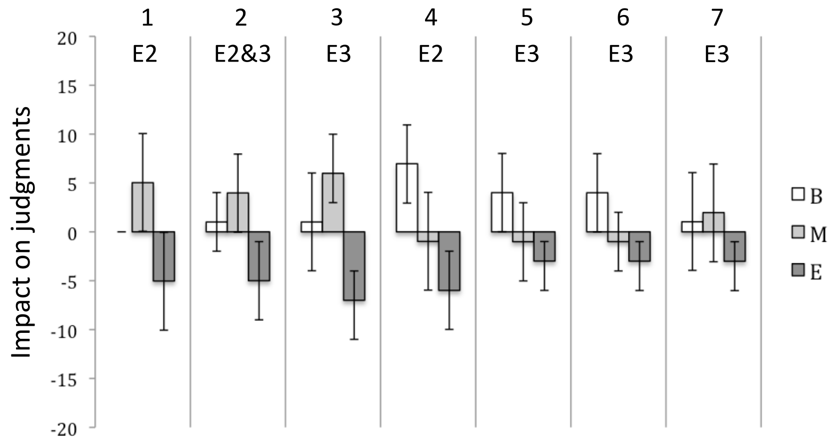


Figure 4.14 (previous and current pages). Seven modification vectors resulting from substituting the first with the fifth scale degree at the end of excerpts closing with a dominant-to-tonic progression.

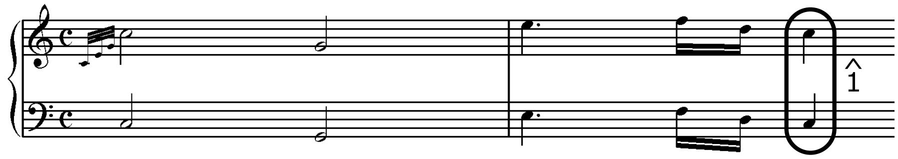
Table 4.11. Average variations caused by substituting the melodies' closing first scale degree with the fifth scale degree.

	Musicians			**Non-musicians**		
	B	**M**	**E**	**B**	**M**	**E**
Avg. vector value	3.4	2.7	-6.1	2.6	2.0	-4.6
Cor. floor/ceiling			-7.4			-4.8
p	> .1	> .1	< .01	> .1	> .1	< .02
Cor. floor/ceiling			< .02			< .02

A third tonal modification type was aimed at assessing the form-functional impact of scale degrees *without* explicit harmonic support. Here, all excerpts consisted in a melody doubled at the octave and the modification was a substitution of the closing first scale degree (likely implying a tonic harmony) with the second scale degree (likely implying a dominant harmony), thus discarding the possibility of closing on an implicit tonic harmony (see Figure 4.15).

Table K (Appendix D) shows the judgment distributions of excerpts involved in that modification. Figure 4.16 shows the individual vectors created by this melodic substitution and Table 4.12 shows the average variation values. Three pairs of excerpts were involved in that modification type, and a fourth pair (vector #4), with melodies identical to those of excerpts from vector #3 (musicians) and vector #1 (non-musicians), but with an explicit harmonic support, has been added for sake of comparison. The overall tendency is, once again, quite obvious: this modification has a constant negative impact on end judgments. Note, however, that the concurrent positive impact on the beginning function was consistent enough to reach significance in non-musicians' data, and that non-musicians' responses were as strong as musicians' responses. These results indicate that participants of both groups are sensitive to the role played by tonality as regards the end function, even without explicit harmonic realization. Moreover, given that the melodies used for these modifications were very short (they contained only 6 notes if we exclude grace notes), these results suggest that a sense of tonality can be induced with as few as five melodic notes.

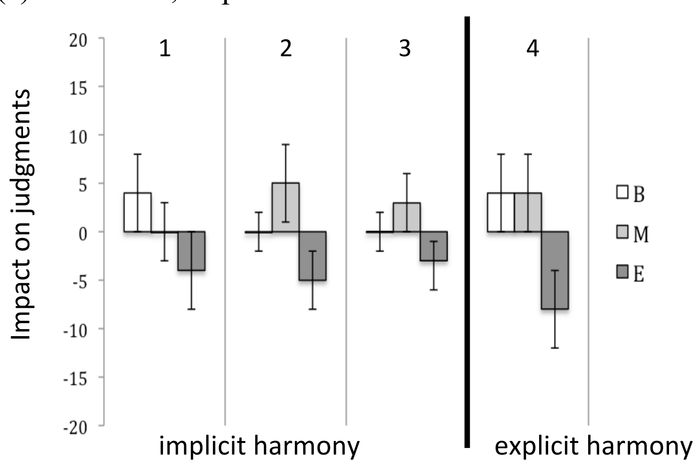
Referential excerpt (Mozart, Piano Sonata in C major,K. 309, i, 1−2)



Comparative excerpt (modification of Mozart, Piano Sonata in C major,K. 309, i, 1−2)

Figure 4.15. A pair of referential and comparative excerpts illustrating a modification to the final scale degree with no explicit harmonic support.

(a) Musicians, Experiment 3.



(b) Non-musicians, Experiment 3.

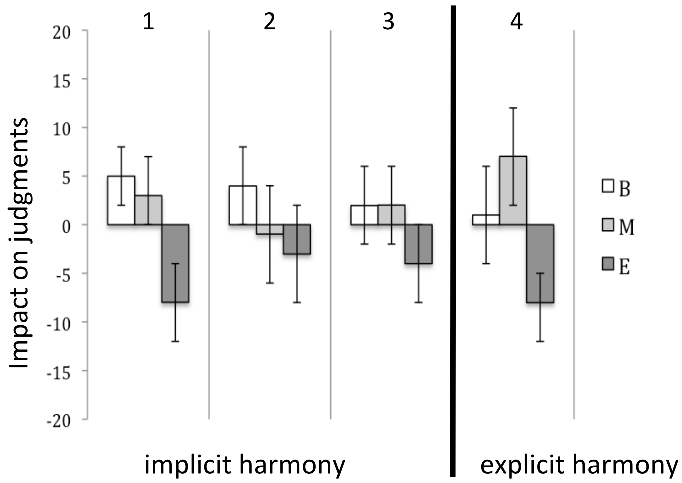


Figure 4.16 (previous and current pages). Four modification vectors resulting from substituting the first with the second scale degree at the end of excerpts. The excerpts involved in the first three vectors were purely melodic while the excerpts from the fourth vector had an explicit harmonic realization.

Table 4.12. Average variations caused by substituting the melodies' closing first scale degree with the second scale degree in a context where there is no explicit harmonic support. (The fourth vector of Figure 23 is not included in the calculations.)

	Musicians			**Non-musicians**		
	B	**M**	**E**	**B**	**M**	**E**
Avg. vector value **Cor. floor/ceiling**	1.3	2.7	-4 -4.5	3.7	1.3	-5
p **Cor. floor/ceiling**	> .2	> .08	< .02 < .05	< .03	> .1	< .02

Other properties

As with associational analyses, several properties did not yield the anticipated results. Below is a summary of the main hypotheses on the form-functional role of properties that our results did not support.

- Tonic emphasis. Augmentations to the level of tonic emphasis did not yield the anticipated increase in musicians' beginning judgments;

- Melodic contour. Modifications creating ascending melodic contours, contrary to our expectations, did not entail a consistent increase of beginning-function judgments and decrease of middle judgments;[16]

- Grouping structure. We showed in the associational analyses of Chapter 3 that longer units tended to be associated with beginnings and shorter ones with middles; however, modifications that shortened unit sizes did not entail a consistent decrease of beginning judgments and increase of middle judgments;

- Harmonic rhythm. Although a faster harmonic rhythm is theoretically more closely linked with middles than beginnings, our modifications involving an acceleration of harmonic rhythm did not entail the expected increase in middle judgments;

- Melody-plus-accompaniment texture. In Experiment 1, we observed that the absence of a clearly defined melody-plus-accompaniment texture

[16] Melodic contour is further discussed in Chapter 6.

impaired the sense of end for non-musicians; however our modifications on this textural property did not support this hypothesis.

Several other modifications to properties, including the downbeat emphasis, the rhythmic components of the unaccompanied anacrusis, the rhythmic relationship between the unaccompanied anacrusis and the following materials, and the "bass-voice anacrusis," did not produce consistent results and will not be discussed at length here.

Summary

Table 4.13 provides a synoptic summary of the average variation values for the modifications that had significant (< .05) or marginally significant (.05 < p < .1) effects on either group of participants. When applicable, we took the corrected values for floor/ceiling effects (see pp. 51−53 above for explanations). We left out average values with significance levels higher than .1. Properties are shown in the same order as they appear above.

A few cautionary remarks about these results are necessary. Although this chart provides a decent overview of the relative strength and level of consistency of different properties' form-functional impact, the comparability of the data remains constrained. First, the occasional disparity in the number of modifications representing different modification types affects the precision of the data,

Table 4.13. Summary of the average variation values with highest significance levels.

	Musicians			Non-musicians		
	B	**M**	**E**	**B**	**M**	**E**
1. Opening tonic→off tonic[i]	-7.4[e]	6.5[e]	0.4[a]			
Unaccompanied anacrusis						
2. Presence→absence	-6.5[a]	6.8[b]		-8.3[c]	7.3[c]	
3. Long→short				-6.3[c]	4.8[c]	
4. With→without texture contrast				-5.3[a]	4.7[a]	
5. Tonic→off-tonic scale degree	-7.3[b]	6.3[b]				
Rhythmic activity increase[i]						
6. In bass/accompaniment			-1.3[b]	-2.7[a]	4.7[c]	-2.0[b]
7. In bass/accompaniment and melody			-0.9[b]	-2.7[b]	3.5[c]	-1.1[a]
Opening tonic						
8. Root-position→inverted	-3.1[b]	3.3[b]		-3.2[b]	2.4[a]	
9. With→without cadence	10.8[b]	7.0[b]	-17.8[d]	5.5[b]	7.8[d]	-13.3[d]
First→other closing scale degree						
10. Explicit harmonic support	3.4[a]	2.7[a]	-7.4[c]	2.6[a]	2.0[a]	-4.6[b]
11. Implicit harmony		2.7[a]	-4.5[b]	3.7[b]		-5[b]

a = $p < .1$; b = $p < .05$; c = $p < .01$; d = $p < .005$; e = $p < .001$

i = data from the "all" condition (data from both Experiments 2 and 3)

especially the significance levels.[17] As a reminder, three main factors caused this disparity, namely: (1) stylistic constraints that severely limited the number of occurrences of some modification types; (2) the quasi-exploratory nature of this study, which often resulted in a compromise between the number of modification

[17] Larger samples yield greater levels of significance for a given effect size.

types investigated and the number of modifications representing each modification type; and (3) the music-theoretical goals with respect to incremental networks, which also constrained our choices of modifications.[18] Further quantitative investigation on those properties—one that would not necessarily prioritize music-theoretical goals to the extent that the current one does—should control for this discrepancy.

Second, issues intrinsic to the comparison vectors themselves slightly restrict the comparability of effect magnitudes. In fact, the amplitude of a given functional-judgment variation depends on the judgment distribution of the referential excerpt. As we discussed above with respect to the floor/ceiling effect, a distribution allowing for larger variations for a given formal function is more likely to entail stronger results than one with limited room for variation. Although we proposed a corrected measurement for such floor/ceiling effects, issues regarding referential excerpts' distribution are not completely solved, and, unfortunately, are quite difficult to control for—that is, one cannot know in advance precisely how participants are going to judge one particular excerpt.

Moreover, one has to be careful about the conclusions concerning specific form-functional effects drawn from these numbers. Indeed, since judgments are categorical, a large fluctuation of judgments in one category will necessarily impact substantially one or both of the other categories. Consequently, a judgment variation in a given category does not automatically mean that the modified

[18] As a reminder, we used incremental modification networks to change listeners' perception in a unique form-functional direction through successive alterations.

property has an impact on this category. One way to address this issue consists of looking at the type of form-functional judgment *transfer* that occurs in individual vectors and averaged data. Let us imagine a continuum that represents all possible levels of "judgment transfer efficiency" (see Table 4.14 below). One extremity of the continuum represents the highest transfer efficiency possible; that is, a variation of a given magnitude in one form-functional category is entirely compensated for by a variation of the same magnitude in the opposite direction in another category. The other extremity of this continuum represents the lowest transfer efficiency possible, that is, a variation of a given magnitude in one category is compensated for by variations by half that magnitude in the opposite direction in the other two categories. Any comparison vector (in a three-category context) will fit somewhere in-between those two extremes.

Table 4.14 provides instances of different levels of judgment transfer efficiency based on fictitious data. For instance, vector I shows a maximal transfer efficiency as all functional-judgment variations occur between the functions of beginning (B) and middle (M) whereas vector VI shows a minimal transfer efficiency as the variation in end judgments (E) is compensated for by variations of equal magnitude in the opposite directions in the other two functions. A gradual decrease in transfer efficiency occurs between vectors II and V.

Table 4.14. Levels of judgment transfer efficiency based on fictitious modification vectors. (Note that every row sums to zero.)

Judgment transfer efficiency	Vector	B	M	E
Maximal	I	-10	+10	0
	II	+10	-9	-1
	III	+8	-10	+2
	IV	-7	+10	-3
	V	+6	+4	-10
Minimal	VI	-5	-5	+10

When considered globally, the data presented in this section show a striking categorical match between formal functions and judgment transfer efficiency. On the one hand, modifications aimed at affecting beginning and middle judgments are those that showed, by far, the highest transfer efficiency on averaged data. Among the eight properties that were expected to affect those functions (see properties 1−8 in Table 4.13), only two, both being related to rhythmic activity increase (see properties 6 and 7 in Table 4.13), did not show a very high transfer rate between beginning and middle functions, but rather a compensation of middle-judgment variation that was fairly equally distributed between beginning and end judgments. Otherwise, most of those properties' vectors have high transfer rates between beginning and middle functions (see Figures 4.3a–b, 4.4a–b, 4.5a, 4.6b, 4.7b, 4.8d, 4.7c–d, and 4.10a–b) and the same can be said about the average variations shown in Table 4.13. As a whole, this illustrates that, as far as those modification types are concerned, we successfully affected listeners' perception of beginning and middles without (much) affecting the perception of end function, as predicted by our hypotheses.

On the other hand, modifications aimed at affecting the end function had overall a much lower transfer efficiency than those affecting the other two categories. To be sure, several individual vectors involving the end function showed a high transfer efficiency, but the transfer happened sometimes with the beginning function, and some other times with the middle function. Consequently, the magnitude of end-values shown in Table 4.13 for properties 9−11 is consistently higher than those of beginning and middle functions, those two being relatively similar to one another. This suggests that, contrary to the properties that allow for distinguishing between beginnings and middles, those defining the end function can be easily manipulated to affect beginning and middle categories in the following way: when strong end-defining properties are implemented, end judgments strongly increase at the expense of judgments for one or both of the remaining categories, and conversely, when strong end-defining properties are removed, beginning and/or middle judgments increase at the expense of end judgments. In other words, strong end-defining properties have the capacity to gather judgments that would otherwise be attributed to the other two functions while strong beginning- and middle-defining properties do not have this capacity. If only end-defining properties can override those of the other two functions, it seems reasonable to claim that these end properties are perceptually stronger than those characterizing the other two functions in participants' decision-making process.

GENERAL SUMMARY: ASSOCIATIONAL AND COMPARATIVE ANALYSES

The results provided in Chapters 3 and 4 were based on two types of analyses: (1) associational analyses (including agreement analyses and multiple regression), which showed large-scale relationships between the distribution of musical properties and trends in participants' form-functional judgments; and (2) comparative analyses, which assessed causal relationships between individual musical properties and participants' form-functional judgments. The short descriptions below summarize qualitatively what those analyses have shown about the properties investigated in this study.

Tonic proportion. Although agreement analyses showed that musicians' consensual beginnings tend to have a larger proportion of tonic harmony than middles, multiple regression and comparative analyses suggest that this parameter has little influence on participants' form-functional judgments, if any. The results of agreements analyses are, as discussed above, most likely a side effect of the high correlation of this property with the 'opening tonic' property, which our analyses revealed to be much more form-functionally efficient.

Opening tonic. All of the above analyses concurred in showing that musicians (only) rely very strongly on this specificity to distinguish beginnings (tonic opening) from middles (off-tonic opening).

Unaccompanied melodic opening. All of the above analyses showed that both musicians and non-musicians use this specificity to distinguish beginnings (presence of the specificity) from middles (absence of the specificity), but that the latter's judgments of beginning and middle depend on this specificity to a greater extent than the former's. Moreover, comparative analyses showed that whereas musicians were particularly sensitive to its opening scale degrees, non-musicians relied mostly on this property's texture contrast and duration.

Rhythm. The results of associational analyses were fairly consistent: higher rhythmic uniformity and onset density are more likely to be associated with middles than beginnings, especially as regards composite and melodic rhythms. Comparative analyses gave qualitatively similar results—although fairly weak ones—as regards form-functional impact (that is, an augmentation of onset density and a diminution of rhythmic variety had a negative impact on beginnings and a positive one on middles), albeit those concerned exclusively non-musicians' with respect to melodic and, mostly, bass/accompanimental rhythmic settings. It seems therefore that, as anticipated, non-musicians' reliance on rhythmic properties is stronger than musicians'. Overall, the results of associational and comparative analyses were hard to reconcile, which forces us to interpret the form-functional impact of rhythm cautiously.

Grouping structure. This parameter—the only property based on analytic judgment as opposed to an objective measurement—yielded consistent tendencies in the musicians' data and relatively inconsistent ones in the non-musicians' data in associational analyses. Overall, excerpts with internal sub-groupings were more likely to be perceived as middles and those without sub-groupings, as beginnings. Our analyses on modifications, however, did not show any form-functional effect of this property.

Opening tonic inversion. Although associational analyses did not show any consistent tendency with respect to this specificity, our analyses on modifications indicated that this property has a weak but consistent effect on both groups, namely, an excerpt with a root-position opening tonic gathers a higher number of beginning judgments and a lesser number of middle judgments than one with an inverted (first inversion) opening tonic.

Other properties. Some music theoretically important properties such as the opening melodic contour, bass contour, and harmonic rhythm were not provided any empirical support with respect to their form-functional efficiency in this study.

Ends. Agreement analyses showed that a closure on tonic harmony is a necessary condition for both groups to entail a consensual end. Other analyses suggested that non-musicians are also influenced by other properties such as a final onset-density decrease, rhythmic variety, and onset density. Comparative analyses, performed only on the harmony of ends, indicated that various aspects of tonality, namely the final chord (either explicit or implicit) and the final scale degree, had a strong impact on both groups' end judgments, which supports the observation about the fundamental role of tonic harmony in expressing the end function that was made above with respect to the agreement analyses.

This chapter, along with the preceding one, presented the results of the main task of this project, namely, the form-functional identification task. But Experiments 2 and 3 also comprised two subsidiary tasks: (1) a speeded-judgment task, aimed at assessing the level of immediacy at which a formal function can be judged; and (2) a rating task, aimed at directly quantifying participants' perceived clarity of form-functional expression. The following chapter presents the results obtained in those subsidiary tasks.

Chapter 5. Incomplete hearings, response times, and form-functional strength

In Chapter 2, we hypothesized that participants of Experiment 1 may have used a sequential decision process to ascribe a formal function to an excerpt. We thus proposed that participants assessed a stimulus's potential for conveying an end function first by evaluating its cadential materials, located at the end of the excerpt. If the answer to that evaluation was negative, they considered its potential for conveying a beginning function, and if this second evaluation was also negative, they chose the last option available, the middle function. A fundamental implication of that hypothesized decision process concerns the level of spontaneity that underlies the perception of those three formal functions. If, indeed, the decision process is sequential, beginning evaluations should be faster than middle evaluations, but slower than end evaluations.

Another implication concerns the strength of form-functional expression. If a middle judgment constitutes a 'fall-back' (or a 'last resort') option, its form-functional expression is most likely weaker than that of beginning and, to a greater extent, end functions. Moreover, a clearly expressed formal function should generate greater levels of consensus among participants of the same expertise group than one that is projected with lesser clarity. In fact, if the expression of a given formal function tends to be unambiguous, most—if not all—participants of the same group should agree on excerpts that project this function *and* those that *do not* project it.[1]

Another issue concerns the localization of form-functionally important materials: (1) can participants make beginning judgments with a lesser amount of musical information than for middle judgments? and (2) to what extent is the musical information conveying the end function localized at the closure of excerpts? This chapter will address these aspects by exploring the results of speeded-judgment tasks and rating strength of Experiments 2 and 3, and by discussing some characteristics of participants' judgment distributions from the second task of those experiments.

EXPERIMENT 2: PARTIAL HEARINGS AND INFORMATION LOCALIZATION

The main goals of the speeded-judgment task in Experiment 2 were twofold:

(1) to evaluate the extent to which end judgments depend on information located towards the end of excerpts;[2] we thus hypothesized that if end judgments depended on materials located at an excerpt's later part, participants' end identifications would be fewer when an excerpt's

---

[1] Those two situations are similar to signal detection theory's categories of "hit" and "correct rejection." However, signal detection theory does not apply to the current analyses since most of the stimuli in Experiments 2 and 3 were *modifications* to original excerpts from Mozart; there were therefore *no correct answers* in the majority of the trials.

[2] Obviously, as already discussed in Chapter 4, the importance of musical information localized at the end of excerpts was also tested by several musical modifications. The analyses presented here are therefore complementary to the observations made in previous chapters.

closing materials are unheard (i.e., when the music is stopped before the end of the excerpt) than when it is heard (i.e., when the excerpt is heard in its entirety).

(2) to evaluate if the middle function is perceived with the same quantity of information as the beginning function; we thus hypothesized that if the beginning function were evaluated with a higher level of immediacy than the middle function, beginning judgments should follow shorter exposures to musical materials than middle judgments.

The speeded-judgment task used in Experiment 2 allowed us to investigate those two issues (see the method section of Chapter 3 for a complete description of the task).

Complete and incomplete hearings

We classified all participants' speeded functional judgments in two categories: (1) those following an *incomplete first hearing* (IFH), representing instances where participants stopped the music prior to the excerpt's last onset; and (2) those following a *complete first hearing* (CFH), representing instances when they stopped the music after the final onset. Note that we discarded all listening times shorter than 500 ms, namely, when participants forgot to hold down the mouse button when performing Task 1. All of our 80 participants made several of those premature releases and reported them as unintentional mouse clicks (total of 151 for musicians and 187 for non-musicians out of 2960 judgments for each group).[3]

Then, for each trial, we compiled participants' *response sequences* in Tasks 1 and 2. For a given participant at a given trial, a response sequence is simply the chronological sequence of his/her form-functional response in the speeded-judgment task (Task 1) and his/her response in the main form-functional judgment task (Task 2). Overall, with three formal functions available in each of the two tasks, nine (3^2) response sequences are possible. From now on, response sequences will be labeled according to the first letters of the functional judgments of Tasks 1 and 2. For instance, "BM" stands for an excerpt judged as a beginning in Task 1 and as a middle in Task 2. Between Tasks 1 and 2, functional judgments could be either *unchanged*, when form-functional judgments are identical in those tasks (three possibilities: BB, MM, EE), or *changed*, when the judgments differ (six possibilities: BM, BE, MB, ME, EB, EM).

Figure 5.1 shows the response sequences of musicians (to the right) and non-musicians (to the left). In each matrix, rows represent judgments made in Task 1 and columns represent those made in Task 2. The two matrices in the upper panels contain judgments following an IFH (n = 1392 and 1516 for musicians and non-musicians) whereas the two matrices in the lower panels contain judgments following a CFH (n = 1417 and 1257 for musicians and non-

---

[3] For both expertise groups, the frequency distribution of those premature button releases loosely resemble a negatively skewed normal distribution around roughly 150 ms with an additional small bump for time values very close to zero. Very few occurrences were between 300 and 500 ms (12 for musicians and 10 for non-musicians).

musicians). (Recall that, by definition, all judgments in Task 2 followed complete hearings).

MUSICIANS — **Task 2**

Task 1: IFH	**B**	**M**	**E**	
B	587	70	42	699
M	43	366	67	476
E	9	77	131	217
	639	513	240	**1392**

Task 1: CFH	**B**	**M**	**E**	
B	469	46	12	527
M	57	544	23	624
E	2	13	251	266
	528	603	286	**1417**

NON-MUSICIANS — **Task 2**

Task 1: IFH	**B**	**M**	**E**	
B	456	71	80	607
M	57	532	159	748
E	13	45	103	161
	526	648	342	**1516**

Task 1: CFH	**B**	**M**	**E**	
B	317	45	19	381
M	62	464	58	584
E	5	27	260	292
	384	536	337	**1257**

Figure 5.1. Comparative matrices of musicians' and non-musicians' functional judgments after an incomplete first hearing (IFH, upper panels) or complete first hearing (CFH, lower panels) in Task 1 and a second, complete hearing in Task 2 (Experiment 2), including the sums of rows and columns (grey) and the grand total (bold grey).

Figure 5.2 shows proportional representations with respect to formal function of the data of Figure 5.1 (values are in percentages). Each one of the four matrices of Figures 5.2a and 5.2b has been calculated from the matrix with the corresponding position in Figure 5.1. Figure 5.2a shows percentages computed on each row, the value of each cell being divided by the sum of the values of the row to which it belongs (all rows sum to 100%). Those values constitute proportional representations of the three response sequences with identical judgments in Task 1 (i.e., the three response sequences with identical first letters); we therefore identify them as *Task 1 proportional representations* (T1PR). Figure 5.2b is similar to Figure 5.2a, but the percentages are instead computed on each column (columns therefore sum to 100%). Those values constitute proportional representations of the three response sequences with identical judgments in Task 2 (i.e., the three response sequences with identical second letters); we therefore identify them as *Task 2 proportional representations* (T2PR). To put it in chronological, and perhaps more intuitive terms: whereas T1PR (Figure 5.2a) shows, in proportional terms, what judgments *follow* a first-hearing judgment for a given function, T2PR (Figure 5.2b) shows what judgments *precede* a second-hearing judgment for a given function.

(a) T1PR

		MUSICIANS Task 2			NON-MUSICIANS Task 2		
		B	**M**	**E**	**B**	**M**	**E**
Task 1: IFH	**B**	83,98	10,01	6,01	75,12	11,70	13,18
	M	9,03	76,89	14,08	7,62	71,12	21,26
	E	4,15	35,48	60,37	8,07	27,95	63,98
Task 1: CFH	**B**	88,99	8,73	2,28	83,20	11,81	4,99
	M	9,13	87,18	3,69	10,62	79,45	9,93
	E	0,75	4,89	94,36	1,71	9,25	89,04

(b) T2PR

		MUSICIANS			**NON-MUSICIANS**		
		Task 2			**Task 2**		
		B	**M**	**E**	**B**	**M**	**E**
Task 1: IFH	**B**	91,86	13,65	17,50	86,69	10,96	23,39
	M	6,73	71,35	27,92	10,84	82,10	46,49
	E	1,41	15,01	54,58	2,47	6,94	30,12
Task 1: CFH	**B**	88,83	7,63	4,20	82,55	8,40	5,64
	M	10,80	90,22	8,04	16,15	86,57	17,21
	E	0,38	2,16	87,76	1,30	5,04	77,15

Figure 5.2 (previous and current pages). Proportional relationships (in percentages) of response sequences calculated on each row (a) and column (b) from the values of Figure 5.1.

With those particularities in mind, we hoped that our data could answer the following questions: (1) will the completeness of the first hearing have an impact on the overall rate of changed answers? (2) will its impact be the strongest on the end function? and (3) will its impact be stronger on non-musicians than on musicians? From those questions, we derived three main hypotheses:

1. the effect of the first hearing's completeness—from now on, the *completeness effect*—on the rate of changed answers. Since formal functions in the CFH condition were evaluated with all the available musical information and those in the IFH condition, with partial information, we expect a higher rate of changed answers in the IFH than the CFH condition;

2. the completeness effect on response sequences. If later materials are paramount to participants' capacity to evaluate the *end* function, (a) we should find a smaller proportion of unchanged end-judgment sequences (EE) in the IFH than in the CFH condition (in both T1PR and T2PR); and (b) the proportional difference between IFH and CFH conditions should be more important for EE than BB and MM sequences;
3. the effect of musicianship on response sequences. Due to their familiarity with the style, musicians should recognize musical signals of a forthcoming closure to a greater extent than non-musicians. They should indeed have a greater tendency than non-musicians to make end-function judgments prior to the excerpt's closure. Also, their capacity to elicit end judgments should depend to a lesser extent than non-musicians on information located at the end of excerpts. We can therefore make several predictions with respect to our results: (a): the completeness effect relative to hypothesis 2a should be stronger on non-musicians than on musicians; (b) the completeness effect on response sequences BE and ME should be more important for non-musicians than musicians; (c) musicians' first-hearing end judgments (namely, EB, EM, and EE sequences) in the IFH condition should proportionally outnumber those of non-musicians; (d) for non-musicians (only), the extent to which second-hearing end judgments proportionally outnumber first-hearing end judgments should be substantially greater in the IFH than the CFH condition; (e) as regards the expected proportional increase of EE sequences from the IFH to the CFH condition (hypothesis 2a), the

percentage difference between the IFH and CFH conditions should be substantially larger in T2PR than T1PR for non-musicians (only).

Hypotheses 1, 3c, and 3d can be addressed through simple percentage-point comparisons based on the data of Figure 5.1. First, as predicted by our first hypothesis, the values of changed answers are generally larger in the IFH than the CFH condition. From these data, we further calculated that changed answers represent roughly 22% and 28% of musicians' and non-musicians' response sequences in the IFH condition whereas those values decrease to 11% and 17%, respectively, in the CFH condition, both percentage differences being statistically significant based on a two-proportion z-test, $p < .001$ (these percentages are not visible on the figure). The effect size of completeness on the rate of changed answers is equivalent for musicians and non-musicians (11% decrease in both cases). Second, as expected from hypothesis 3c, the proportion of musicians' first-hearing end judgments (those judgments are represented by the sum of last row's entries) is 5.0% higher than that of non-musicians in IFH, this difference being statistically significant (two-proportion z-test, $p < .001$). The effect size is, however, relatively modest and, as will be discussed further below, this positive percentage difference is mostly due to musicians' high proportion of ME sequences in the IFH condition. Third, as predicted in hypothesis 3d, the percentage-point superiority of non-musicians' second-hearing end judgments (sum of last column's entries) over first-hearing end judgments went from 12.0% in IFH to 3.6% in CFH. For the sake of comparison, those percentage point differences were of 1.7% and 1.4%, respectively, for musicians in those two conditions. Otherwise said, whereas musicians' relative proportion of first- and second-hearing end judgments tends to be approximately equal in both IFH and CFH conditions, for non-musicians, second-hearing end judgments outnumber first-hearing end judgments to a much greater extent in the IFH than the CFH condition.[4]

To be sure, other observations relevant to our hypotheses could be made directly from Figure 5.1. For instance, a striking property of those data concerns the outstanding number of non-musicians' ME sequences (159). This number is by far superior to all other instances of changed answers in this experiment and, moreover, constitutes the only instance of a changed-answer sequence outnumbering an unchanged-answer sequence (namely, the 103 occurrences of the EE sequence), an observation relevant to both hypotheses 2 and 3. In order to fully address those two hypotheses, however, proper quantification of the completeness effect (hypothesis 2) and the effect of musicianship (hypothesis 3) was necessary. To do so, we used the proportional representations of Figure 5.2.

We compared those proportional-representation matrices in two different ways. First, we subtracted the entries of IFH matrices from those of the corresponding cells in the CFH matrices to calculate the completeness effect. Second, we subtracted the entries of musicians' matrices from those of the corresponding cells in non-musicians' matrices for both IFH and CFH conditions

---

[4] We did not specifically predict, however, that second-hearing end judgments would be more numerous than first-hearing end judgments in the CFH condition. Our prediction concerned the extent to which non-musicians' numerical superiority of second-hearing end judgments would decrease from the IFH to the CFH condition.

to compute the effect of expertise (musicianship). Those simple percentage-point differences—a total of 72—were accompanied with two-proportion z-tests.[5] Figure 5.3 shows the completeness effect and Figure 5.4, the effect of musicianship. Non-significant percentage differences are in grey. Since the sum of rows (T1PR) and columns (T2PR) in Figure 5.2 are constant (they all sum to 100%), percentage differences based on those values necessarily generate rows (T1PR) and columns (T2PR) that sum to zero. Therefore, as with the comparison vectors of Chapter 4, the largest magnitude of percentage difference for one response pattern is exactly compensated for by percentage differences in the opposite direction for the other two response patterns from the same row (T1PR) or column (T2PR). Tables 5.1 and 5.2 show only the statistically significant percentage differences of the completeness effect and expertise effect, respectively, sorted in descending order of absolute magnitude of the difference. For the current purposes, only the most salient tendencies—those involving the highest significant percentage differences—will be discussed.

[5] 9 cells per matrix multiplied by 4 matrices per figure multiplied by 2 conditions (completeness and musicianship), for a total of 72 comparisons.

		MUSICIANS			NON-MUSICIANS		
		B	M	E	B	M	E
T1PR	B	5,0	-1,3	-3,7	8,1	0,1	**-8,2**
	M	0,1	**10,3**	**-10,4**	3,0	**8,3**	**-11,3**
	E	-3,4	**-30,6**	**34,0**	-6,4	**-18,7**	**25,1**
T2PR	B	-3,0	-6,0	**-13,3**	-4,1	-2,6	**-17,8**
	M	4,1	**18,9**	**-19,9**	5,3	4,5	**-29,3**
	E	-1,0	**-12,9**	**33,2**	-1,2	-1,9	**47,0**

Figure 5.3. Completeness effect on response sequences; p = N.S. (grey); $p < .05$ (black); $p < .0001$ (bold).

		IFH			CFH		
		B	M	E	B	M	E
T1PR	B	**-8,9**	1,7	**7,2**	-5,8	3,1	2,7
	M	-1,4	-5,8	7,2	1,5	-7,7	**6,2**
	E	3,9	-7,5	3,6	1,0	4,4	-5,3
T2PR	B	-5,2	-2,7	5,9	-6,3	0,8	1,4
	M	4,1	**10,8**	**18,6**	5,4	-3,7	**9,2**
	E	1,1	-8,1	**-24,5**	0,9	2,9	-10,6

Figure 5.4. Effect of musicianship on response sequences; p = N.S. (grey); $p < .05$ (black); $p < .0001$ (bold).

Table 5.1. Completeness effect on response sequences for musicians (Mus) and non-musicians (NM) sorted by magnitude of percentage differences. Percentage differences come from the subtraction of the IFH data from that of the CFH data.

Response sequence	T1PR or T2PR	Group	% difference	*p*
EE	T2PR	NM	47.0	< .001
EE	T1PR	Mus	34.0	< .001
EE	T2PR	Mus	33.2	< .001
EM	T1PR	Mus	−30.6	< .001
ME	T2PR	NM	−29.3	< .001
EE	T1PR	NM	25.1	< .001
ME	T2PR	Mus	−19.9	< .001
MM	T2PR	Mus	18.9	< .001
EM	T1PR	NM	−18.7	< .001
BE	T2PR	NM	−17.8	< .001
BE	T2PR	Mus	−13.3	< .001
EM	T2PR	Mus	−12.9	< .001
ME	T1PR	NM	−11.3	< .001
ME	T1PR	Mus	−10.4	< .001
MM	T1PR	Mus	10.3	< .001
MM	T1PR	NM	8.3	< .001
BE	T1PR	NM	−8.2	< .001
BB	T1PR	NM	8.1	< .05
EB	T1PR	NM	−6.4	< .05
BM	T2PR	Mus	−6.0	< .001
MB	T2PR	NM	5.3	< .05
BB	T1PR	Mus	5.0	< .05
MM	T2PR	NM	4.5	< .05
MB	T2PR	Mus	4.1	< .05
BE	T1PR	Mus	−3.7	< .05
EB	T1PR	Mus	−3.4	< .05

Table 5.2. Effect of musicianship for IFH and CFH conditions sorted by magnitude of percentage differences. Percentage differences come from the subtraction of the musicians' data from that of the non-musicians' data.

Response sequence	T1PR or T2PR	Completeness	% difference	*p*
EE	T2PR	IFH	−24.5	< .001
ME	T2PR	IFH	18.6	< .001
MM	T2PR	IFH	10.8	< .001
EE	T2PR	CFH	−10.6	< .001
ME	T2PR	CFH	9.2	< .001
BB	T1PR	IFH	−8.9	< .001
EM	T2PR	IFH	−8.1	< .05
MM	T1PR	CFH	−7.7	< .001
ME	T1PR	IFH	7.2	< .05
BE	T1PR	IFH	7.2	< .001
BB	T2PR	CFH	−6.3	< .05
ME	T1PR	CFH	6.2	< .001
BE	T2PR	IFH	5.9	< .05
BB	T1PR	CFH	−5.8	< .05
MM	T1PR	IFH	−5.8	< .05
MB	T2PR	CFH	5.4	< .05
EE	T1PR	CFH	−5.3	< .05
BB	T2PR	IFH	−5.2	< .05
EM	T1PR	CFH	4.4	< .05
MB	T2PR	IFH	4.1	< .05
BE	T1PR	CFH	2.7	< .05

Let us now summarize our results with respect to the completeness effect. In each one of the four matrices of Figure 5.3, the strongest percentage differences concern the unchanged end response sequence (EE). This globally shows that, as predicted in hypothesis 2b, incomplete hearings mostly affected the perception of the end function. Moreover, that the percentage differences are positive mean that the proportional representation of the EE sequence is significantly higher in CFH than IFH, which concurs with hypothesis 2a. Note however that whereas musicians' percentage differences between T1PR and T2PR are virtually equal (34.0% and 33.2%, respectively), those of non-musicians' are much higher for T2PR than T1PR (47.0% and 25.1%). For non-musicians, therefore, the proportional increase in unchanged end judgments (EE) from IFH to CFH conditions was due to a much higher rate of change of first-hearing end judgments than second-hearing end judgments, an observation that is consistent with hypothesis 3e. The strong percentage decrease of ME sequences in T2PR (−29.3% and −19.9% for non-musicians and musicians, respectively) reveals the main cause of this relative deficit of EE response sequences in the IFH condition: participants evaluated a great many excerpts as *middles* after an IFH. The important gap between musicians' and non-musicians' percentage differences suggests that although musical information located at the very end of excerpts is critical to all participants' end judgments, it is more so for non-musicians than musicians. Those results are partially consistent with hypothesis 3b: whereas they concur with the anticipated difference between musicians and non-musicians, they suggest that the completeness effect is substantially stronger on the ME sequence than the BE sequence (−17.8% and −13.3% for non-musicians and musicians, respectively), a particularity that our original hypothesis did not address.

Substantial percentage decreases also involved the EM response sequence. Contrary to the ME sequence, the decrease for the EM sequence in T1PR was stronger for musicians than non-musicians (−30.6% and −18.7%, respectively). Accordingly to hypothesis 3c, this stronger percentage difference for musicians shows their greater tendency than non-musicians to elicit end judgments after incomplete hearings, which suggests that they have a greater propensity to predict an end function prior to the arrival of closing materials (most likely, cadential materials). To be sure, several of musicians' predictions were deemed wrong after a second, complete hearing. In fact, musicians' high increase of MM sequences in T2PR also indicates the extent to which musicians wrongly anticipated the arrival of end-related musical materials in IFH.

Although several other comparisons gave significant results, commenting all of them would be unnecessary. For our purposes, it suffices to notice that completeness affects first and foremost the perception of the end function, and, secondarily, the middle function. Overall, when musical information at the end of excerpts is unavailable, participants tend to confound the end function with the middle function to a greater extent than the beginning function.

As regards the effects of musicianship, two response sequences gave outstanding percentage differences. First, as visible on Figure 5.4 and Table 5.2**,** the EE sequence in the IFH condition with T2PR is much less frequent in non-musicians' than musicians' data (−24.5% between musicians and non-musicians). This shows that, with an incomplete first excerpt, musicians' unchanged end judgments are significantly more frequent than non-musicians', which is consistent with hypothesis 3a. Note that the size of this effect is reduced substantially—although it is still statistically significant—in the CFH condition in T2PR (−10.6%). Second, the ME sequence in the IFH condition with T2PR is much more frequent in non-musicians' than musicians' data (−18.6%). Those results support hypothesis 3b as regards the ME response sequence and further indicate that, as already mentioned above, the effect of musicianship is much stronger on the ME than the BE sequence.

One last observation about the results of Table 5.2 concerns the unchanged answers (BB, MM, and EE response sequences). Apart from the MM sequence in the IFH with T2PR, all statistically significant percentage differences of unchanged answer sequences are negative, that is, percentages are higher for musicians than non-musicians. By definition, higher rates of unchanged answers correspond to lower rates of changed answers, which could be interpreted as a measure of functional "stability" from a perceptual standpoint. In that respect, musicians' functional decisions seem to enjoy a higher overall level of stability than non-musicians', with the exception of the middle function in the IFH condition with T2PR, a tangible side-effect of the aforementioned musicians' higher proportion of ME response sequences—explained above as their higher propensity for anticipating ends—in the IFH condition with T2PR.

Hearing times: beginning and middle judgments

The previous section showed the extent to which end judgments depend on musical information located towards the later portion of excerpts. The goal of the current section is to assess the level of immediacy that characterizes the perception of beginning and middle functions, or, more precisely, the level of efficiency of functional expression based on the "amount" of music, on a temporal basis, that is necessary to project those functions. To address this issue, we simply compared the timings of beginning and middle judgments in the speeded-judgment task (Task 1 of Experiment 2). As a reminder, to complete this task, participants activated the music by holding down the mouse button and released the button when they had enough musical information to make a first functional judgment. We measured the time during which the mouse button was held down, but not the time required to provide the form-functional judgment (we measured reaction times between the end of an excerpt and the form-functional judgment in Experiment 3; further details are provided below). Based on the hypothesis that beginnings have a higher level of functional efficiency than middles and on the assumption that a function with a higher functional efficiency can be conveyed with a lesser amount of musical information, we expected shorter listening times for beginnings than middles.

As discussed above, the functional judgments of Task 1 followed either a complete or an incomplete hearing. It is important to note that whereas the timings of incomplete hearings correspond exactly to the amount of music heard prior to the first judgment, timings of complete hearings include the last onset and, for most trials, an additional lapse of time between the end of the excerpt and the release of the mouse button, a time delay that participants may have used for making their form-functional decision. Since our main interests concerned the exact amount of music heard prior to a beginning or middle judgment, we only paid attention to incomplete hearings.

Table 5.3 shows the results of two-tailed t-tests on the average beginning and middle listening times of participants of each group for incomplete hearings. Contrary to our expectations, there was no effect of function on listening times and we therefore reject the hypothesis according to which beginnings can be expressed with a lesser amount of musical information than middles.

Table 5.3. Average (Avg.) timings of musicians' and non-musicians' beginning (B) and middle (M) responses for incomplete hearings.

	Musicians			**Non-musicians**		
Function	**Avg.**	**S.D.**	***p***	**Avg.**	**S.D.**	***p***
B	2.22	0.41	> .6	2.00	0.36	> .5
M	2.17	0.52		1.94	0.38	

EXPERIMENT 3: SPEEDED FUNCTIONAL JUDGMENTS ON COMPLETE HEARINGS

Whereas the speeded-judgment task of Experiment 2 measured the duration of music required to make a functional judgment, that of Experiment 3 measured the response time between the end of an excerpt and the functional judgment *per se*. Those response times therefore provide valuable information with respect to the spontaneity of the form-functional decision, and consequently, allow us to gather information about the aforementioned sequential decision-making process. As we hypothesized that the end function would be the first option to be considered, followed by the beginning function, and finally, the middle function, we expected the smallest response times for ends, the largest ones for middles, with those of beginnings lying in between.

To test the effect of musicianship and formal function on response times, we conducted a two-way analysis of variance (ANOVA). There was no effect of function, $F(2, 114) = 1.29$, $p > .2$, or musicianship, $F(1, 114) = 0.73$, $p > .3$ and no interaction, $F(2, 114) = 1.15$, $p > .3$. Post-hoc testing with Holm-Bonferroni method showed no effect either and only a t-test between musicians' response times of end and middle functions barely reached significance ($p = .05$). Figure 5.5 illustrates the average response times and 95% confidence intervals. As can be seen on the figure, musicians show a slight tendency to provide faster end responses than beginning and middle responses, but this tendency is not significant, as indicated by the substantial overlap between error bars.

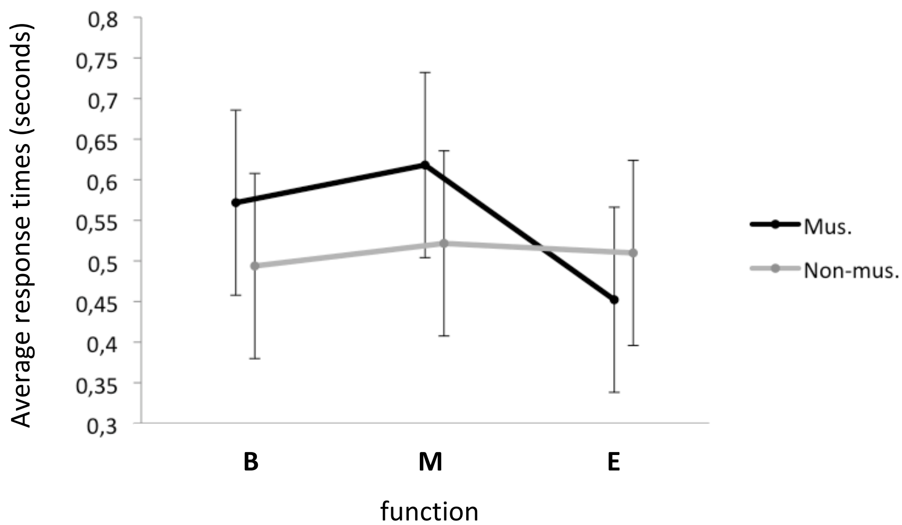


Figure 5.5. Average response times (in seconds) with 95% confidence intervals for musicians' (Mus.) and non-musicians' (Non-mus.) beginning (B), middle (M), and end (E) judgments.

Strength-of-function ratings

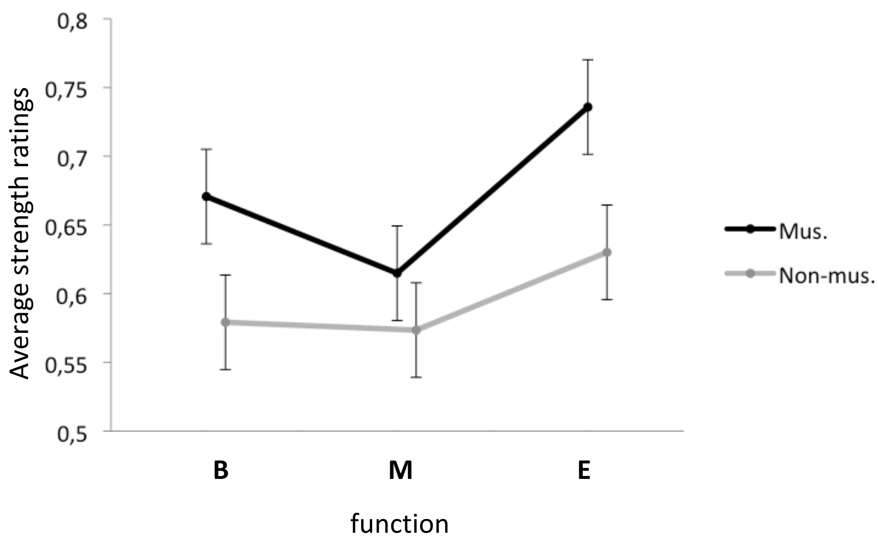
In Experiment 1, we found that musicians and non-musicians rated the strength of excerpts' form-functional expression in qualitatively similar, but quantitatively different ways. Indeed, the relative response patterns were analogous in both groups—ends received the strongest ratings, followed by beginnings and middles—but musicians' ratings were significantly stronger than non-musicians'. Since the rating task was identical in our three experiments, we expected a similar outcome in Experiments 2 and 3.

As with the speeded-judgment task of Experiment 3, we used a 2-way ANOVA to test the effect of function and musicianship on strength ratings.[6] In

[6] The ratings were normalized to ensure that each participant's ratings lied between 0 to 1.

both Experiments 2 and 3, we found a strong effect of function, $F(2, 234) = 13.94$, $p < .0001$ (Experiment 2) and $F(2, 114) = 9.91$, $p = .0001$ (Experiment 3), musicianship, $F(1, 234) = 32.57$, $p < .0001$ (Experiment 2) and $F(1, 114) = 26.6$, $p < .0001$ (Experiment 3), and, only in Experiment 3, a significant interaction between those two factors, $F(2, 234) = 1.95$, $p > .1$ (Experiment 2) and $F(2, 114) = 3.25$, $p < .05$ (Experiment 3). Post-hoc testing with Holm-Bonferroni method showed that musicians' end ratings were significantly higher than all other ratings by musicians and non-musicians in both Experiments 2 and 3, and that non-musicians' beginning and middle ratings were significantly lower than musicians' beginning ratings in Experiment 2 (only). Average strength ratings and 95% confidence intervals appear in Figures 5.6a (Experiment 2) and 5.6b (Experiment 3). Although the general silhouette of rating patterns—especially those of musicians—are somewhat concurrent to our predictions, only musicians' end ratings are consistently stronger than those of the other functions. Whereas the difference between musicians' beginning and middle ratings is not strong and consistent enough to reach statistical significance, non-musicians' ratings are even less distinguishable from one another. T-tests conducted on all functions showed that, as predicted, musicians' ratings were significantly higher than non-musicians' in both Experiments ($p < .0001$ in both cases).

(a)



(b)

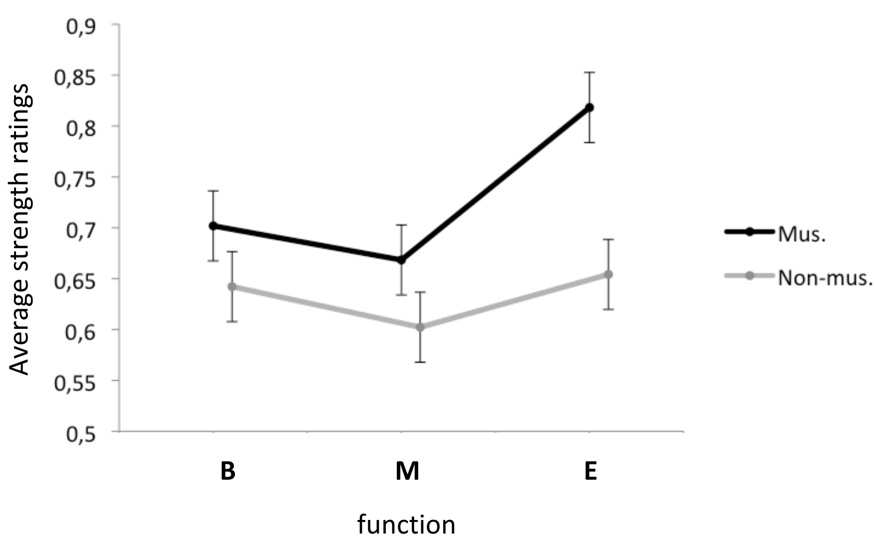


Figure 5.6. Average ratings and confidence intervals for musicians' (Mus.) and non-musicians' (Non-mus.) ratings of beginnings (B), middles (M), and ends (E) in Experiments 2 (a) and 3 (b).

JUDGMENTS FREQUENCY DISTRIBUTIONS

Another way to assess clarity of functional expression is through the level of consensus among participants of the same expertise group. If we assume that a clearer functional expression leads to a higher level of consensus, we should expect a majority of participants of the same group to detect excerpts that clearly convey a given formal function and reject those that do not convey it. For instance, if functions *x*, *y*, and *z* were all clearly expressed—let us consider this hypothetical situation as the best-case scenario—one would likely obtain form-functional judgment distributions similar to those shown in Table 5.4a (based on fictitious data with 20 "participants"). Those distributions would indeed have several entries equal or close to the maximum number (20) of functional judgments for the clearly expressed function and twice as many entries equal or close to the minimum number (zero) of judgments for the other two categories. By contrast, if those functions were poorly projected—the worst-case scenario—judgment distributions would most likely resemble those of Table 5.4b. The entries constituting those distributions would be equal or close to chance levels, that is, revolving around six and seven (20 ÷ 3 = 6.7). Frequency distributions and their proportional representation of data of Tables 5.4a and 5.4b are shown in Tables 5.5a and 5.5b, respectively.[7]

---

[7] For those frequency distributions, each entry in Table 5.4 is tallied and classified in the appropriate category. Then, the proportional representation shows what percentage of all entries a particular category represents (this column sums to 100%).

Table 5.4. Fictitious judgment distributions (for 20 "participants") for clearly expressed (a) and ambiguously expressed (b) functions X, Y, and Z.

(a)

X	Y	Z
0	0	20
19	1	0
1	18	1
0	19	1
20	0	0
3	0	17
0	2	18

(b)

X	Y	Z
7	7	6
8	4	8
5	7	8
6	8	6
7	6	7
6	5	9
8	6	6

Table 5.5. Frequency distributions and their proportional representation based on the data of Table 5.4 for (a) clearly expressed ("best-case scenario") and (b) ambiguously expressed ("worst-case scenario") functions.

(a)

Judgment categories	Frequency	Proportional representation (%)
18–20	6	28.6
15–17	1	4.8
12–14	0	0
9–11	0	0
6–8	0	0
3–5	1	4.8
0–2	13	61.9

(b)

Judgment categories	Frequency	Proportional representation (%)
18–20	0	0
15–17	0	0
12–14	0	0
9–11	1	4.8
6–8	17	81.0
3–5	3	14.3
0–2	0	0

To be sure, we can expect some functions (say, X, Y, or Z) to be more clearly expressed than others. In such cases, the frequency distributions of the clearer functions would be closer to that of Table 5.5a while those of the ambiguously expressed functions will resemble that of Table 5.5b to a greater extent. With that in mind, let us turn our data from Experiments 2 and 3. Tables 5.6, 5.7, and 5.8 present musicians' and non-musicians' frequency distributions and proportional representations of beginning, middle, and end judgments. To facilitate the comparison between those frequency distributions, Figure 5.7 illustrates the content of Tables 5.5, 5.6, 5.7, and 5.8 in diagrams. As can be seen on the figure, the frequency distribution of the end function (Table 5.8) is the one that most resembles the best-case scenario presented in Table 5.5a. Roughly speaking, the other distributions (Tables 5.6 (beginnings) and 5.7 (middles)) are somewhere in-between the best- and worst-case scenarios presented above.

Table 5.6. Frequency distributions and their proportional representation for beginning judgments in Experiments 2 (a) and 3 (b).

(a)

	Musicians		**Non-musicians**	
Judgment categories	**Freq.**	**Prop. rep. (%)**	**Freq.**	**Prop. rep. (%)**
18–20	7	4.7	6	4.1
15–17	23	15.5	5	3.4
12–14	19	12.8	19	12.8
9–11	22	14.9	18	12.2
6–8	22	14.9	32	21.6
3–5	18	12.2	27	18.2
0–2	37	25.0	41	27.7

(b)

	Musicians		**Non-musicians**	
Judgment categories	**Freq.**	**Prop. rep. (%)**	**Freq.**	**Prop. rep. (%)**
18–20	4	2.7	0	0
15–17	13	8.8	14	9.5
12–14	24	16.2	11	7.4
9–11	25	16.9	20	13.5
6–8	13	8.8	26	17.6
3–5	19	12.8	26	17.6
0–2	50	33.8	51	34.5

Table 5.7. Frequency distributions and their proportional representation for middle judgments in Experiments 2 (a) and 3 (b).

(a)

	Musicians		**Non-musicians**	
Judgment categories	**Freq.**	**Prop. rep. (%)**	**Freq.**	**Prop. rep. (%)**
18–20	7	4.7	4	2.7
15–17	18	12.2	16	10.8
12–14	17	11.5	24	16.2
9–11	22	14.9	30	20.3
6–8	27	18.2	25	16.9
3–5	25	16.9	23	15.5
0–2	32	21.6	26	17.6

(b)

	Musicians		**Non-musicians**	
Judgment categories	**Freq.**	**Prop. rep. (%)**	**Freq.**	**Prop. rep. (%)**
18–20	7	4.7	4	2.7
15–17	15	10.1	15	10.1
12–14	15	10.1	26	17.6
9–11	23	15.5	32	21.6
6–8	25	16.9	30	20.3
3–5	27	18.2	33	22.3
0–2	36	24.3	8	5.4

Table 5.8. Frequency distributions and their proportional representation for end judgments in Experiments 2 (a) and 3 (b).

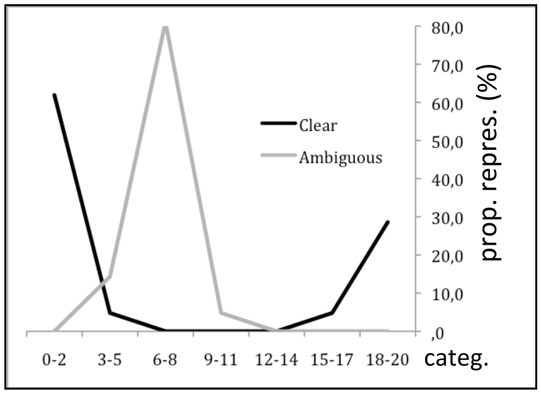
(a)

	Musicians		Non-musicians	
Judgment categories	**Freq.**	**Prop. rep. (%)**	**Freq.**	**Prop. rep. (%)**
18–20	16	10.8	12	8.1
15–17	4	2.7	6	4.1
12–14	2	1.4	5	3.4
9–11	3	2.0	8	5.4
6–8	6	4.1	16	10.8
3–5	11	7.4	25	16.8
0–2	106	71.6	76	51.4

(b)

	Musicians		Non-musicians	
Judgment categories	**Freq.**	**Prop. rep. (%)**	**Freq.**	**Prop. rep. (%)**
18–20	27	18.2	3	2.0
15–17	8	5.4	12	8.1
12–14	2	1.4	8	5.4
9–11	2	1.4	16	10.8
6–8	7	4.7	11	7.4
3–5	13	8.8	32	21.6
0–2	89	60.1	66	44.6

Hypothetical scenarios for clearly and ambiguously expressed functions



Experiment 2 **Experiment 3**

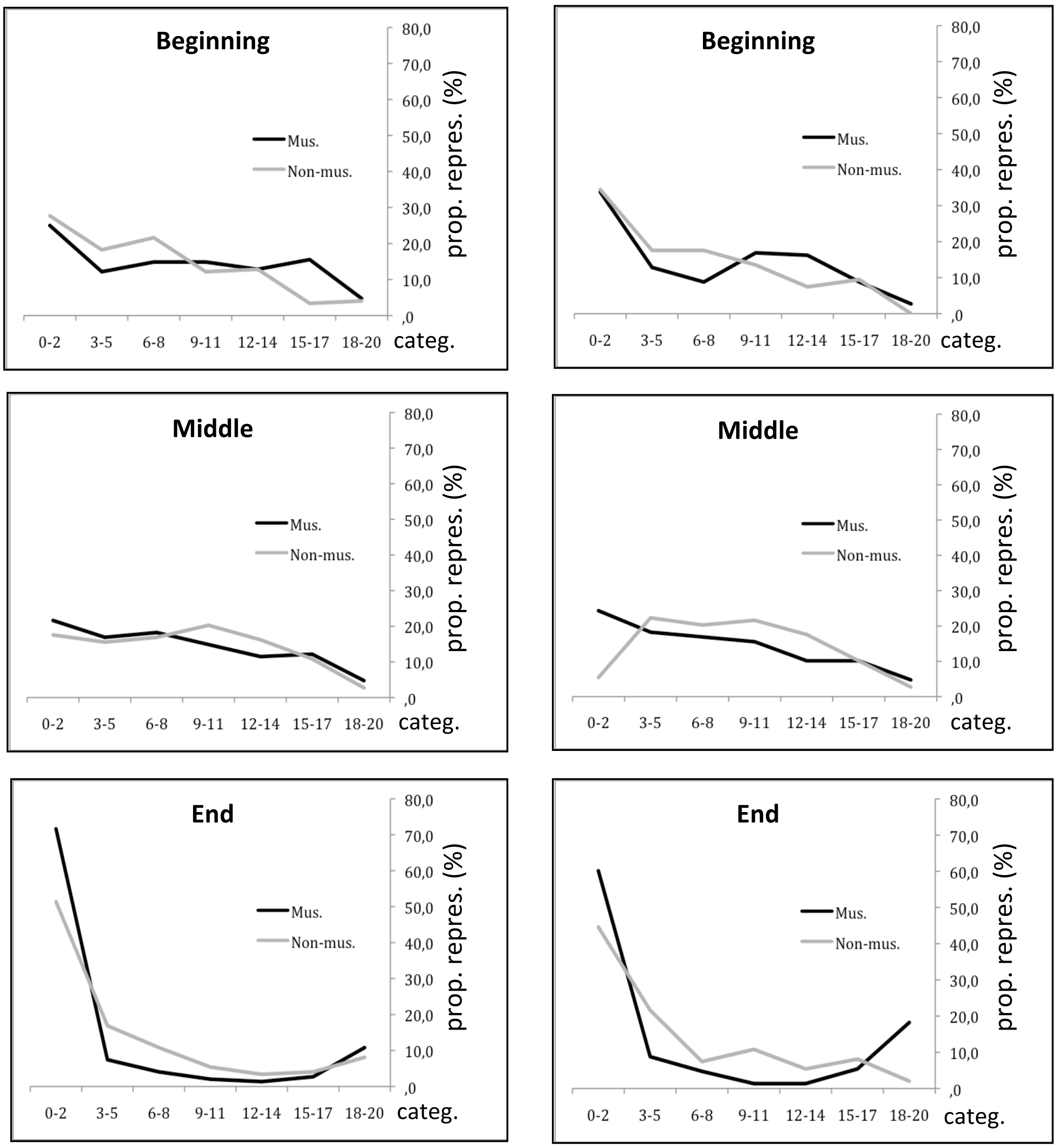


Figure 5.7 (previous page). Proportional representation of hypothetical scenarios as well as beginning, middle, and end judgments for musicians and non-musicians in Experiments 2 and 3.

We used contingency tables to test the effect of experiment, musicianship, and function on the frequency distributions presented above. The following remarks summarize our calculations and our most salient findings. First, to compute the effect of experiment, two series—one per expertise group—of three contingency tables—one per function—compared frequency distributions of Experiments 2 and 3. We found a relatively weak effect of experiment only for non-musicians with respect to two types of frequency distributions, namely for (1) beginning judgments, $\chi^2(6) = 14.2$, $p < .05$; and (2) end judgments, $\chi^2(6) = 13.2$, $p < .05$. Otherwise, frequency distributions were highly consistent between experiments. Second, to compute the effect of musicianship, two series—one per experiment—of three contingency tables—one per function—compared musicians' and non-musicians' frequency distributions. There was an effect of musicianship in all conditions ($14.9 < \chi^2(6) < 46.8$, $.001 < p < .05$) except for the frequency distributions of middles in Experiment 2, $\chi^2(6) = 4.1$, $p > .1$. Otherwise, all of musicians' frequency distributions were significantly closer to the best-case scenario presented above (Figure 5.6a) than non-musicians' distributions. Third, to compute the effect of function, two groups—one per expertise group—of two series—one per experiment—of three contingency tables compared pairs of frequency distributions (3 pairs possible: BM, BE, ME). They showed an effect of function in all conditions ($12.7 < \chi^2(6) < 97.2$, $.001 < p < .05$), except for musicians' beginnings and middles in both experiments, $\chi^2(6) = 2.7$, $p > .1$, and

$\chi^2(6) = 10.6$, $p > .1$, respectively. Otherwise, (1) ends' frequency distributions were significantly closer to the best-case scenario than beginnings' and middles' distributions;[8] and (2) for non-musicians, beginnings' frequency distributions were closer to the best-case scenario than middles' distributions. We also compared—with the same statistical tools—our data to distribution templates generated by chance to test the extent to which distributions were analogous to the worst-case scenario. All distributions were, however, significantly different from those templates.[9]

Overall, if we accept the aforementioned assumption that links form-functional clarity and the levels of agreement in participants' functional judgments, those analyses suggest that (1) ends are projected in a clearer way than beginnings and middles for both expertise groups; (2) form-functional expression of beginnings and middles is equivalent for musicians while the former tend to be clearer than the latter for non-musicians; and (3) functional perception is generally clearer for musicians than non-musicians.

SUMMARY

The aim of this Chapter was to address issues concerning (1) the level of spontaneity underlying the perception of beginnings, middles, and ends; (2) the strength (or clarity) of expression of those functions; and (3) the localization of

---

[8] That there were a greater number of modifications involving the beginning and middle functions than the end function may partly contribute to explain these results.

[9] Those analyses generated, by far, the strongest statistical differences among all of our analyses with contingency tables.

musical information for functional judgments. Regarding the latter issue, we showed that excerpts' closing points contained highly important musical information for perceiving an end function, and that non-musicians relied on that information to a greater extent than musicians to elicit end judgments. Our results further suggest that musicians have a greater capacity than non-musicians to anticipate the forthcoming arrival of end-related properties, which may—at least partly—explain musicians' lesser dependence upon information located at excerpts' closing point to judge excerpts as ends. The results of the speeded-judgment task of Experiment 2 showed that middle and beginning judgments tend to be based on equal quantities of musical information, which suggests that the information that helps distinguish those functions is located over similar time spans.

Concerning the level of perceptual spontaneity (from the speeded-judgment task of Experiment 3), we saw that response times were similar for all functions within both groups and that musicians' slight tendency to elicit end judgments faster than beginning and middle judgments was not statistically significant. There is no evidence, therefore, to reject the null hypothesis regarding the effect of function on reaction times.

As regards form-functional strength (based on analyses of the rating tasks of Experiments 2 and 3 and those on judgments frequency distributions), our results can be summarized as follows:

1. Musicians tend to give higher ratings of strength of functional expression to ends while those for beginnings and middles tend to be relatively

similar. Non-musicians' ratings are clustered together to a much greater extent;

2. For musicians, the results of analyses on functional judgments frequency distributions resemble strongly those of ratings. For non-musicians, analyses on frequency distributions showed that the clarity of functional expression is maximal for ends and minimal for middles, with beginnings in-between. That the results of frequency-distribution analyses are much more salient than those of rating analyses reveals that, for non-musicians, a conflict exists between indirect (unconscious) measurements based on the behavioral data of groups of individuals (frequency distributions) and direct (conscious) measurements provided by individuals (strength ratings).

Those results are obviously not sufficient to make strong conclusions about the hypothesized sequential decision process. While some results—especially as regards clarity or strength of functional expression—seem to support such an interpretation, others don't—notably those of response times. No results, however, constitute clear, statistically significant counter-evidence to such a process and further investigation would be necessary to provide a clearer diagnostic as far as this issue is concerned.

Overall, our results tend to confirm what was intuitively expected prior to our series of experiments, that is, musical materials can convey the end function in a clearer way than beginning and middle functions. What our results have further demonstrated, however, is musicians' greater awareness than non-musicians' of that gap in form-functional expression.

We have now reached the end of our threefold results section, and we will turn to Chapter 6, in which the results exposed in Chapters 3, 4, and 5 will be discussed in further detail.

Chapter 6. Perceptual and music-theoretical implications of experimental results

The aim of this chapter is to discuss the results presented in Chapters 3, 4, and 5. We first describe the three functional categories of beginning, middle, and end with respect to prototype theory. We also pay particular attention to the temporal localization of properties that define those functions and, by means of analyses of selected excerpts, to the possible ways those properties can combine to create more or less perceptually salient form-functional effects. We then take a step further and propose a speculative interpretation on how the intrinsic properties of musical materials interact with contextual information in larger musical contexts, and how this interaction may affect the perception of certain aspects of musical form, especially as regards structural boundaries. We finally address a few questions relative to our methodology.

FORM-FUNCTIONAL PROTOTYPES

As demonstrated in the previous chapters, form-functional expression relies on combinations of multiple musical properties. In fact, none of the three functional categories explored in the current study were exclusively defined through a collection of necessary *and* sufficient criteria. Rather, our results suggest that participants conceive of these categories along the lines of prototype theory, according to which some configurations of properties generate membership profiles that better represent a category than other configurations

(Barsalou, 1992; Zbikowski, 2002). Indeed, as we observed in the previous chapters, musicians or non-musicians perceive some excerpts as better representatives of the beginning, middle, or end category than others.

In order to make a form-functional judgment, participants focus—intuitively or not—on specific properties that characterize the musical excerpt they are presented with. The judgment is thus an assessment of the excerpt's typicality with respect to a participant's mental representation of a given category, itself defined by a set of properties. The properties that best characterize a member of a category are those that are shared with the greatest number of members of that category and those that maximize the differentiation with members of other categories (Markman & Wisniewski, 1997; Rosch, 1978). Before elaborating on how functional categorization can be influenced by different combinations of the properties described in Chapters 2, 3, and 4, we will discuss an important feature of musical information: its localization.

Form-functional information localization

As explained in Chapter 3 (pp. 61–62), we call *specificities* those properties that are localized at specific *time-points* and distinguish them from those that are projected over larger *time-spans*, termed *parameters*.[1] Figure 6.1 illustrates the link between two possible evaluation processes and those two types of properties. First, in order to judge if an excerpt functions as the beginning,

[1] For our purposes, it is not necessary to use a strict, quantifiable definition of time-point and time-span. This binary opposition is rather used qualitatively to distinguish information that is rather temporally restricted (time-point) from information that is temporally distributed (time-span).

middle, or end of a given structural unit (for our purposes, a theme), participants must have—or potentially create—a mental representation of some of the functional attributes that characterize this unit. As shown in Figure 6.1a, one of the possible strategies that participants may use—likely in an intuitive way—consists in comparing the opening and closing time-points of an excerpt with those of the mental representation of the structural unit. Then, as illustrated below the figure, a simple combination of positive (Y) and negative (N) matches may enable participants to make a judgment: Y/N yields beginning; N/Y, end; and N/N, middle. The Y/Y combination, however, does not correspond to a single intra-thematic function and therefore forces the participant to either (1) determine which one of those matches should override the other (we will propose a solution to that conflict below); or (2) use other information to make a proper judgment. Another way to assess formal functionality would consist in evaluating the information contained throughout excerpts and associating this information to a particular time-span in the abstract representation of the entire musical unit, as illustrated in Figure 6.1b. The obvious advantage of the time-point evaluation strategy is its economy of mental of resources, as it allows listeners to make a judgment by drawing their attention to very limited amounts of musical information. Our results, however, suggest that both strategies are used, depending on the available musical information and expertise.

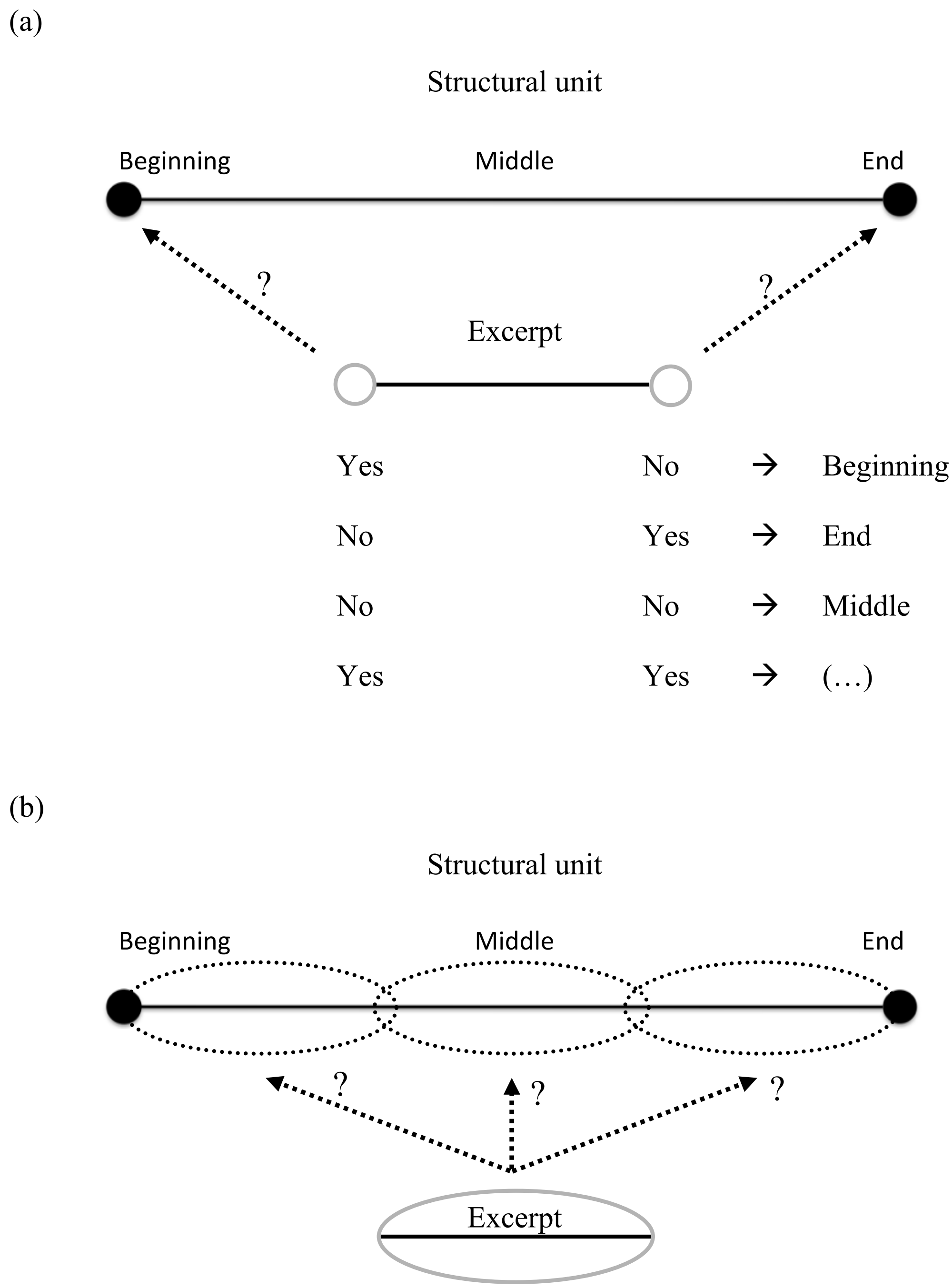


Figure 6.1. Schematic representation of the form-functional evaluation process based on evaluation of opening/closing time-points (a) and larger time-spans (b).

The results presented in the previous chapters show that the strongest contribution to participants' functional judgments came from musical information located at the excerpts' opening and closing time-points. At the closing point, participants of both groups relied heavily on their perceiving tonic harmony (including the first scale degree) to evaluate the end function. At the opening point, musicians counted on the same property, while non-musicians used the unaccompanied melodic opening to distinguish beginnings from middles. Although all of these properties acted as necessary conditions to entail consensual functional evaluations, these specificities alone could not account for all functional judgments. With respect to the end function, our analyses suggest that information adjacent to the final tonic harmony—the cadential dominant—was also highly influential. And for non-musicians, we can add the property of rhythmic density decrease, a process that may start slightly earlier than the cadential dominant. All in all—and this is supported by the discussion on changed and unchanged responses in Chapter 5—most of the information used for end judgments was circumscribed towards the end of excerpts, which corresponds to a greater extent to the "time-point" model presented in Figure 6.1a than the "time-span" model of Figure 6.1b.

As regards beginnings and middles, critical information tends to be much less clustered. Whereas the unaccompanied melodic opening cue is located at an excerpt's opening time-point, several rhythmic features—especially the melody's level of rhythmic uniformity but also, to a lesser extent, onset density—are necessarily appraised over larger time-spans by participants of both groups. And, as already discussed in Chapter 5, the results of the speeded-judgment task in

Experiment 2 showed us that the information used for beginning and middle judgments was located over time spans of similar magnitude (Table 5.3). Those observations strongly suggest that both "time-point" and "time-span" evaluation strategies play a role in beginning and middle judgments.

Although it is still speculative at this stage, our data suggest that there might be several different ways in which participants made middle judgments. First, the "positive" way, for excerpts presenting several strong middle properties, for instance, a high onset density and a low rhythmic variety; second, the "negative" way, which might result from a number of different factors:

(a) the excerpt may project no clear sense of beginning and end. The middle judgment would therefore constitute a 'fall-back' option that follows this fully negative evaluation of beginning and end properties;

(b) the excerpt may project a partial sense of end but may not comply with one of the functions' necessary conditions. Such excerpts would therefore be represented as "failed ends." Several of musicians' EM response sequences discussed in Chapter 5 likely correspond to such a situation. Among the excerpts that yielded this sequence, many were characterized with a disrupted harmonic or melodic motion prior to the completion of a perfect authentic cadence. Also, musicians' and non-musicians' middle evaluations for excerpts ending with a deceptive cadence would fall into that category;

(c) the excerpt may contain conflicting form-functional cues, that is, perceptually strong "evidence" for more than one function. In such cases, a middle judgment would rather represent a state of indecision—for instance, the participant cannot tell whether an excerpt is a beginning or an end, both options being highly probable—than a fall-back option, as in (a).

With respect to these positive and negative options, our results suggest that there might be an important difference between musicians' and non-musicians' middle judgments. Let us recall that, as discussed in Chapter 3 and in the General summary of Chapter 4, participants of each group used a specific information type located at an excerpts' opening time-point in order to differentiate beginnings and middles. For musicians, all consensual beginnings opened with tonic harmony; this property was therefore a necessary condition for unequivocal perception of that function. For non-musicians, virtually all consensual middles did *not* open with an unaccompanied melodic opening; this was therefore a quasi-necessary condition for a clear perception of a middle function at the group level. (The very few excerpts that infringed that latter rule are characterized by a special configuration of properties that will be discussed further below.) In other words, it is as though the information found at the opening time-points was used as a powerful filter both for beginning judgments by musicians and for middle judgments by non-musicians. However, contrary to musicians, non-musicians' filter was based upon the *absence* of a property—the unaccompanied melodic opening; therefore the absence of a property was a stronger classification criterion than its presence. This observation suggests that non-musicians may use the "negative" evaluation strategy to a greater extent than musicians for middle judgments—especially as regards scenarios (a), (c), and (d) presented above. If so, this could provide an explanation for non-musicians' higher rate of middle judgments than beginning and end judgments in all of our experiments, and for the results of our analyses on frequency distributions that showed that middles have a weaker strength of expression for non-musicians than musicians (see Chapter 5).

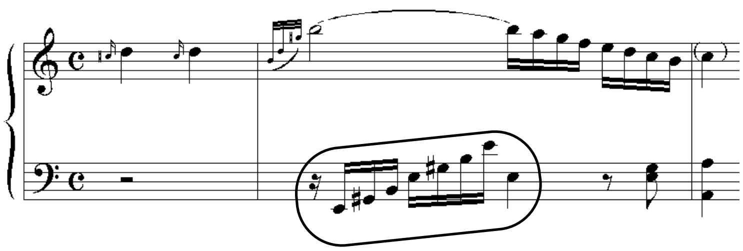
Musical properties

Tonality and harmony

As evidenced by listeners' reaction to tonal and harmonic changes, many functional judgments are based on participants' tonal intuitions or knowledge. The establishment of a tonal center—a phenomenon that music psychologists call "tonal induction" or "key-finding"—constitutes a preliminary step to the attribution of the functional role that harmonies play within a musical passage (e.g., tonic harmony, dominant harmony, etc.). Even though most of our excerpts' tonal center was clearly defined from a music-theoretical point of view, one might rightfully wonder whether that was the case from a perceptual perspective. Studies on tonality induction show that very little information is required for listeners to establish a given tonal center, especially (1) the presence of both scale-degrees 4 and 7 (Brown, Butler, & Jones, 1994; Butler, 1989; Krumhansl, 1990b); and (2) an emphasis on the scale degrees belonging to the tonic harmony (Krumhansl & Kessler, 1982; Krumhansl, 1990a). In that regard, 89.2% of all excerpts in Experiments 2 and 3 contained both scale degrees 4 and 7, and the overwhelming majority of the remainder markedly emphasized the notes of the tonic triad. Overall, only 5 of the 296 excerpts used in Experiments 2 and 3 could be considered as tonally ambiguous (mostly from a perceptual perspective) by failing to fulfill those two conditions. Obviously, we did not verify if the tonal center perceived by our participants corresponded to what a musical analysis would identify. However the strong and consistent effect of specific modifications with tonal implications on participants' judgment distributions demonstrate that they successfully did so in the majority of cases.

The most striking finding of this study concerns the form-functional role of tonic harmony at the excerpts' opening and closing time-points. As a reminder, tonic harmony was crucial in projecting the end function for both groups. Contrary to musicians, however, it had little or no bearing on non-musicians' perception of beginning and middle functions (see Figures 3.7, 4.15, and 4.17). Figure 6.2 represents quite clearly the marked difference between musicians' and non-musicians' form-functional interpretation of the opening harmony (excerpts B13 and B13-1 in Appendix C). Figures 6.2a and 6.2b are one modification apart: whereas the former (the opening measures of the subordinate theme of the first movement of Mozart's Piano Sonata in C major, K. 279) opens with a dominant of the second degree, the latter opens with the local tonic harmony of G major (the key of the subordinate theme). On the one hand, musicians' response to that modification is particularly strong, as their response profile shifts directly from a consensual middle to a consensual beginning.[2] On the other hand, non-musicians' judgment distributions are largely the same for each excerpt.[3]

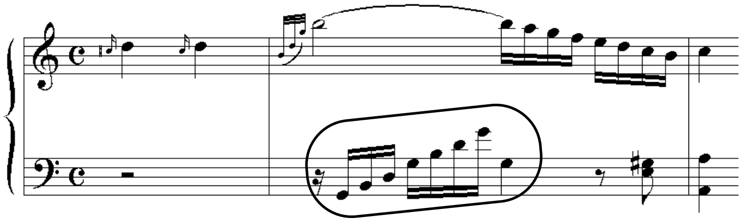
(a) Mozart, Piano Sonata in C major, K. 279, i, 17−18



	B	M	E
mu	2	17	1
nm	14	6	0

GM: [V] ii

(b) Modification of (a)



	B	M	E
mu	16	4	0
nm	15	5	0

GM: I [V] ii

Figure 6.2. Original (a) and modified (b) excerpts from Experiment 3 and functional judgment distributions of the two participant groups.

Prior to conducting our experiments, we did not expect such a strong interaction of property localization (closing vs. opening time-points) and expertise

---

[3] Note that although the impact on non-musicians' judgments was not significant, this operation provided Figure 6.1b with the extra beginning judgment that Figure 6.2a was missing to reach the threshold of functional consensus.

(musicians vs. non-musicians) on the perception of formal functions. Indeed, the music-psychological literature did not offer much to anticipate such a form-functionally differentiated use of harmony between expertise groups. Although it is impossible to provide a full explanation for that difference between expertise groups, we can nevertheless identify several elements that may account for such a difference, all of which deserve further investigation.

Perception of tonality (tonal center). A possible explanation for this difference between groups in the use of the opening tonic harmony may be that, at the excerpts' opening time-point, non-musicians did not accumulate enough tonal information to properly determine the tonal center. We must recall, however, that the results discussed here are those of the *second* form-functional judgment and that, prior to this judgment, participants had already heard the excerpt, either partially (Experiment 2, IFH condition; see Chapter 5) or completely (Experiment 2, CFH condition, and all first hearings in Experiment 3), in order to make a first functional judgment. It is likely, therefore, that enough musical information had already been available to non-musicians for intuiting an excerpt's tonal center.

Memory. Another explanation for this difference might be that non-musicians, granted that they were able to determine the appropriate tonal center, could not retain the impression of "tension" or "stability" entailed by non-tonic or tonic opening harmonies as vividly as musicians by the time the excerpt was finished.[4] But since excerpts lasted about 3.5 seconds on average and were at most 5

[4] For more information about the link between tension and harmony, see Bigand (1993, 1997), Bigand & Parncutt (1999), and Bigand, Parncutt, & Lerdahl, (1996).

seconds long, it seems improbable that the time-point corresponding to the opening harmonic event had already exceeded the temporal capacities of participants' short-term memory by the time they provided a functional judgment. Indeed, studies show that the limit of the psychological time window within which musical events are salient—what Paul Fraisse has called the *perceptual* or *psychological present*—is somewhere between 3 and 10 seconds (Bigand, 1993; Clarke, 1987; Fraisse, 1974; Snyder, 2000). Moreover, it is probable that the first hearing of the excerpt had both clarified its tonal context and reinforced the memory trace of that opening event, which makes the memory-insufficiency explanation even less probable.

Form-functional representation. It is likely that non-musicians' intuitive representation of the beginning function does not comprise a component such as "opening with tonal stability." Unlike the case for end function, which requires a tonally stable closing point, non-musicians may conceive of the onset of a phrases' tonal trajectory as a motion process that does not need to depart from a stable time-point. We consider this third explanation as the most probable, but further empirical investigation would be required to support it. As regards musicians, it is unclear whether their form-functional representation of the beginning function would have been acquired through training—harmony being a fundamental topic in music theory courses—or through greater exposure to the repertoire from the Classical period, both possibilities being of course non-mutually exclusive.

Unaccompanied melodic opening: texture and meter

As noted earlier, even though both participant groups used the unaccompanied melodic opening at the excerpts' opening time-points to distinguish between beginnings and middles, non-musicians' reliance on this property largely surpassed that of musicians. As far as the nature of that specificity is concerned, it is hard to quantify the respective form-functional contributions of textural contrast on the one hand and metric interpretation (i.e., upbeat-to-downbeat motion) on the other hand. Nevertheless, it seems that both components help provide a strong sense of syntax: the same way that an upbeat-to-downbeat motion constitutes a hierarchical move from a subordinate (weaker) to a primary (stronger) metric category, the motion from a partial texture (single voice) to complete texture (melody plus accompaniment) may be conceived as a hierarchical move from a subordinate (incomplete) to a primary (the "default" or standard texture setting in that style) texture category.[5] As such, both metric and texture components seem to represent a syntactical impulse from a "pre-beginning" to a "real beginning" and it is therefore not surprising that participants strongly associated the unaccompanied melodic opening with the beginning function.

Rhythmic parameters

The rhythmic properties that we addressed in our experiments were essentially parameters, that is, quantifiable properties active over time-spans

---

[5] It should be noted that theorists do not traditionally conceive of texture as being syntactic.

rather than time-points.[6] One of the most striking results as regards rhythm concerns the functional effects of complete rhythmic uniformity (in other words, a coefficient of rhythmic variety, CRV, of zero; see Chapter 3 pp. 87–91). We initially expected participants' responses—especially non-musicians'—to be influenced by higher or lesser levels of rhythmic variety, which we believed was linked with a sense of "singability" that characterizes beginnings to a greater extent than middles.[7] However we did not expect the dichotomy between complete and incomplete levels of rhythmic *uniformity* (the logical opposite of variety) to create such clear response profiles between consensual beginnings (of which *none* had a completely uniform melody) and consensual middles (see Figure 3.9). We were especially astonished to see the strength of the impact of that property on musicians' functional judgments. Let us illustrate that effect on musicians with an example of an alteration that affected the melody's rhythmic uniformity.

As Figure 6.3 shows, these two excerpts are one modification apart (the changes are indicated with a circle; see excerpts B10-6 and B10-10 in Appendix C). This parametric alteration turned a melody that had a high level of rhythmic uniformity (Figure 6.3a) to one with a complete rhythmic uniformity (Figure

---

[6] Note that our analyses on rhythm could have also involved localization characteristics, such as a "high onset density opening" or a "high opening coefficient of rhythmic variety". Such elements were not included for sake of simplicity.

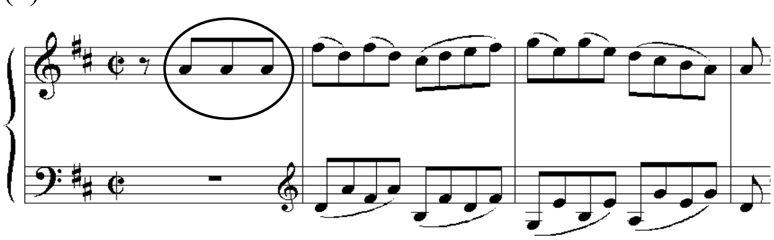
[7] "Singability" is actually a term that was used by several musician and non-musician [check] participants in the verbalization task of Experiment 1. We obviously do not intend to reduce this term to its rhythmic component, but we took the liberty to suppose that rhythmic variety would—at least partly—contribute to a melody's "singability".

6.3b). Although the difference between these excerpts is fairly minor in terms of information content, musicians' judgment distributions illustrate the extent to which that modification altered their perception of the beginning function: whereas Figure 6.3a constitutes a consensual beginning (it gathered 16 beginning judgments), the formal function projected by Figure 6.3b is highly ambiguous, as the judgments are divided equally between the beginning and middle function. As the results shown in Chapter 3 and this example suggest, rhythmic uniformity may have a relatively strong impact—at least on musicians—when considered from a dichotomous "all or nothing" perspective rather than from a gradual, linear perspective.[8]

(a)

	B	M	E
mu	16	4	0
nm	9	8	3

(b)



	B	M	E
mu	10	10	0
nm	11	7	2

Figure 6.3. Two modifications of the opening measures of the third movement of Mozart's Piano Sonata in D major, K. 284 with participants' functional judgment distributions.

[8] Obviously, the fact that this rhythmic alteration affected the unaccompanied anacrusis—as opposed to a potentially less important time-point in the excerpt—may also contribute to explain musicians' responses.

Melodic contour

The property of melodic contour was barely addressed in this study. Three main reasons account for why we did not thoroughly investigate contour differentiation. First, while analyzing the data of our first experiment, it became clear that the opening and closing melodic scale degrees had a fairly tangible impact on perceived formal function, a consideration that would impose severe restrictions as regards the possibilities of realizing modifications involving contour. Indeed, if the opening and closing scale degrees have to be preserved, it may be very challenging, for instance, to change a globally descending contour to an ascending one unless transposing one of those two scale degrees an octave above or below. Second, a problematic aspect of this property is that it operates simultaneously at many different structural levels. For instance, descriptors such as "opening melodic contour" can be musically realized in multiple ways, from the simplest ones (ascending arpeggiation, or ascending stepwise motion) to more complex ones (a pattern of broken thirds that ascends by stepwise motion, a pattern of stepwise descending thirds that globally ascends, a melody that globally ascends but locally revolves around pivot notes, or even one that globally ascends but locally descends in stepwise motion, etc).[9] It seems therefore very difficult to predict a uniform perceptual impact from such a large set of possible musical realizations and, similarly, to realize musical modifications that would be comparable at all structural levels. Third, another difficulty concerns the

[9] Note that, for in such an investigation, Marvin and Laprade's (1987) theory of contour would prove useful to quantify variations in melodic contour.

localization of the functionally relevant information. For instance, is the functional efficiency of an "ascending melodic contour" maximal when the contour ascends during the complete duration of the excerpt (ca. two measures), during the excerpt's opening or closing measure, or during its opening or closing beat? A proper investigation of contour would have required a pool of experimental stimuli that could allow us to control all of the above variables and, as such, an entire experiment should have been dedicated to this investigation. As this would have been realized at the expense of several other properties, we decided to investigate only a few general aspects of melodic contour (for instance, turning a "globally static" contour into a "globally ascending" one in excerpts where we expected the final scale degree to have limited influence on the perceived formal function). As briefly mentioned in Chapter 4, those modifications did not give consistent results.

Specificities, parameters, and combinations

As observed in Chapter 4, comparative analyses generally gave results that were much weaker and inconsistent with parameters, such as rhythmic activity, grouping structure and tonic proportion, than with specificities, such as opening/closing harmonies or the unaccompanied melodic opening. One explanation for this observation is that, contrary to the impact of musical specificities, which can be easily tested by adding or removing them, the impact of musical parameters depends on *how much* a given property has changed. To use Leonard Meyer's terminology (Meyer, 1998), the parameters such as the ones mentioned earlier are *statistical:* they are organized along a continuum and conceived in terms of amount. On the contrary, the specificities discussed above are *syntactic* in that they involve functionally related categories. One can therefore hypothesize that a given parametric modification has an impact only above a certain threshold on that continuum, and it is possible that our alterations did not necessarily reach that threshold.

Another explanation for the inconsistency of the effect of parametric modifications is that the perceptual strength of such modifications may depend on the "musical environment", that is, the specific *combinations* of properties that characterize an excerpt within which the parametric alteration takes places. For instance, an increase in rhythmic activity (a property associated with the middle function) may have a stronger perceptual effect if the original excerpt has a high onset density and a melody that closes on the fifth scale degree (properties more typical of middles) than if it has a low onset density and a melody that closes on the first scale degree (properties atypical of middles).

Of course, those two explanations—the "intensity" with which parameters are expressed and the musical environment in which a parametric change takes place—are not mutually exclusive: they may both account for the form-functional impact (or lack thereof) of modifications. Let us illustrate these proposals with some specific cases.

(a)

DM: V I

	B	M	E
mu	1	17	2
nm	0	16	4

(b)

DM: I IV

	B	M	E
mu	1	19	0
nm	4	16	0

Figure 6.4. Two modifications of measures 5−7 of the third movement of Mozart's Piano Sonata in D major, K. 311, with participant groups' functional judgment distributions.

Figure 6.4 shows a pair of excerpts derived from measures 5−7 of the third movement of Mozart's Piano Sonata in D major, K. 311 (see excerpts M7-3 and M7-4 in Appendix B). The principal difference between those excerpts resides in the harmonic setting: the harmony of Figure 6.4b is essentially a fourth higher than that of Figure 6.4a, which turns a dominant-tonic progression into a tonic-subdominant one.[10] Given the hypothesized strength of the opening harmony on musicians' responses, we originally thought that musicians' beginning judgments

---

[10] Note, however, that the bass patterns are slightly different: when writing Figure 6.4a, we made sure that the dominant 7th (G) was present in the accompaniment to clarify the diatonic context, which had a minor side effect on the contour of the accompanimental pattern. Also, for sake of voice-leading coherence, we changed the last melodic interval in Figure 6.4a.

for the excerpt opening with tonic harmony—Figure 6.4b—would have substantially outnumbered those for the excerpt opening with dominant, off-tonic harmony—Figure 6.4a.[11] Ironically, this is precisely what happened for non-musicians, while musicians' beginning judgments remained the same despite this harmonic modification.

How can we make sense of such results? Two factors may explain the lack of effect of the opening tonic on musicians. First, both excerpts' intrinsic properties strongly contribute to projecting a middle function: the melodic and the accompanimental rhythmic settings are completely uniform (CRV value of zero); the melodic onset density is very high—it actually ranks among the top 8% in our pool of stimuli; and the second measure constitutes an exact repetition of the first one, which provides a strong sense of internal sub-grouping. It seems, therefore, that the combination of parameters with "extreme" values overrides the effect of a specificity—the opening tonic harmony—that is otherwise very influential as regards musicians' beginning and middle judgments.

Second, we must recall that an opening tonic is a specificity that constitutes a *necessary* but *not* a *sufficient* condition to entail consensual beginning evaluations among musicians. It logically follows that, unlike a sufficient or quasi-sufficient condition (such as the presence of a PAC, for musicians only), this property does *not necessarily* generate consensual beginning

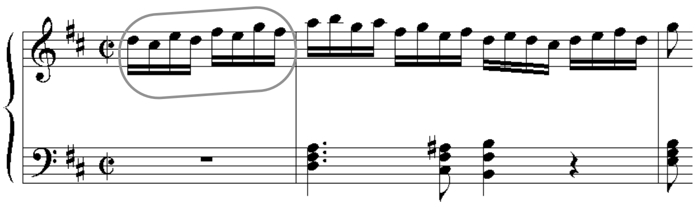
[11] As can be seen, tonic harmony is not solely located at the excerpts' opening time-points. One must recall, however, that the "opening tonic" property was defined according to the harmony located at that time-point *regardless* of the materials that followed it. In several excerpts, indeed, the opening tonic is only on the first beat.

evaluations despite its latent capacity to influence these judgments. This example illustrates the extent to which the effect of a property modification is contingent upon the "musical environment" in which it takes places.[12] As a consequence, for instance, we could predict that removing the opening tonic of an excerpt that contains other beginning properties would entail a severe decrease in musicians' beginning judgments. However, as the above examples demonstrate, we could not make the same prediction if a similar modification were made to an excerpt with several middle properties. This observation is critical: it restricts the extent to which we can predict the form-functional efficiency of a given property, since this property's functional impact can be strongly tempered by other properties.

Figure 6.5 further illustrates the combined influence of rhythmic uniformity and onset density, but this time, on non-musicians' functional judgments. The example shows a pair of excerpts, both being modifications of the first two measures of Variation III of the third movement of Mozart's Piano Sonata in D major, K. 284 (see excerpts B17 and B17-1 in Appendix C). The onset density of the unaccompanied melodic opening of Figure 6.5b is half that of Figure 6.5a (those features are indicated with circles). As a result, the melody of Figure 6.5b displays a higher level of rhythmic variety than that of Figure 6.5a, itself characterized by a complete rhythmic uniformity. Notice that the

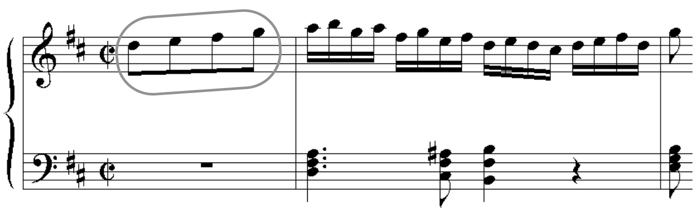
[12] This pair of examples was the most extreme case of an inefficient modification involving the opening tonic. However, most other instances of inefficient tonic-opening modifications also involved high levels of onset density and/or rhythmic uniformity (see, for instance, excerpts B19-1 and B20-1 in Appendix C).

(a)



	B	M	E
mu	2	18	0
nm	4	15	1

(b)



	B	M	E
mu	5	15	0
nm	15	4	1

Figure 6.5. Two modifications of the opening two measures of the third variation of the third movement of Mozart's Piano Sonata in D major, K. 284, with participant groups' functional judgment distributions.

judgment distribution of Figure 6.5a presents an unusual property: although the excerpt features an unaccompanied melodic opening, non-musicians' middle judgments reached the threshold of consensus.[13] Similar to the argument made with respect to Figure 6.4, we propose that the interaction between the parameters of rhythmic uniformity and onset density as well as the intensity at which these parameters are expressed contribute to explaining non-musicians' peculiar form-functional response.[14] In fact, the judgment distributions of Figure 6.5b

---

[13] Only three of the non-musicians' consensual middles featured an unaccompanied melodic opening in Experiments 2 and 3. Figure 6.5a was one of them, together with another excerpt from the same family with an identical rhythmic setting in its melody. The third one, M13-4 can be found in Appendix C.

[14] Not only does the coefficient of rhythmic variety have a value of zero but the level of onset density of Figure 6.5a also ranks first of all of our stimuli.

substantiate our analytical interpretation, inasmuch as the relatively lower onset density that characterizes its unaccompanied melodic opening—which thus creates rhythmic variety at the excerpt level—is accompanied by a marked shift in the non-musicians' judgment profile from a consensual middle to a consensual beginning.[15] Note that, in comparison, the musicians' reaction to that modification is quite modest, which exemplifies the aforementioned difference in the level of importance granted to that property by both expertise groups.[16] Note that Figure 6.5a is one of the three excerpts in our entire series of experiments for which musicians and non-musicians reached *consensus* (with at least 15 judgments for one function) on *different* functions.

Figures 6.4 and 6.5 suggest that a strong interaction between the parameters of rhythmic uniformity and onset density can project the middle function very efficiently. Indeed, these two parameters can override the cues that musicians and non-musicians tend to rely on to distinguish beginnings and middles. Such a similar form-functional effect across groups may be due to commonalities in schematic representations of the middle function. For instance,

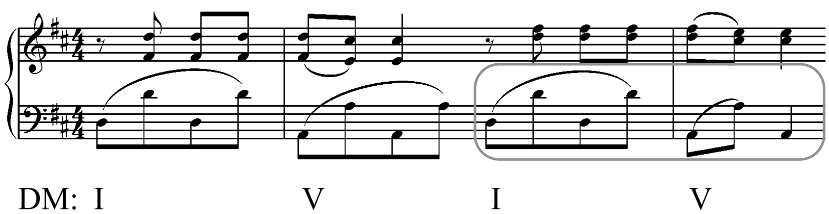
---

[15] Both the melodic and rhythmic settings of the unaccompanied melodic opening of Figure 6.5a are actually much more typical of a "lead-in"—a short melodic fragment that links the end of a previous thematic unit to the beginning of the following one—than of a genuine unaccompanied anacrusis. But as mentioned earlier, the term "unaccompanied melodic opening" can include the unaccompanied anacrusis as well as any type of melodic configuration that starts prior to the onset of the accompaniment.

[16] As a reminder, both musicians and non-musicians associated the unaccompanied melodic opening with the beginning function. However, as shown in Figure 4.4 and Table 4.3, and, most of all, in Figure 3.6, non-musicians relied on that property to a greater extent than musicians to differentiate beginnings and middles.

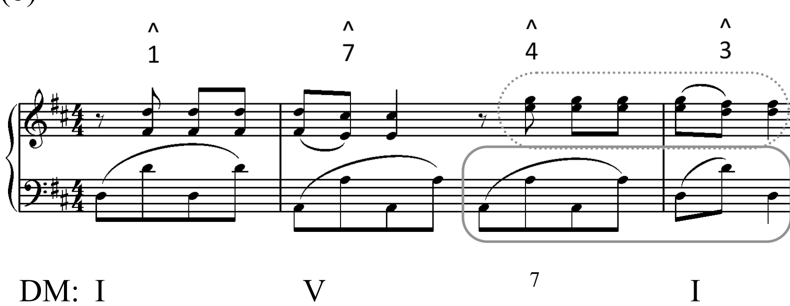
Eitan & Granot (2006) have shown that musical “intensifications” of parameters such as the attack rate translate into acceleration of participants’ “imagined speed.” As such, this cross-modal mapping involving motion imagery may contribute to listeners’ intuitive representation of the middle function. If so, such parametric configurations likely entail *positive* evaluations of the middle function (see the discussion on positive and negative middle evaluations above).

(a)



	B	M	E
mu	6	13	1
nm	3	16	1

(b)



	B	M	E
mu	14	6	0
nm	5	15	0

Figure 6.6. Two modifications based on measures 5–6 of the first movement of Mozart’s Piano Sonata in D major, K. 284, and participants’ judgment distributions (Experiment 2).

Let us turn now to a parameter that had no consistent effect of participants’ functional judgments: grouping structure. Figure 6.6 shows two modifications based on measures 5–6 of the first movement of Mozart’s Piano Sonata in D major, K. 284 (see excerpts M4-2 and M4-3 in Appendix B). The positions of the last two harmonies of Figure 6.6a were switched in Figure 6.6b.[17] In Figure 6.6a, the harmonic setting was intended to reinforce the internal sub-grouping induced by the upper voices by creating a repeated tonic-dominant harmonic progression that *paralleled* the upper voices' repeated pattern. To the contrary, in Figure 6.6c, the modification was intended to weaken the sub-grouping effect by creating a larger arch-form tonic-dominant-tonic progression that *contradicted* the melodic-rhythmic pattern in the upper voices.[18]

Unlike other modifications made to the grouping structure, this one had a very strong impact on musicians' functional judgments. A possible explanation for such a strong effect may be that this modification yielded a pattern in the upper voice that strongly resembles a voice-leading schema frequently used in mid- to late eighteenth-century music. As noted above the upper voice of Figure 6.6b, the progression of scale degrees 1-7-4-3 partly outlines what Robert Gjerdingen has called a "Meyer," (Gjerdingen, 2007), a schema frequently found at the onset of a theme. Although Figure 6.6b does not the contain the Meyer's succession of scale degrees 1-2-7-1 in the bass, the overall harmonic-melodic setting may be close enough to the original schema to have a positive impact on beginning judgments.

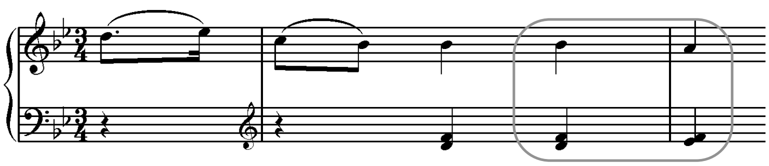
---

[17] Note that the latter harmonic modification had a minor side effect on the upper voices' pitch content (indicated with a dotted circle in Figure 6.6c).

[18] It is possible that the perceived metrical structure differed from the written structure in these two examples. Indeed, with no context provided, it is likely that participants heard the opening tonic harmony as the downbeat.

Overall, this example illustrates that although grouping structure had little influence on participants' functional judgments, this parameter may, in special circumstances, be functionally efficient. More generally, it shows that factors other than the musical properties investigated in the current study may also contribute to influence participants' functional decisions, such as the voice-leading schemata described above.

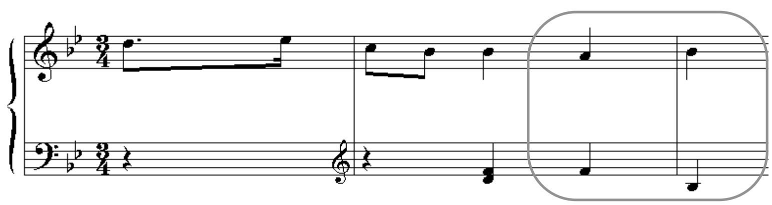
(a) Mozart, Piano Sonata in B-flat major, K. 282, ii, 1−2



	B	M	E
mu	16	4	0
nm	8	10	2

B-flat M: I ^{6} V $^{4}_{2}$

(b) Modification of (a)



	B	M	E
mu	2	1	17
nm	0	0	20

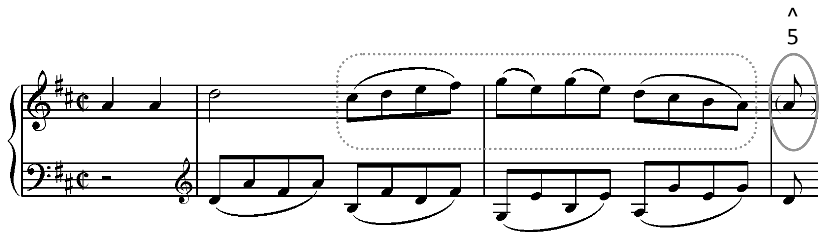
B-flat M: I ^{6} V I

Figure 6.7. Original (a; Experiment 3) and modified (b; Experiment 2) excerpts with participants' functional judgment distributions.

Figure 6.7 shows our most flamboyant case of purposely created antagonistic interaction of properties (see excerpts B9 in Appendix C and B9-4 in Appendix B). The original excerpt (Figure 6.7a), a thematic beginning taken from the third movement of Mozart's Piano Sonata in B-flat major (K. 282), presented several properties that we expected participants to associate with the beginning function, namely, a fairly extended and rhythmically varied unaccompanied melodic opening and an opening tonic (the latter was intended to affect only musicians). While it was indeed perceived unequivocally as a beginning by musicians, non-musicians' perception was, surprisingly, quite ambiguous. In any case, the modification shown in Figure 6.7b substituted the last two chords of the original excerpt with a dominant-tonic progression in order to form a perfect authentic cadence, and thereby, a strong sense of closure. The response was then equally clear for both groups: Figure 6.7b was perceived as a consensual end.

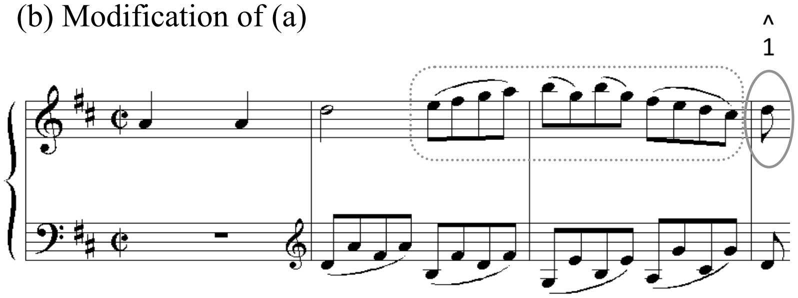
A very similar case can be found in Figure 6.8 (see excerpts B10 and B10-13 in Appendix C). Here, the original excerpt—the opening measures of the third movement of Mozart's Piano Sonata in D major, K. 284—counts as one of our strongest beginnings when taking into account both musicians' and non-musicians' judgments. Similarly to Figure 6.7b, the modification shown in Figure 6.8b consisted of adding a perfect authentic cadence at the end of an excerpt whose other properties strongly project a beginning function—for instance, a marked unaccompanied anacrusis with a characteristic ascending leap of fourth. Contrary to Figure 6.7b, however, this modification only affected the melody since the final harmonic progression was already suitable for a PAC. The goal of the modification was to conclude the excerpt on the first scale degree, approached by descending stepwise motion. For this reason, a relatively large segment of the melody was transposed, as indicated with the dotted boxes in Figure 6.7; however the melodic contour was essentially preserved. As can be seen by comparing the judgment distributions of Figures 6.8a and 6.8b, the impact of the added PAC was much weaker than that of Figure 6.7, especially as regards non-musicians, for which the impression of beginning was quite persistent (12 of participants' judgments) despite the presence of the PAC. To be sure, among all excerpts ending with a PAC in our three experiments, Figure 6.8b was the one that received—by far—the smallest number of end judgments. Moreover, as far as musicians are concerned, a PAC generating such a low rate of end judgments definitely constitutes a rare exception.[19]

(a) Mozart, Piano Sonata in D major, K. 284, iii, 1−3



	B	M	E
mu	18	2	0
nm	16	3	1

(b) Modification of (a)



	B	M	E
mu	7	4	9
nm	12	4	4

Figure 6.8. Original (a) and modified (b) excerpts with participants' functional judgment distributions.

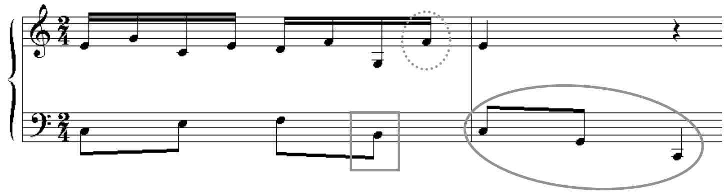
Figures 6.7 and 6.8 relate to an important element of the "time-point" functional evaluation strategy illustrated earlier in Figure 6.1. Among the combinations of matches between an excerpts' opening and closing time-points and their respective equivalents at the "imagined" thematic level, one such

[19] Only two other excerpts closing with a PAC did not pass the threshold of consensual end evaluation, but they both received as many as 14 end judgments.

combination is still unaddressed: the one in which both matches are positive (Y/Y). Figures 6.7 and 6.8 can help us understand how participants in such a conflicting situation make a functional evaluation. Our results suggest that, depending on the situation, a PAC at best completely overrides beginning features (Figure 6.7b, especially for musicians) and creates a very strong impression of end. At worst, a PAC has a modest influence and, together with the beginning properties, creates a functionally ambiguous impression (Figure 6.8b). Our results indeed suggest that, in general, beginning properties do not have the perceptual strength to completely override a PAC and thus express a clear sense of beginning *despite* the presence of such a cadence. According to our results and intuitions, we conjecture that—at least for musicians, and probably for non-musicians as well—strong end properties such as the PAC will completely override strong beginning properties most of the time.

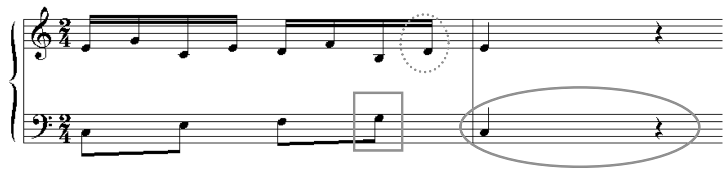
The modifications shown in Figure 6.9 come from a mixed network of modifications based on the closing measures of the main theme of the third movement of Mozart's Piano Sonata in C major, K. 279 (see excerpts E3-1, E3-2, and E3-5 in Appendix B). Figure 6.9a and 6.9b were chosen to illustrate the relative effects of two end properties: (1) the position of the dominant (that is, root-position vs. inversion), a structural feature that is necessary, but not sufficient, for a dominant-tonic progression to be classified as an authentic cadence (that property is indicated with a square); and (2) the post-cadential descending bass arpeggiation, a rhetorical feature whose presence is entirely

(a)



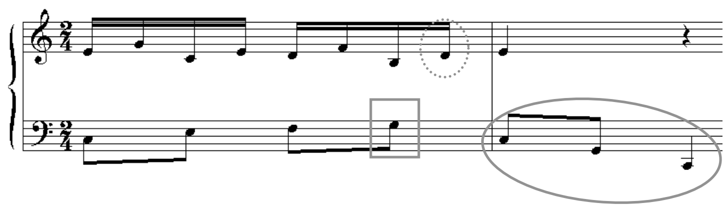
	B	M	E
mu	1	1	18
nm	0	2	18

(b)



	B	M	E
mu	0	9	11
nm	0	10	10

(c)

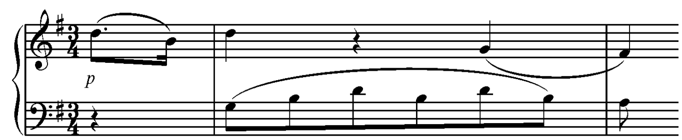


	B	M	E
mu	0	2	18
nm	0	0	20

Figure 6.9. Three modifications of the closing measures of the main theme (measures 9−10) of the third movement of Mozart's Piano Sonata in C major, K. 279, with participants' functional judgment distributions (Experiment 2).

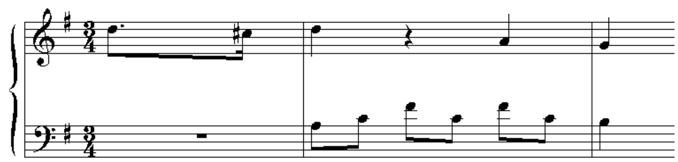
optional to the definition of an authentic cadence (indicated with an oval). This comparison shows that an excerpt featuring a descending bass arpeggiation projects a much stronger sense of end (despite the inversion of the dominant harmony) than the excerpt with a root-position dominant without the descending bass arpeggiation. Note that the slight contour difference between Figure 6.9a and 6.9b (indicated with a dotted circle) does not contribute to explain participants' behavior; Figure 6.9c, with the same contour as Figure 6.9b, controls for that difference and further illustrates the strong form-functional impact of the descending bass arpeggiation. Overall, this example calls attention to the possible gap between, on one hand, the theoretical importance granted to a structural property such as the position of the cadential dominant, and, on the other hand, this property's perceptual importance. Moreover, this example shows the impact of properties other than the perfect authentic cadence on musicians' perception of the end function, an aspect that was not captured by the large-scale analyses shown in the previous chapters.

(a) Mozart, Piano Sonata in G major, K. 283, i, 1−2



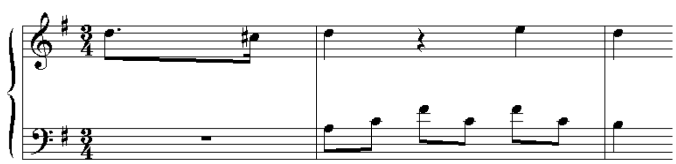
	B	M	E
mu	20	0	0
nm	17	3	0

(b) Modification of (a)



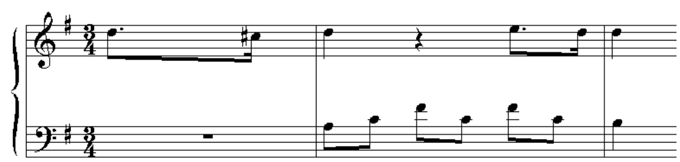
	B	M	E
mu	4	8	8
nm	7	6	7

(c) Modification of (b)



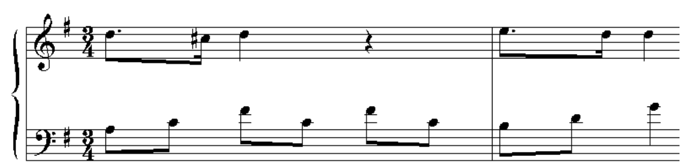
	B	M	E
mu	7	13	0
nm	14	5	1

(d) Modification of (c)



	B	M	E
mu	4	15	1
nm	10	10	0

(e) Modification of (d)



	B	M	E
mu	1	19	0
nm	5	14	1

Figure 6.10. Incremental series of modifications based on the opening measures of the first movement Mozart's Piano Sonata in G major, K. 283.

We will finish this section by taking a brief look at a series of incremental modifications illustrated in Figure 6.10 (see excerpt B3 in Appendix A and excerpts B3-1, B3-2, B3-3, and B3-4 in Appendix B).[20] This particular network was used in Experiment 2, although the original excerpt—the opening measures of Mozart's Piano Sonata in G major, K. 283—was only tested in Experiment 1.[21] The goal of this incremental series of modifications was to gradually orient, through successive steps, participants' perception of a beginning function towards that of a middle function. The following remarks summarize the most important steps in the modification process:

a. The original excerpt projects a very clear sense of beginning, probably due to its configuration of strong beginning properties: (1) a rhythmically varied unaccompanied anacrusis; (2) an opening tonic (for musicians only); (3) a high level of rhythmic diversity in the melody; (4) a fairly moderate onset density; (5) an Alberti-bass accompaniment. Note that the descending contour does not impair the strong consensus on the beginning function.

[20] A fuller description of the modification networks we used in Experiments 2 and 3 was provided in Chapter 3.

[21] Let us recall that, in Experiment 1, participants had greater exposure to the stimuli—excerpts were heard three times and not twice as in Experiments 2 and 3—and they completed a verbalization task. Their functional judgments ostensibly resulted from a greater level of analysis than those of Experiments 2 and 3. Because of those methodological differences, comparisons between the judgment distributions of Experiment 1 and those of Experiments 2 and 3 must be made cautiously, especially as regards the effect size.

b. The reversal of the tonic and dominant harmonies creates a highly ambiguous form-functional context. The “loss” of the opening tonic was expected to affect musicians’ beginning and middle judgments. This harmonic switch, together with its side effect on the melody, also created a closing dominant-tonic motion which, with its concomitant descending motion from the second to the first scale degree in the melody, likely projected an end function for several participants.[22]

c. The alteration of the melodic contour strongly impaired the sense of ending for both groups, as it removed the first scale degree from the final time-point and substituted it with the fifth degree (the diminutions of end judgments were significant in both groups). Note how strongly musicians and non-musicians judgment distributions differ once those “lost” end judgments are redistributed between the beginning and middle functions: a majority of musicians, seemingly influenced by the opening dominant harmony, judged this excerpt as a middle, whereas a majority of non-musicians, most likely influenced by the unaccompanied anacrusis, judged it as a beginning. This exemplifies, once again, the gap in the importance that musicians and non-musicians grant to those two properties (the

---

[22] Note that explaining non-musicians’ relatively large number of middle judgments is quite challenging—this excerpt exhibits none of the properties that non-musicians normally attribute to middles. However, we might posit, along the lines of the aforementioned hypothesis on the conception of the middle function, that several participants from that group interpret a middle judgment as the best option when confronted with form-functional ambiguity, even though the competing properties do not involve the middle function *per se*, as is the case in the current example.

opening tonic and the unaccompanied anacrusis) in distinguishing between beginnings and middles.

d. The rhythmic alteration at the end of the melodic pattern was intended to reinforce the sense of internal sub-grouping through repeating exactly the rhythmic figures used in the opening motive. Even though this modification also augmented the coefficient of rhythmic variety in melodic and composite rhythm, we expected this higher level of internal sub-grouping to have a positive effect on middle judgments and a negative one on beginning judgments. Note that although the effect on participants' judgments was the one expected, none of these variations were significant.

e. The removal of the unaccompanied anacrusis had the expected effect of strengthening this excerpt's projection of the middle function. Although the magnitude of the impact on judgments was similar for both groups, only musicians' judgment variations of beginning and middle were statistically significant.

As a result, the excerpt at the end of this incremental chain of modifications constitutes a (highly) consensual middle for musicians and a fairly clear one for non-musicians.[23] As noted above, some of the modifications did not have a significant impact on functional judgments. In seems nevertheless reasonable to propose that, when convolved together, those modifications' contribution may have a tangible impact on the overall projection of the middle

[23] A single supplementary middle judgment would have allowed it to pass the established threshold for consensual functional evaluation

function. Although some incremental modification networks were not as functionally successful as expected, the current example shows the extent to which we managed to cast participants' impressions in one specific form-functional direction.

Overall, the analyses presented in this section call attention to the complexity of the interaction among properties in different musical contexts. It mostly warns against the possibility of false negative errors in the interpretation of the statistical results presented in the previous chapters, especially as regards musical parameters. That is, we cannot necessarily conclude, from the modest results obtained in comparative analyses of parameters (such as grouping structure or rhythmic activity), that those parameters do not have any form-functional impact. As suggested in Chapter 4 and earlier in this chapter, we suspect that the effect of parametric modifications is greatly influenced by the perceptual threshold above which a certain amount of form-functional change is perceived as well as by the amount of expression of other parameters in comparative and referential excerpts. More generally, the form-functional impact of any one modification—either as a specificity or as a parameter—is likely influenced by the context in which it takes place, this context being itself defined by the global interaction of properties that can be more or less associated with a specific function and, for parameters, expressed at various "intensity levels" (say, a very high onset density, a moderate rhythmic uniformity, etc.). Seeing as the above analyses hinted at ways in which certain parameters could be perceptually efficient as far as formal functions are concerned, rigorous testing of those speculative interpretations is required before making strong conclusions about the effect of those parameters.

We acknowledge that several other musical characteristics that were not investigated in this study may also have a strong form-functional relevance. Let us mention, for instance, some acoustical features such as the level of sensory consonance or dissonance (what might be called "concord" and "discord," respectively, in music-theory writings; for example, see Meyer, 1998); or certain spectral properties of pitch combinations engendered by different uses of register (such as pitch height or the distance between the melody and the accompaniment), etc. Listeners may also be influenced by the recognition of rhythmic or voice-leading patterns. For example, an Alberti-bass accompaniment may have stronger form-functional connotations than any other accompaniment based on chordal arpeggiation. Similarly, we proposed earlier with respect to Figure 6.6 that certain voice-leading schemata may affect listeners' form-functional impressions (Gjerdingen, 1986, 1988, 1996, 2007). Although we believe that an integrative model combining all of these characteristics (including the properties currently studied) would have an impressive explanatory power, such an endeavor is largely beyond the scope of our project at this point.

INTRINSIC FORMAL FUNCTIONALITY AND "REAL LISTENING"

Obviously, evaluating whether short excerpts are beginnings, middles, or ends of larger passages has little to do with our common music-listening experience. To be sure, in "real listening," the materials are in constant interaction with contextual information and, within larger musical contexts, we don't perceive music as a disembodied succession of musical "chunks" representing the functions of beginnings, middles, and ends. Although our findings cannot provide a faithful representation of real-time perception of entire musical pieces, they can serve as a basis for explaining some aspects of experienced musical temporality. Now that we have discussed the form-functional implications of several properties, we can go slightly further and conjecture the way intrinsic form-functional information may interact with the surrounding context at a larger scale than the intra-thematic level.

Figure 6.11. The link between the end of the transition and the beginning of the subordinate theme in measures 15−19 of the first movement of Mozart's Piano Sonata in C major, K. 279.

Figure 6.11 shows a passage that links the end of the transition (indicated by letter 'a') with the beginning of the subordinate theme ('b') of the first movement of Mozart's Piano Sonata in C major (K. 279), already discussed in Figure 6.2. Let us describe this passage from the perspective of the beginning of the subordinate theme ('b'). Information *extrinsic* to this thematic beginning clearly indicates a structural boundary, especially the quarter-note rest that follows the half-cadential harmonic closure of the transition and the arrival of new material. In addition to this combination of cues, which relate to the Gestalt principles of proximity and similarity respectively (Deliège, 1987, 1989, 2001),[24] the half-cadence itself may also contribute to conveying a sense of end.[25] As regards *intrinsic* form-functional information (as noted earlier in Figure 6.2), this theme opening contains strong beginning properties—especially its unaccompanied anacrusis—as well as strong middle properties (at least for musicians)—especially its off-tonic opening, but also its high onset density.[26] With these extrinsic and intrinsic characteristics in mind, one could understand the esthetic consequences of Mozart's using perceptually conflicting form-functional properties at the onset of the subordinate theme: whereas contextual information as well as the aforementioned beginning-related properties help to articulate formal clarity, the use of middle-related properties are likely to add a sense of momentum, of formal fluidity, or perhaps even to create an impression

---

[24] The principle of similarity is a tendency to perceive similar elements as being part of the same group and different elements as being part of different groups. The principle of proximity is similar, but relates to the distance between elements.

[25] The perceptual strength of the half cadence was not tested in this project; but let us suppose that in such a context, several musically trained listeners could use this property to understand that the transition's harmonic trajectory has reached its ending point.

[26] A more complete music-theoretical account of the middle properties of this thematic opening may also include other characteristics such as its contrapuntal setting as well as, when the following measures are taken into consideration, the use of sequential harmonies. The form-functional impact of those properties was not tested in this project.

that we are "starting" (contextual information) in the "middle" (intrinsic information).

Figure 6.12. The link between the end of the transition and the beginning of the subordinate theme in measures 16−28 of the first movement of Mozart's Piano Sonata in C minor, K. 457.

Similarly to Figure 6.11, the passage shown in Figure 6.12 presents the link between the transition ('a') and the subordinate theme ('b') in the first movement of Mozart's Piano Sonata in C minor (K. 457). The information extrinsic to the beginning of the subordinate theme is, however, much more ambiguous because of the way in which the transition "ends": this highly atypical transition leads directly to the beginning of the following section without a rest or even a half-cadence, therefore, without projecting a proper sense of intrinsic ending. With respect to context, therefore, the strongest cues that indicate the possibility of a structural boundary relate to the Gestalt similarity principle, that is, the arrival of contrasting musical materials, dynamics and mode (from C *minor* to E-flat *major*).[27] At the same, however, we must note the extent to which the structural ambiguity created by the absence of clear ending cues is compensated for by the use of strong beginning properties, especially the opening tonic, the high level of rhythmic variety in the melody, and the moderate onset density (particularly when compared to the previous triplets in the melody).[28] Therefore, from the point of view of form perception, the intrinsic properties of the thematic beginning can be used to clarify a contextually ambiguous situation. This example thus stands in complete opposition to Figure 6.11, where ambiguous intrinsic properties were used in a clearly defined formal context.

Our last musical analysis shows a passage from the subordinate theme of the first movement of Mozart's Piano Sonata in B-flat major (K. 281; Figure 6.13). Whereas the previous example showed how the properties of the musical materials helped to clarify a contextually ambiguous context, the musical properties of Example 12 create a functionally ambiguous situation. Starting at measure 29 ('b'), a cadential progression leads to a strong cadential dominant. However, the melodic goal of that progression, that is, the first scale degree, is missing from the downbeat of measure 30 (c). Such a gesture—termed *evaded*

---

[27] Whereas for musicians with substantial training in 18th-century music theory, the mode change might be a tangible signal of the onset of the subordinate theme, we doubt that such a cue would be perceptually salient for the majority of non-musicians.

[28] Other properties could be mentioned, such as the use of an Alberti-bass accompaniment (with moderate onset density) as well as the immediate repetition of the opening two measures, which creates a 4-bar *presentation*—typically a beginning function—when including measures 25–26 in our analysis.

Figure 6.13. Evaded cadences in the subordinate theme of the first movement of Mozart's Piano Sonata in B-flat major, K. 281.

cadence—serves to delay closure and is fairly common in subordinate themes. What is less common in such a context, though, is the use of materials such as these found at measure 30 ('c'). Indeed, the descending arpeggiation of the tonic triad in the lower voice and its parallel ornamented version in the upper voice represent a strong closing gesture highly typical of a *post-cadential*, "after-the-end" function, one that was not studied in this project, but that has nonetheless been theorized by Caplin (e.g., 1998, 2009).

But how could a passage function as an "after-the-end" without a proper ending? In fact, the intrinsic properties of the materials at 'c' seem perceptually compelling to the extent that they frequently mislead music-theory undergraduate students to interpret the downbeat of measure 30 as a perfect authentic cadence.[29] They would accordingly interpret the passage that follows ('d') as post-cadential, despite the fact that this passage constitutes an identical return of the materials of measure 27 (a), another typical feature of evaded cadences (Schmalfeldt, 1992).[30] This example shows the extent to which larger-scale contextual cues—here the return at measure 31 ('d') of materials from measure 27 ('a'), a formally important event from both Gestalt (according to the similarity principle) and music-theoretical perspectives—can become secondary when local functional information is perceived as very strong.

With these three analyses, I have speculated on how some specific interactions between materials' contextual and intrinsic properties may give rise to several perceptual effects at, or near, thematic boundaries. I then propose that intrinsic, extrinsic, divergent, and convergent form-functional cues should be conceived as different compositional possibilities, which themselves rest on the perceptual effects created by the interactions of different musical properties. In that respect, I hope that this project has contributed to providing guidelines in establishing what kinds of properties can entail specific form-functional impressions for musicians and non-musicians.

---

[29] From my own experience as a teaching assistant and an instructor, I have repeatedly seen students reporting the materials of measure 30 as being a strong argument in favor of such an interpretation.

[30] Janet Schmalfeldt referred to this compositional particularity as the "one more time" technique.

METHODOLOGICAL ISSUES

I conclude the discussion by addressing four issues regarding my methodology and propose potential improvements for future empirical testing of this sort. The first issue concerns knowledge-based judgments, that is, participants evaluating an excerpt's formal function based on their knowledge of that excerpt as opposed to its intrinsic properties. As mentioned in Chapter 2, the results of the familiarity task indicated that excerpt familiarity explained a very small percentage of our data. Nonetheless, it would be possible to *completely* eradicate the influence of prior knowledge by composing all of our experimental stimuli.

The second issue relates to carry-over effects, that is, the influence of earlier trials on the outcome of subsequent trials. Using several modifications of the same excerpt has the important advantage of offering a controlled environment to measure the effect of a given property on form-functional responses. Indeed, when comparing the effect of modifications A and B, confounding variables are minimal if both modifications are made on the same excerpt.[31] Former hearings of excerpts from the same family can, however, influence participants' functional judgment of subsequent ones, thereby creating a "resistance" to form-functional change. Although participants were explicitly instructed to ignore previous trials (within the same experiment), it is impossible to disregard such a possibility. Consequently, such a hypothesized resistance may decrease the observed strength of some properties' form-functional effect and thereby augment the risk of false negative errors, that is, concluding that a

[31] A confounding variable relates to the interference caused by a third variable.

property has no effect while, in reality, it has one. In our experiments, excerpts belonging to extended modification networks were more prone to such problems, despite our attempt to control for carry-over effects by adding several intervening excerpts between those belonging to the same network ("family"). A good compromise would be to limit the size of modification networks to two or three excerpts, which would limit such carry-over effects within a randomized-order experimental setting.

The third issue concerns the lesser attention devoted to the end function. Indeed, that there were fewer modifications intended to affect the perception of ends may have contributed to the generally higher level of functional clarity conveyed by excerpts projecting this function. In that respect, an experimental design with an equal number of modifications affecting each function would strengthen our inferences as regards their relative perceptual clarity.

The fourth issue relates to the measurement of properties' effect sizes. As mentioned in Chapter 4, the number of specific modifications varied from one property to another, which likely influenced the effect size and, to a much greater extent, significance levels. For a direct comparison of different properties' effect sizes, a small number of properties should be selected and each property should be modified an equal number of times.

REFERENCES

Barsalou, L. W. (1992). *Cognitive psychology: An overview for cognitive scientists*. Hillsdale, N.J.: L. Erlbaum.

Bigand E. (1993). The influence of implicit harmony, rhythm and musical training on the abstraction of "tension-relaxation schemas" in tonal musical phrases. *Contemporary Music Review, 9*, 123–137.

Bigand, E. (1997). Perceiving musical stability: The effect of tonal structure, rhythm, and musical expertise.

Bigand, E., & Parncutt, R. (1999). Perceiving musical tension in long chord sequences. *Psychological Research, 62*, 237–254.

Bigand, E., Parncutt, R., & Lerdahl, F. (1996). Perception of musical tension in short chord sequences: The influence of harmonic function, sensory dissonance, horizontal motion, and musical training. *Perception & Psychophysics, 58*, 124–141.

Brown, H., Butler, D., & Jones, M. R. (1994). Musical and temporal influences on key discovery. *Music Perception, 11*, 371–407.

Butler, D. (1989). Describing the perception of tonality in music: A critique of the tonal hierarchy theory and a proposal for a theory of intervallic rivalry. *Music Perception, 6*, 219–242.

Caplin, W. E. (1998). *Classical form: A theory of formal functions for the instrumental music of Haydn, Mozart, and Beethoven.* New York: Oxford University Press.

Caplin, W. E., Hepokoski, J., & Webster, J. (2009). *Musical form, forms, &* Formenlehre: *Three methodological reflections*. P. Bergé (Ed.). Leuven: Leuven University Press.

Clarke, F. (1987). Levels of structure in the organization of musical time. *Contemporary Music Review. 2*, 211–237.

Deliège, I. (1987). Grouping conditions in listening to music: An approach to Lerdahl & Jackendoff's grouping preference rules. *Music Perception, 4*, 325–360.

Deliège, I. (1989). A perceptual approach to contemporary musical forms. *Contemporary Music Review, 4*, 213−230.

Deliège, I. (2001b). Similarity perception ↔ categorization ↔ cue abstraction. *Music Perception, 18*, 233−243.

Eitan, Z., & Granot, R. Y. (2006). How music moves: Musical parameters and listeners' images of motion. *Music Perception, 23*, 221–247.

Fraisse, P. (1974). Psychologie du rythme. Paris: Presses universitaires de France.

Gjerdingen, R. O. (1986). The formation and deformation of classic/romantic phrase schemata: A theoretical model and historical study. *Music Theory Spectrum, 8*, 25–43.

Gjerdingen, R. O. (1988). *A classic turn of phrase: Music and the psychology of convention.* Philadelphia: University of Pennsylvania Press.

Gjerdingen, R. O. (1996). Courtly behaviors. *Music Perception, 13*, 365–382.

Gjerdingen, R. O. (2007). *Music in the galant style*. Oxford and New York: Oxford University Press.

Krumhansl, C. (1990a). *Cognitive foundations of musical pitch*. Oxford University Press.

Krumhansl, C. (1990b). Tonal hierarchies and rare intervals in music cognition. *Music Perception, 7*, 309–324.

Krumhansl, C., & Kessler, E. J. (1982). Tracing the dynamic changes in perceived tonal organization in a spatial representation of musical keys. *Psychological Review, 89*, 334–368.

Markman, A. A., & Wisniewski, E. J. (1997). Similar and different: The differentiation of basic-level categories. *Journal of Experimental Psychology: Leaning, Memory, and Cognition, 23*, 54−70.

Marvin, E. W., & Laprade, P. A. (1987). Relating musical contours: Extensions of a theory of contour. *Journal of Music Theory, 31*, 225–267.

Meyer, L. B. (1998). A universe of universals. *The Journal of Musicology, 16*, 3–25.

Rosch, E. (1978). Principles of categorization. In E. Rosch & B. Lloyd (Eds.), *Cognition and Categorization* (pp. 27−48). London: Erlbaum.

Schmalfeldt, J. (1992). Cadential processes: The evaded cadence and the 'one more time' technique. *Journal of Musicological Research, 12,* 1–52.

Snyder, B. (2000). *Music and memory: An introduction*. Cambridge, MA: MIT Press.

Zbikowski, L. M. (2002). *Conceptualizing music: Cognitive structure, theory, and analysis*. New York: Oxford University Press.

Chapter 7. Conclusions

This dissertation investigated the perception of intrinsic formal functionality in the piano sonatas of W. A. Mozart. We asked three fundamental questions: (1) can listeners properly identify the formal function (beginning, middle, or end) of out-of-context musical excerpts? (2) is there an effect of musical training on the accuracy of functional judgments? and (3) what are the musical properties that musicians and non-musicians associate with the functions of beginning, middle, and end?

The first experiment was designed to answer the first two questions. Participants heard excerpts taken from the beginning, middle, and end of themes from Mozart's piano sonatas and categorized them accordingly. Our results showed that all functions were identified significantly and comfortably above chance level, which indicates that formal functions can be expressed with minimal amounts of musical information, that is, less than 5 seconds of music. The results also showed that, as expected, musicians fared better than non-musicians in the evaluation task. Moreover, ends were, by far, the most accurately identified, while beginnings and middles seemed harder to distinguish from one another.

The second and third experiments sought to answer the third question. In these two experiments, we generally devoted greater attention to the properties that helped participants differentiate beginnings from middles. Although the main task was similar to that of Experiment 1, we did not present participants with original excerpts, but rather modifications of those originals according to specific hypotheses regarding the form-functional role of certain musical properties. The most remarkable results concerned the interaction of musicianship and tonality on the perception of beginnings and ends: whereas participants of both groups relied strongly on tonal cues (closing tonic harmony and first scale degree) to identify ends, only musicians used such cues (opening tonic harmony) to distinguish beginnings from middles. To the contrary, non-musicians relied heavily—and to a much greater extent than musicians—on unaccompanied melodic openings to make this distinction. Generally speaking, rhythmic properties had similar effects on both groups: a faster and more uniform rhythm tended to be associated with the middle function and a slower and more varied rhythm, with the beginning function. We have seen, however, that parametric modifications involving the level of rhythmic activity had a stronger influence on non-musicians' responses (see Chapter 4). We also briefly mentioned properties that, globally speaking, had a weak, inconsistent, or negligible effect on participants' functional decisions, among them being the grouping structure, the inversion of tonic harmony, harmonic rhythm, and the level of emphasis on tonic harmony.

As a whole, we can summarize the effect of musical properties on musicians and non-musicians as follows. First, some properties had no effect on musicians or non-musicians. Second, few properties affected a single group. Third, several properties had a similar effect on both groups. Fourth, *no* property had a different effect on different groups. These observations remind us that, as a whole, musicians and non-musicians perceived formal functionality in a relatively similar way, even more so if we put aside the particular case of the opening tonic harmony. Although non-musicians' data were noisier, less consistent, and, from my own perspective as a music theorist, harder to predict than those of musicians, the differences between expertise groups were often more quantitative than qualitative. This perceptual similarity between groups therefore questions—or at least should tone down—music theorists' assumption that listeners require a high level of familiarity with a musical style to be able to 'understand' what it conveys. Although expertise seems to enhance the perception of temporality, our results suggest that it is not a pre-requisite to such perception.

In Chapters 1, 2, and 5, we addressed a subsidiary topic: the categorization process of beginnings, middles, and ends. The end function was hypothesized as the strongest function, followed by the beginning function, and finally, the middle function. The end function should therefore be easier to categorize than the weaker functions, which suggests that it should be categorized the fastest, be rated the strongest, and yield the highest levels of consensus among participants of a group. Similarly, beginnings should be easier to categorize than middles, and consequently be categorized faster, be rated as stronger, and yield higher consensus than middles. As reported at the end of Chapter 5, there was no effect of function on participants' response times, and only musicians provided significantly stronger ratings for ends than for beginnings and middles. Analyses on the frequency distributions of the judgments, however, showed that there was a significantly stronger consensus for ends than for the other two functions, and this conclusion held for both expertise groups. Overall, there is no evidence to support the sequential decision process that we hypothesized (that is, when judging an excerpt, listeners would consider the end option first, then the beginning option, and finally, the middle option); yet, our data indicate that ends are more strongly conveyed than beginnings and middles. As mentioned in Chapter 1, the fact that ends share a greater number of surface features than beginnings and middles might contribute to explaining such a difference. Further empirical research would be required to investigate this question thoroughly.

Chapter 6 discussed the results of Experiments 2 and 3. We saw that some crucial musical information was localized at the opening and closing time-points of excerpts, but that information available over larger time-spans—mostly rhythmic information—was also important for form-functional decisions. We also speculated on some important limitations concerning the form-functional efficiency of individual properties. First, as concerns musical parameters (the properties quantifiable on a graded or continuous scale), we proposed that the intensity at which a parameter is expressed might have a very strong influence on its functional impact. Hence, this influence might vary in a non-uniform way at different degrees of intensity: for instance, the perceptual difference between a very high rhythmic uniformity and a complete rhythmic uniformity might be much more important than the difference between a moderately high rhythmic uniformity and very low rhythmic uniformity (thus a high rhythmic variety). Second, we proposed that the efficiency of a given property might depend on the musical environment in which it takes place. This idea is consistent with prototype theory, which shows that a perceptual object is a good representative of a category when it shares a high number of properties with other members of the same category. Thus an excerpt with many properties expressing a single function will be likely identified as an accurate representative of that function, regardless of contradictory evidence. For instance, even though property X is strongly related to function A, an excerpt that contains *many* properties that relate to function B will be perceived as projecting function B regardless of the presence or absence of property X. We have seen, however, that on some occasions, certain properties, such as the perfect authentic cadence, may be strong enough to override other perceptual properties and shift participants' perception towards another function, namely, the end function. Overall, a precise measurement of individual properties' form-functional influence within highly complex stimuli such as ours would require a more sophisticated statistical framework.

Finally, we proposed some ideas concerning the way intrinsic and contextual information might interact at a larger scale than the intra-thematic level. Our musical analyses showed cases in which strong contextual Gestalt-based grouping cues (e.g., Deliège, 1987; Lerdahl & Jackendoff, 1983) could complement, parallel, or contradict intrinsic form-functional information to create various perceptual impressions such as, say, the sense that a given subordinate theme "begins in the middle." Although purely conjectural at this stage, these are the kinds of interactions that could be investigated at a larger scale in order to assess the perception of temporality within listening conditions that have a higher ecological validity than those involved in the current project. Such an investigation could, for instance, address the contentious issue of large-scale formal syntax. What would be the perceptual implications of, say, a binary form in which the beginning of the first phrase projected a much clearer intrinsic formal functionality than that of the second (contextually defined) beginning? What would be the perceptual implications of the opposite situation? What about the respective strength of phrase endings? In that respect, the findings of this study could help create various configurations of properties that would allow empirical research on these questions to be conducted.

References

Deliège, I. (1987). Grouping conditions in listening to music: An approach to Lerdahl & Jackendoff's grouping preference rules. *Music Perception, 4*, 325–360.

Lerdahl, F., & Jackendoff, R. (1983). *A generative theory of tonal music*. Cambridge, MA: MIT Press.

Bibliography

Addessi, A., & Caterina, R. (2000). Perceptual musical analysis: Segmentation and perception of tension. *Musicae Scientiae, 4*, 31–54.

Agawu, K. (1987). Concepts of closure and Chopin's opus 28. *Music Theory Spectrum, 9*, 1–17.

Agawu, K. (1991). *Playing with signs*. Princeton: Princeton University Press.

Anson-Cartwright, M. (2007). Concepts of closure in tonal music: A critical study. *Theory and Practice, 32*, 1–18.

Auhagen, W., & Vos, P. G. (2000). Experimental methods in tonality induction research: A review. *Music Perception, 17*, 417–436.

Batt, R. (1987). Comments on 'The effects of instrumentation, playing style, and structure in the Goldberg variations by Johann Sebastian Bach.' *Music Perception, 5*, 207–213.

Barsalou, L. W. (1992). *Cognitive psychology: An overview for cognitive scientists*. Hillsdale, N.J.: L. Erlbaum.

Berry, W. (1976). *Structural functions in music*. Englewood Cliffs: Prentice-Hall.

Berry, W. (1989). *Musical Structure and performance*. New Haven & London: Yale University Press.

Bharucha, J. J. (1984). Anchoring effects in music: The resolution of dissonance. *Cognitive Psychology, 16*, 485–518.

Bharucha, J., & Krumhansl, C. (1983). The representation of harmonic structure in music: Hierarchies of stability as a function of context. *Cognition, 13*, 63−102.

Bharucha, J., & Stoeckig, K. (1986). Reaction time and musical expectancy: Priming of chords. *Journal of Experimental Psychology: Human Perception and Performance, 12*, 403–410.

Bharucha, J., & Stoeckig, K. (1987). Priming of chords: Spreading activation or overlapping frequency spectra? *Perception & Psychophysics, 41*, 519–524.

Biederman, I. (1987). Recognition-by-components: A theory of human image understanding. *Psychological Review, 94*, 115–147.

Bigand E. (1993). The influence of implicit harmony, rhythm and musical training on the abstraction of "tension-relaxation schemas" in tonal musical phrases. *Contemporary Music Review, 9*, 123–137.

Bigand, E. (1997). Perceiving musical stability: The effect of tonal structure, rhythm, and musical expertise.

Bigand, E., Madurell, F., Tillmann, B., & Pineau, M. (1999). Effect of global structure and temporal organization on chord processing. *Journal of Experimental Psychology: Human Perception and Performance, 25*, 184–197.

Bigand, E., & Parncutt, R. (1999). Perceiving musical tension in long chord sequences. *Psychological Research, 62*, 237–254.

Bigand, E., Parncutt, R., & Lerdahl, F. (1996). Perception of musical tension in short chord sequences: The influence of harmonic function, sensory dissonance, horizontal motion, and musical training. *Perception & Psychophysics, 58*, 124–141.

Bigand, E., & Pineau, M. (1997). Context effects on musical expectancy. *Perception & Psychophysics, 59*, 1098–1107.

Bigand, E., Poulin, B., Tillmann, B., Madurell, F., & D'Adamo, D. A. (2003). Sensory versus cognitive components in harmonic priming. *Journal of Experimental Psychology: Human Perception and Performance, 29*, 159 –171.

Bigand, E., Tillmann, B., Poulin, B., D'Adamo, D. A., & Madurell, F. (2001). The effect of harmonic context on phoneme monitoring in vocal music. *Cognition*, *81*, B11–B20.

Bigand, E., Tillmann, B., Poulin-Charronnat, B., & Manderlier, D. (2005). Repetition priming: Is music special? *The Quarterly Journal of Experimental Psychology, 58A*, 1347–1375.

Blombach, A. (1987). Phrase and cadence: A study of terminology and definition. *Journal of Music Theory Pedagogy, 1*, 225–251.

Boltz, M. (1989a). Perceiving the end: Effects of tonal relationships on melodic completion. *Journal of Experimental Psychology: Human Perception and Performance, 15*, 749–761.

Boltz, M. (1989b). Rhythm and "good endings": Effects of temporal structure on tonality judgments. *Perception & Psychophysics, 46*, 9–17.

Bonds, M. E. (1991). *Wordless rhetoric: Musical form and the metaphor of the oration*. Cambridge, MA: Harvard University Press.

Brown, H. (1988). The interplay of set content and temporal context in a functional theory of tonality perception. *Music Perception, 5*, 219–250.

Brown, H., & Butler, D. (1981). Diatonic trichords as minimal tonal cue-cells. *In Theory Only, 5*, 37–55.

Brown, H., Butler, D., & Jones, M. R. (1994). Musical and temporal influences on key discovery. *Music Perception, 11*, 371–407.

Browne, R. (1981). Tonal implications of the diatonic set. *In Theory Only*, 5, 3–21.

Butler, D. (1989). Describing the perception of tonality in music: A critique of the tonal hierarchy theory and a proposal for a theory of intervallic rivalry. *Music Perception, 6*, 219–242.

Caplin, W. E. (1998). *Classical form: A theory of formal functions for the instrumental music of Haydn, Mozart, and Beethoven.* New York: Oxford University Press.

Caplin, W. E. (2004). The classical cadence: Conceptions and misconceptions. *Journal of the American Musicological Society, 57*, 51–117.

Caplin, W. E. (2005). On the relation of musical *topoi* to formal function. *Eighteenth-Century Music, 2*, 113−124.

Caplin, W. E., Hepokoski, J., & Webster, J. (2009). *Musical form, forms, &* Formenlehre: *Three methodological reflections*. P. Bergé (Ed.). Leuven: Leuven University Press.

Clarke, F. (1987). Levels of structure in the organization of musical time. *Contemporary Music Review. 2*, 211–237.

Clarke, E. (1989). Mind the gap: formal structures and psychological processes in music. *Contemporary Music Review, 3*, 1–13.

Clarke, E., & Cook, N. (Eds.). (2004). *Empirical musicology: Aims, methods, prospects*. Oxford: Oxford University Press.

Clarke, E., & Krumhansl, C. (1990). Perceiving musical time. *Music Perception, 7*, 213−252.

Cohen, A. J. (1991). Tonality and perception: Musical scales primed by excerpts from *The well-tempered clavier* of J. S. Bach. *Psychological Research, 53*, 305–314.

Cook, N. (1987). The perception of large-scale tonal closure. *Music Perception, 5*, 197−206.

Cook, N. (1994). Perception: A perspective from music theory. In R. Aiello (Ed.), *Musical perceptions* (pp. 64–95). New York: Oxford University Press.

Cuddy, L. L. (1997). Tonal relations. In I. Deliège & J. Sloboda (Eds.), *Perception and cognition of music* (pp. 329–352). Hove, East Sussex, UK: Taylor & Francis.

Cuddy, L. L., & Badertscher, B. (1987). Recovery of the tonal hierarchy: Some comparisons across age and levels of musical experience. *Perception & Psychophysics, 41*, 609–620.

Cuddy, L. L., Cohen, A. J., Mewjort, D. J. K. (1981). Perception of structure in short melodic sequences. *Journal of Experimental Psychology: Human Perception and Performance, 7*(4), 869–883.

Cuddy, L., L., & Lunney, C. A. (1995). Expectancies generated by melodic intervals: Perceptual judgments of melodic continuity. *Perception & Psychophysics, 57*, 451–462.

Darcy, W., & Hepokoski, J. (2006). *Elements of sonata theory: Norms, types, and deformations in the late eighteenth-century sonata*. New York: Oxford University Press.

Debellis, M. (2002). Analysis as articulation. *Journal of Aesthetic and Art Criticism, 60*, 119−135.

Deliège, I. (1987). Grouping conditions in listening to music: An approach to Lerdahl & Jackendoff's grouping preference rules. *Music Perception, 4*, 325–360.

Deliège, I. (1989). A perceptual approach to contemporary musical forms. *Contemporary Music Review, 4*, 213−230.

Deliège, I. (1993). Mechanisms in cue abstraction for memory in musical time. *Contemporary Music Review, 9*, 191−205.

Deliège, I., & El Ahmadi, A. (1990). Mechanisms of cue extraction in musical groupings: A study of perception on Sequenza VI for viola solo by L. Berio. *Psychology of Music*, *18*, 18–44.

Deliège, I. (2001a). Prototype effect in music listening: An empirical approach to the notion of imprint. *Music Perception, 18*, 371−407.

Deliège, I. (2001b). Similarity perception ↔ categorization ↔ cue abstraction. *Music Perception, 18*, 233−243.

Deliège, I., Mélen, M., Stammers, D., & Cross, I. (1996). Musical schemata in real-time listening to a piece of music. *Music Perception, 14*, 117−160.

Dibben, N. (1994). The cognitive reality of hierarchical structure in tonal and atonal music. *Music Perception, 12*, 1–25.

Dibben, N. (2003). Musical materials, perception, and listening. In M. Clayton, T. Herbert, & R. Middleton (Eds.), *The cultural study of music: A critical introduction.* New York: Routledge.

Eitan, Z., & Granot, R. Y. (2006). How music moves: Musical parameters and listeners' images of motion. *Music Perception, 23*, 221–247.

Eitan, Z., & Granot, R. Y. (2008). Growing oranges on Mozart's apple tree: "Inner form" and aesthetic judgment. *Music Perception, 25*, 397−417.

Fraisse, P. (1974). Psychologie du rythme. Paris: Presses universitaires de France.

Francès, R. (1984). La perception de la musique. Paris: Librairie philosophique J. Vrin.

Gjerdingen, R. O. (1986). The formation and deformation of classic/romantic phrase schemata: A theoretical model and historical study. *Music Theory Spectrum, 8*, 25–43.

Gjerdingen, R. O. (1988). *A classic turn of phrase: Music and the psychology of convention.* Philadelphia: University of Pennsylvania Press.

Gjerdingen, R. O. (1996). Courtly behaviors. *Music Perception, 13*, 365–382.

Gjerdingen, R. O. (2007). *Music in the galant style*. Oxford and New York: Oxford University Press.

Gotlieb, H., & Konečni, V. J. (1985). The effects of instrumentation, playing style, and structure in the Goldberg Variations by Johann Sebastian Bach. *Music Perception, 3*, 87−102.

Gurney, E. (1880). *The power of sound*. London: Smith, Elder.

Hanninen, D. A. (2001). Orientations, criteria, segments: A general theory of segmentation for music analysis. *Journal of Music Theory, 45*, 345–433.

Hatten, R. S. (1992). Interpreting deception in music. *In Theory Only, 12*, 31–50.

Hatten, R. S. (1994). *Musical meaning in Beethoven: Markedness, correlation, and interpretation*. Bloomington: Indiana University Press.

Hatten, R. S. (2005). *Interpreting musical gestures, topics, and tropes: Mozart, Beethoven, Schubert*. Bloomington: Indiana University Press.

Holtmeier, L. (2002). Reconstructing Mozart. *Music Analysis, 21*, 307−325.

Huovinen, E. (2006). Varieties of musicological empiricism. *Empirical Musicology Review, 1*, 12–27.

Huron, D. (1999a). Empiricism and post-modernism: Systematic Musicology in a postmodern age. *The 1999 Ernst Bloch Lectures*, University of California, Berkeley. http://musicog.ohio-state.edu/Music220/Bloch.lectures/3.Methodology.html.

Huron, D. (1999b). Music and Mind: Foundations of Cognitive Musicology. *The 1999 Ernst Bloch Lectures*, University of California, Berkeley. http://musicog.ohio-state.edu/Music220/Bloch.lectures/1.Preamble.html.

Huron, D. (1999c). What is a musical feature? Forte's analysis of Brahms opus 51, no.1 revisited. The 1999 Ernst Bloch Lectures, University of California, Berkeley. http://musicog.ohio-state.edu/Music220/Bloch.lectures/4.Analysis.html.

Huron, D., & Parncutt, R. (1993). An improved theory of tonality perception incorporating pitch salience and echoic memory. *Psychomusicology, 12*, 154–171.

Hutchins, S., & Palmer, C. (2008). Repetition priming in music. *Journal of Experimental Psychology: Human Perception and Performance, 34*, 693–707.

Jones, M. R., & Boltz, M. G. (1989). Dynamic attending and responses to time. *Psychological Review, 96*, 459–491.

Jones, M. R., Boltz, M. G., & Klein, J. M. (1993). Expected endings and judged duration. *Memory & Cognition, 21*, 646–665.

Jusczyk, P. W., & Krumhansl, C. (1993). Pitch and rhythmic patterns affecting infants' sensitivity to musical phrase structure. *Journal of Experimental Psychology: Human Perception and Performance, 19*, 627−640.

Karno, M., & Konečni, V. J. (1992). The effects of structural interventions in the first movement of Mozart's Symphony in G minor K. 550 on aesthetic preference. *Music Perception, 10*, 63−72.

Koch, H. C. (1969). *Versuch einer Anleitung zur Composition*. Hildesheim: G. Olms. (Original work published 1782−1793).

Konečni, V. J. (1984). Elusive effects of artists' "messages." In W. R. Crozier & A. J. Chapman (Eds.), *Cognitive processes in the perception of art* (pp. 71−93). Amsterdam: North-Holland Press.

Konečni, V. J. (1987). Response to Robert Batt. *Music Perception, 5*, 215−217.

Knösche, T. T., Neuhaus, C., Haueisen, J., Alter, K., Maess, B., Witte, O. W., & Friederici, A. D. (2005). Perception of phrase structure in music. *Human Brain Mapping, 24*, 259−273.

Kramer, J. (1973). Multiple and non-linear time in Beethoven's opus 135. *Perspectives of New Music, 11*, 122−145.

Kramer, J. (1981). New temporalities in music. *Critical Inquiry, 7*, 539−556.

Kramer, J. D. (1982). Beginnings and endings in western art music. *Canadian University Music Review, 3*, 1−14.

Kramer, J. D. (1988). *The time of music*. New York: Schirmer Books.

Krumhansl, C. (1979). The psychological representation of musical pitch in a tonal context. *Cognitive Psychology, 11*, 346–374.

Krumhansl, C. (1990a). *Cognitive foundations of musical pitch*. Oxford University Press.

Krumhansl, C. (1990b). Tonal hierarchies and rare intervals in music cognition. *Music Perception, 7*, 309–324.

Krumhansl, C. (1995). Music psychology and music theory: Problems and prospects. *Music Theory Spectrum, 17*, 53–80.

Krumhansl, C. (1996). A perceptual analysis of Mozart's piano sonata K. 282: Segmentation, tension, and musical ideas. *Music Perception, 13*, 401−432.

Krumhansl, C. (1998). Topic in music: An empirical study of memorability, openness, and emotion in Mozart's String Quintet in C Major and Beethoven's String Quartet in A Minor. *Music Perception, 16*, 119−134.

Krumhansl, C., & Jusczyk, P. W. (1990). Infants' perception of phrase structure in music. *Psychological Science, 1*, 70−73.

Krumhansl, C., & Kessler, E. J. (1982). Tracing the dynamic changes in perceived tonal organization in a spatial representation of musical keys. *Psychological Review, 89*, 334–368.

Krumhansl, C., & Shepard, R. N. (1979). Quantification of the hierarchy of tonal functions within a diatonic context. *Journal of Experimental Psychology: Human Perception and Performances, 5*, 579–594.

Lalitte, P., & Bigand, E. (2006). Music in the moment? Revisiting the effect of large-scale structures. *Perceptual and Motor Skills, 103*, 811−828.

Lalitte, P., Bigand, E., Poulin-Charronnat, B., McAdams, S., Delbé, C., & D'Adamo, D. (2004). The perceptual structure of thematic materials in *The angel of death*. *Music Perception, 22*, 265−296.

Lamont, A. (1998). Music, education, and the development of pitch perception: The role of context, age and musical experience. *Psychology of Music, 26*, 7–25.

Leman, M. (1995). *Music and schemata theory: Cognitive foundations of systematic musicology*. Berlin: Springer.

Lerdahl, F., & Jackendoff, R. (1983). *A generative theory of tonal music*. Cambridge, MA: MIT Press.

Lerdahl, F. (1996). Calculating tonal tension. *Music Perception, 13*, 319–363.

Levinson, J. (1997). *Music in the moment*. Ithaca, NY: Cornell University Press.

Levy, J. M. (1981). Gesture, form, and syntax in Haydn's music. In J. P. Larson, Howard Serwer, and James Webster (Eds.), *Haydn Studies* (pp. 355−62). New York: Norton.

Levy, J. M. (1982). Texture as a sign in classic and early romantic music. *Journal of the American Musicological Society, 35*, 482−531.

Lochhead, J. (1979). The temporal in Beethoven's opus 135: When are ends beginnings? *In Theory Only, 4*, 3−30.

Markman, A. A., & Wisniewski, E. J. (1997). Similar and different: The differentiation of basic-level categories. *Journal of Experimental Psychology: Leaning, Memory, and Cognition, 23*, 54−70.

Marmel, F., & Tillmann, B. (2009). Tonal priming beyond tonics. *Music Perception, 26*, 211−221.

Marmel, F., Tillmann, B., & Dowling, W. J. (2008). Tonal expectations influence pitch perception. *Perception & Psychophysics, 70*, 841−852.

Marvin, E. W., & Brinkman, A. (1999). The effect of modulation and formal manipulation on perception of tonic closure by expert listeners. *Music Perception, 16*, 389−407.

Marvin, E. W., & Laprade, P. A. (1987). Relating musical contours: Extensions of a theory of contour. *Journal of Music Theory, 31*, 225–267.

Mattheson, J. (1981). *Der vollkommene Capellmeister.* (E. C. Harriss, Trans., and Ed.). Ann Arbor: UMI Research Press. (Original work published 1739).

McAdams, S. (1989). Psychological constraints on form-bearing dimensions in music. *Contemporary Music Review, 4*, 181−198.

McAdams, S., & Bigand, E. (Eds.). (1993). *Thinking in sound: The cognitive psychology of human audition*. Oxford: Clarendon Press.

McAdams, S., Vines, B. W., Vieillard, S., Smith, B. K., & Reynolds, R. (2004). Influences of large-scale form on continuous ratings in response to a contemporary piece in a live concert setting. *Music Perception, 22*, 297−350.

McCreless, P. (2002). Music and rhetoric. In T. Christensen (Ed.). *The Cambridge history of Western music theory* (pp. 847-879). Cambridge: Cambridge University Press.

Meyer, L. B. (1973). *Explaining music: Essays and explorations*. Berkeley: University of California Press.

Meyer, L. B. (1989). *Style and music: Theory, history, and Ideology*. Philadelphia: University of Pennsylvania Press.

Meyer, L. B. (1998). A universe of universals. *The Journal of Musicology, 16*, 3–25.

Mozart, W. A. (1977). *Klaviersonaten, Band I* [Score]. E. Herttrich (Ed.). München: G. Henle Verlag.

Oram, N., & Cuddy, L. L. (1995). Responsiveness of Western adults to pitch distributional information in melodic sequences. *Psychological Research, 57*, 103−118.

Palmer, C., & Krumhansl, C. (1987a). Independent temporal and pitch structures in determination of musical phrases. *Journal of Experimental Psychology: Human Perception and Performance, 13*, 116−126.

Palmer, C., & Krumhansl, C. (1987b). Pitch and temporal contributions to musical phrase perception: Effects of harmony, performance timing, and familiarity. *Perception & Psychophysics, 41*, 505−518.

Poulin-Charronnat, B., Bigand, E., Madurell, F. (2005). The influence of voice leading on harmonic priming. *Music Perception, 22*, 613−627.

Ratner, L. G. (1980). *Classic music: Expression, form and style*. New York: Schirmer Books.

Ratz, E. (1973). *Einführung in die musikalische Formenlehre: Über Formprinzipien in den Inventionen und Fugen J. S. Bachs und ihre Bedeutung für die Kompositionstechnik Beethovens*. (3rd ed.). Vienna: Universal.

Rosch, E. (1978). Principles of categorization. In E. Rosch & B. Lloyd (Eds.), *Cognition and Categorization* (pp. 27−48). London: Erlbaum.

Rosen, C. (1988). *Sonata forms*. New York: W. W. Norton.

Rosen, C. (1997). *The classical style: Haydn, Mozart, Beethoven*. New York: W. W. Norton.

Rosner, B. S., & Narmour, E. (1992). Harmonic closure: Music theory and perception. *Music Perception, 9*, 383−412.

Schellenberg, G. E., Bigand, E., Poulin-Charronnat, B., Garnier, C., Stevens, C. (2005). Children's implicit knowledge of harmony in Western music. *Developmental Science, 8*, 551−566.

Schmalfeldt, J. (1992). Cadential processes: The evaded cadence and the 'one more time' technique. *Journal of Musicological Research, 12,* 1–52.

Schmuckler, M. A., Boltz, M. G. (1994). Harmonic and rhythmic influences on musical expectancy. *Perception & Psychophysics, 56*, 313–325.

Schoenberg, A. (1967). *Fundamentals of musical composition*. G. Strang and L. Stein (Eds.). London: Faber and Faber.

Sisman, E. (1982). Small and expanded forms: Koch's model and Haydn's music. *The Musical Quarterly, 68*, 444−475.

Snyder, B. (2000). *Music and memory: An introduction*. Cambridge, MA: MIT Press.

Spitzer, M. (1996). The retransition as sign: Listener-oriented approaches to tonal closure in Haydn sonata-form movements. *Journal of the Royal Musical Association, 121*, 11−45.

Stoffer, T. H. (1985). Representation of phrase structure in the perception of music. *Music Perception, 3*, 191–220.

Stoïanova, I. (1978). *Geste, texte, musique*. Paris: Union Générale d'édition.

Tafuri, J., Baldi, G., & Caterina, R. (2003/2004). Beginnings, and endings in the musical improvisations of children aged 7 to 10 years. In *Musicae Scientiae,* Special issue on musical creativity, 157–174.

Tan, N. Aiello, R., & Beaver, T. G. (1981). Harmonic structure as a determinant of melodic organization. *Memory & Cognition, 14*, 1–36.

Tan, S., & Spackman, M. P. (2005). Listeners' judgments of the musical unity of structurally altered and intact musical compositions. *Psychology of Music, 33*, 133–153.

Tan, S., Spackman, M. P., & Peaslee, C. L. (2006). The effects of repeated exposure on liking and judgment of musical unity of intact and patchwork compositions. *Music Perception, 23*, 407–421.

Temperley, D. (2003). End-accented phrases: An analytical exploration. *Journal of Music Theory, 47*, 125–154.

Temperley, D. (1999). The question of purpose in music theory: Description, suggestion, and explanation. *Current Musicology, 66*, 66−85.

Temperley, D., & Marvin, E. W. (2008). Pitch-class distribution and the identification of key. *Music Perception, 25*, 193–212.

Tillmann, B., & Bigand, E. (1996). Does formal musical structure affect perception of musical expressiveness? *Psychology of Music, 24*, 3−17.

Tillmann, B., Bigand, E., Escoffier, N., & Lalitte, P. (2006). The influence of musical relatedness on timbre discrimination. *European Psychology: Human Perception and Performance, 34*, 1031−1043.

Tillmann, B., Bigand, E., & Madurell, F. (1998). Local versus global processing of harmonic cadences in the solution of musical puzzles. *Psychological Research, 61,* 157−174.

Tillmann, B., Bigand, E., & Pineau, M. (1998). Effects of global and local contexts on harmonic expectancy. *Music Perception, 16*, 99−117.

Tillmann, B. Bharucha, J. J., & Bigand, E. (2000). Implicit learning of tonality: A serf-organizing approach. *Psychological Review, 107*, 885−913.

Tillmann, B., & Bigand, E. (2001). Global context effect in normal and scrambled musical sequences. *Journal of Experimental Psychology: Human Perception and Performance, 27*, 1185−1196.

Tillmann, B., & Bigand, E. (2002). A comparative review of priming effects in language and music. In P. McKevitt and S. O. Nuallain (Eds.), *Language, vision, and music*. Amsterdam, Netherlands: John Benjamins.

Tillmann, B., & Bigand, E. (2004). The Relative Importance of Local and Global Structures in Music Perception. *The Journal of Aesthetics and Art Criticism, 62*, 211–222.

Tillmann, B., Peretz, I., Bigand, E., & Gosselin, N. (2007). Harmonic priming in an amusic patient: The power of implicit tasks. *Cognitive Neuropsychology, 24*, 603−622.

Vickers, B. (1984). Figures of rhetoric/figures of music? *Rhetorica: A Journal of the History of Rhetoric, 2*, 1−44.

Vos, P. G. (1999). Key implications of ascending fourth and descending fifth openings. *Psychology of Music, 27*, 4−17.

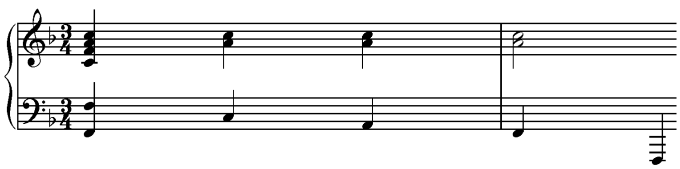
Vos, P. G. (2000). Tonality induction: Theoretical problems and dilemmas. *Music Perception, 17*, 403–416.

Zbikowski, L. M. (2002). *Conceptualizing music: Cognitive structure, theory, and analysis*. New York: Oxford University Press.

Appendix A

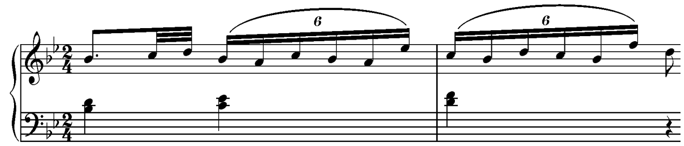
Experiment 1: Musical excerpts and form-functional judgment distributions[1]

B1. Piano Sonata in F major, K. 270, i, 1−2



	B	M	E
mu	9	2	9
nm	5	5	10

B2. Piano Sonata in B-flat major, K. 281, i, 1−2



	B	M	E
mu	17	3	0
nm	7	12	1

B3. Piano Sonata in G major, K. 283, i, 1−2

	B	M	E
mu	20	0	0
nm	17	3	0

B4. Piano Sonata in D major, K. 284, i, 1−2

	B	M	E
mu	17	3	0
nm	7	12	1

B5. Piano Sonata in F major, K. 280, i, 13−15

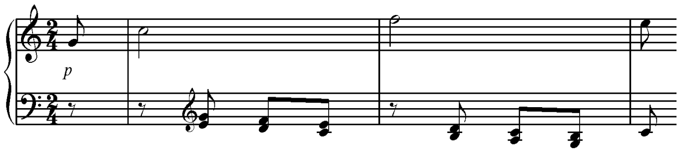
	B	M	E
mu	2	18	0
nm	3	15	2

B6. Piano Sonata in C major, K. 279, ii, 1−2

	B	M	E
mu	13	7	0
nm	6	13	1

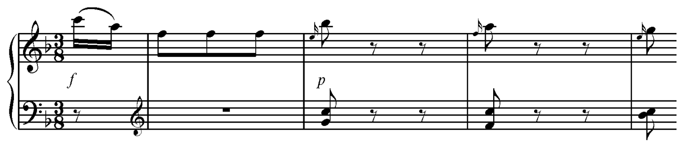
[1] As a reminder, dynamics and articulation were not tested in this project.

B7. Piano Sonata in C major, K. 279, iii, 1–3



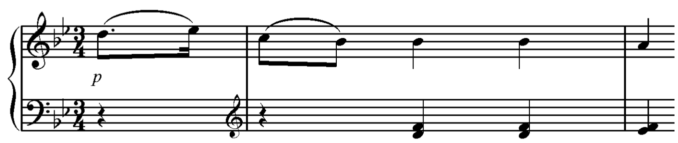
	B	M	E
mu	8	11	1
nm	12	7	1

B8. Piano Sonata in F major, K. 280, iii, 1–4



	B	M	E
mu	10	8	2
nm	8	9	3

B9. Piano Sonata in F major, K. 282, ii, 1–2

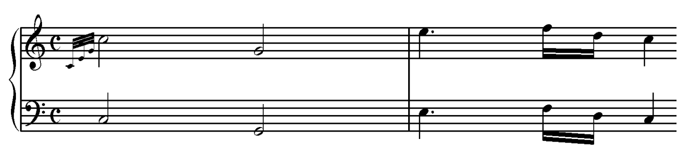


	B	M	E
mu	17	2	1
nm	13	6	1

B10. Piano Sonata in D major, K. 284, iii, 1–3

	B	M	E
mu	18	2	0
nm	16	3	1

B11. Piano Sonata in C major, K. 309, i, 1–2

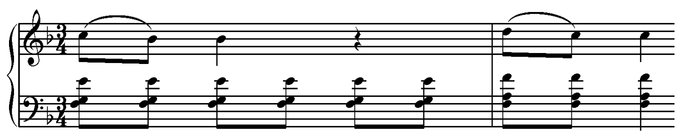


	B	M	E
mu	19	0	1
nm	7	8	5

B12. Piano Sonata in D major, K. 311, i, 1–2

	B	M	E
mu	19	1	0
nm	14	6	0

M1. Piano Sonata in F major, K. 280, i, 5−6

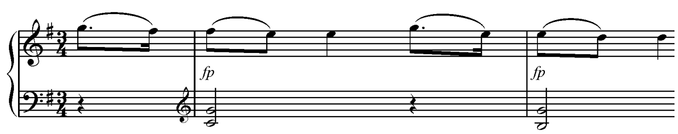


	B	M	E
mu	0	20	0
nm	0	20	0

M2. Piano Sonata in E-flat major, K. 282, ii, 5−7

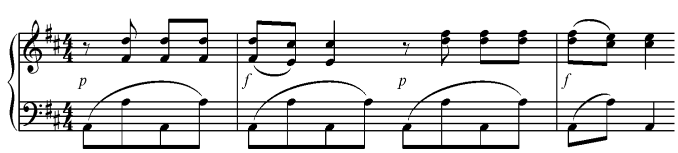
	B	M	E
mu	1	19	0
nm	5	15	0

M3. Piano Sonata in G major, K. 283, i, 5−6



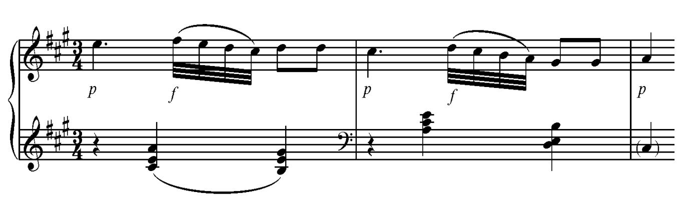
	B	M	E
mu	5	15	0
nm	10	10	0

M4. Piano Sonata in D major, K. 284, i, 5−6



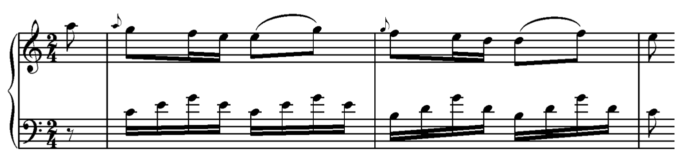
	B	M	E
mu	2	18	0
nm	7	11	2

M5. Piano Sonata in D major, K. 284, ii, 5−7



	B	M	E
mu	13	7	0
nm	10	7	3

M6. Piano Sonata in C major, K. 309, iii, 5−7



	B	M	E
mu	6	13	1
nm	8	11	1

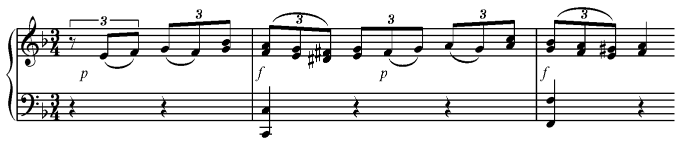
M7. Piano Sonata in D major, K. 311, iii, 5–7

	B	M	E
mu	14	6	0
nm	7	12	1

M8. Piano Sonata in A minor, K. 310, i, 6–7

	B	M	E
mu	1	19	0
nm	5	13	2

M9. Piano Sonata in C major, K. 279, ii, 7–8



	B	M	E
mu	4	15	1
nm	6	13	1

M10. Piano Sonata in B-flat major, K. 281, ii, 7–8

	B	M	E
mu	6	14	0
nm	6	14	0

M11. Piano Sonata in B-flat major, K. 281, i, 12–14

	B	M	E
mu	0	17	3
nm	2	11	7

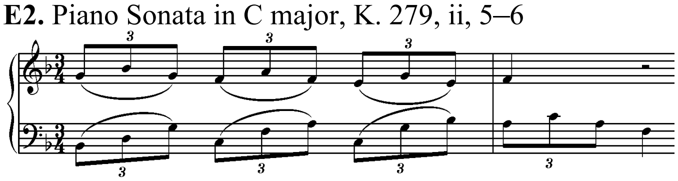
M12. Piano Sonata in C major, K. 279, i, 5–6

	B	M	E
mu	10	10	0
nm	3	17	0

E1. Piano Sonata in C major, K. 279, i, 11–12

	B	M	E
mu	0	0	20
nm	2	10	8

E2. Piano Sonata in C major, K. 279, ii, 5–6



	B	M	E
mu	0	0	20
nm	0	3	17

E3. Piano Sonata in C major, K. 279, iii, 9–10

	B	M	E
mu	1	0	19
nm	0	3	17

E4. Piano Sonata in F major, K. 280, i, 12–13

	B	M	E
mu	0	1	19
nm	1	0	19

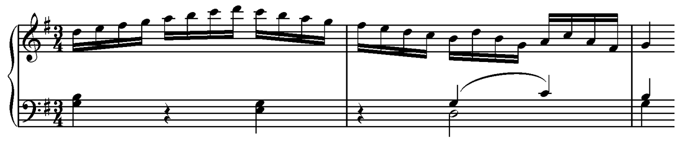
E5. Piano Sonata in F major, K. 280, iii, 13–16

	B	M	E
mu	0	0	20
nm	0	1	19

E6. Piano Sonata in B-flat major, K. 281, iii, 6–8

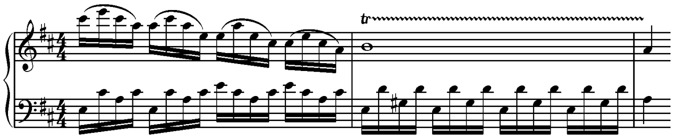
	B	M	E
mu	0	0	20
nm	2	0	18

E7. Piano Sonata in G major, K. 283, i, 8–10



	B	M	E
mu	0	0	20
nm	1	3	16

E8. Piano Sonata in D major, K. 284, i, 48–50



	B	M	E
mu	0	0	20
nm	0	7	13

E9. Piano Sonata in D major, K. 284, ii, 15–16

	B	M	E
mu	0	0	20
nm	1	4	15

E10. Piano Sonata in C major, K. 309, iii, 18–19

	B	M	E
mu	0	1	19
nm	0	3	17

E11. Piano Sonata in D major, K. 311, i, 30–32

	B	M	E
mu	0	0	20
nm	0	5	15

E12. Piano Sonata in D major, K. 311, iii, 15–16

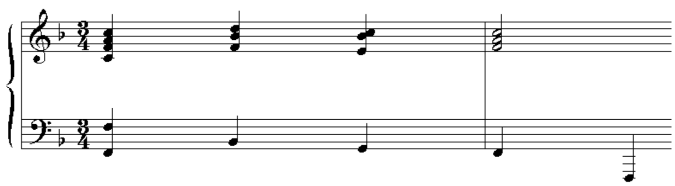
	B	M	E
mu	0	1	19
nm	1	5	14

B, M, and E stand for beginning, middle, and end, respectively; 'mu' and 'nm' stand for musicians and non-musicians.

Appendix B

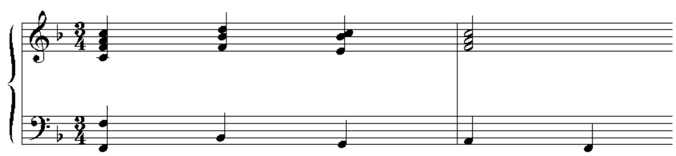
Experiment 2: Musical excerpts and form-functional judgment distributions[1]

B1-1



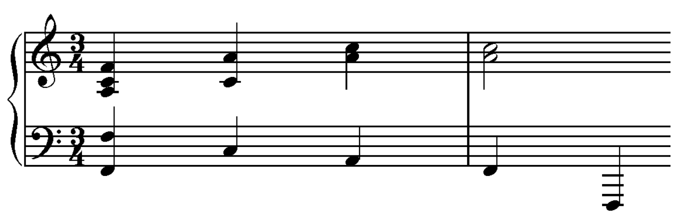
	B	M	E
mu	3	0	17
nm	0	0	20

B1-2



	B	M	E
mu	0	6	14
nm	0	8	12

B1-3

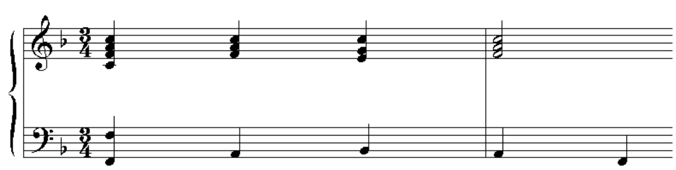


	B	M	E
mu	3	2	15
nm	1	1	18

B1-4

	B	M	E
mu	11	3	6
nm	1	9	10

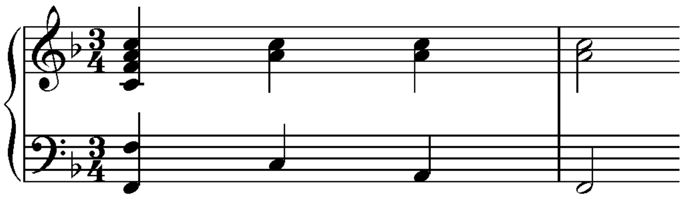
B1-5



	B	M	E
mu	6	6	8
nm	1	3	16

[1] Excerpts already used in Experiment 1 and were provided the same labels as in Appendix A. Examples that are one modification apart are not necessarily adjacent in the list.

B1-6

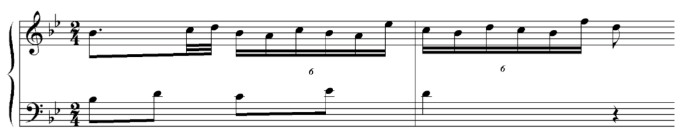


	B	M	E
mu	4	1	15
nm	2	2	16

B2-1

	B	M	E
mu	15	5	0
nm	9	10	1

B2-2



	B	M	E
mu	10	9	1
nm	6	13	1

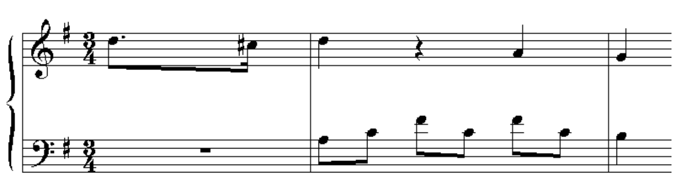
B2-3

	B	M	E
mu	12	8	0
nm	3	16	1

B2-4 (33% slower than original)

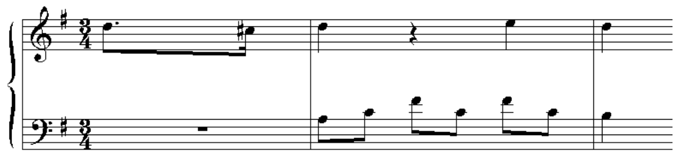
	B	M	E
mu	17	3	0
nm	14	5	1

B3-1



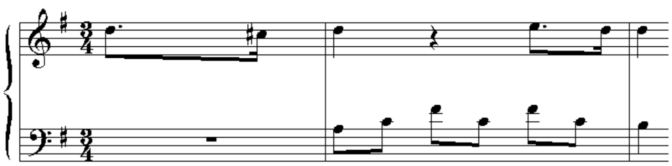
	B	M	E
mu	4	8	8
nm	7	6	7

B3-2



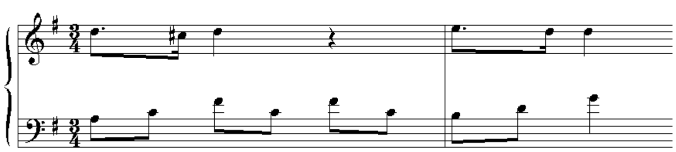
	B	M	E
mu	7	13	0
nm	14	5	1

B3-3



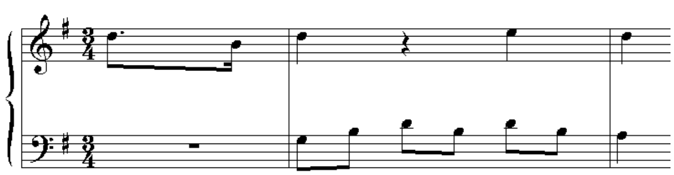
	B	M	E
mu	4	15	1
nm	10	10	0

B3-4



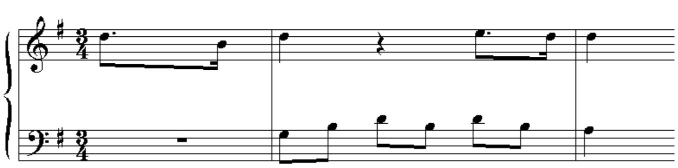
	B	M	E
mu	1	19	0
nm	5	14	1

B3-5



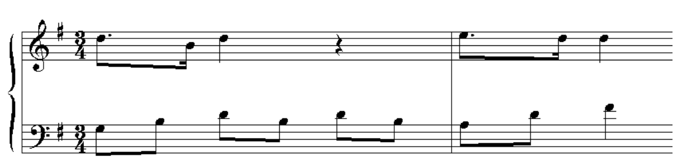
	B	M	E
mu	7	13	0
nm	12	7	1

B3-6



	B	M	E
mu	19	1	0
nm	16	4	0

B3-7

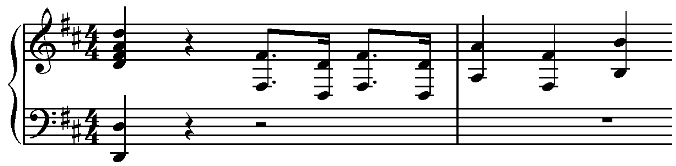


	B	M	E
mu	12	8	0
nm	7	12	1

B4-1

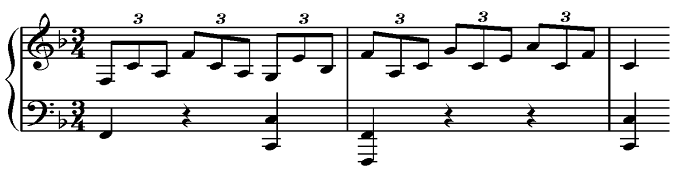
	B	M	E
mu	6	12	2
nm	3	13	4

B4-2



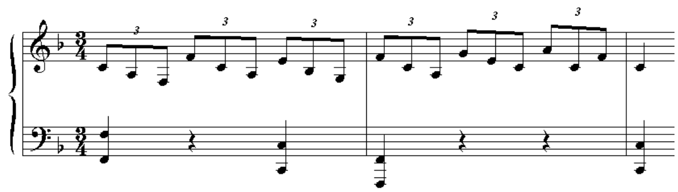
	B	M	E
mu	8	11	1
nm	2	11	7

B5-1



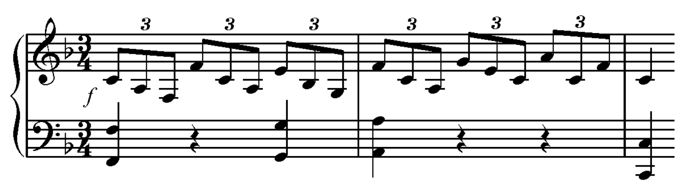
	B	M	E
mu	5	15	0
nm	2	15	3

B5-2



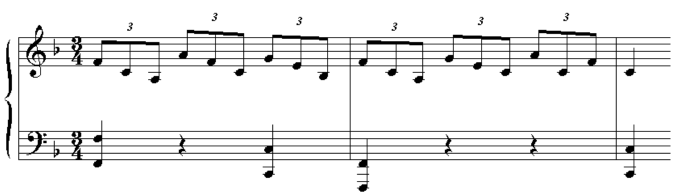
	B	M	E
mu	5	15	0
nm	3	13	4

B5-3



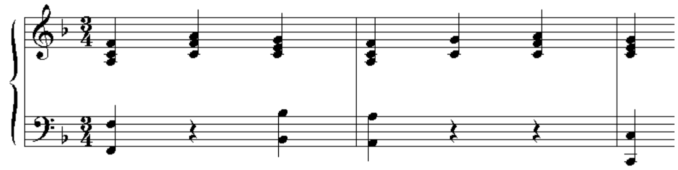
	B	M	E
mu	4	16	0
nm	4	13	3

B5-4



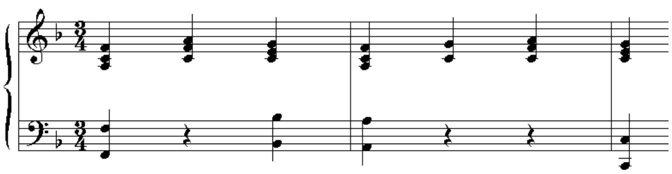
	B	M	E
mu	8	11	1
nm	4	12	4

B5-5



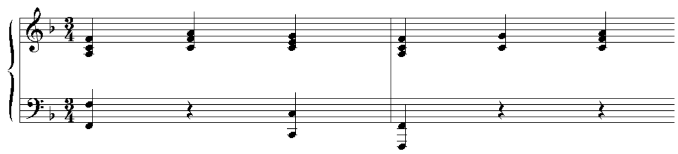
	B	M	E
mu	8	12	0
nm	4	11	5

B5-6



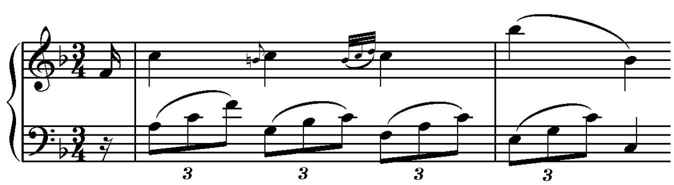
	B	M	E
mu	11	7	2
nm	9	8	3

B5-7



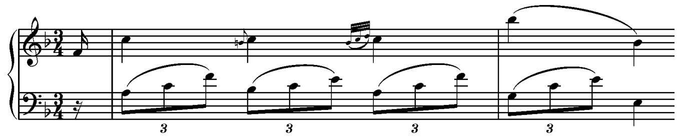
	B	M	E
mu	11	7	2
nm	7	11	2

B6-1



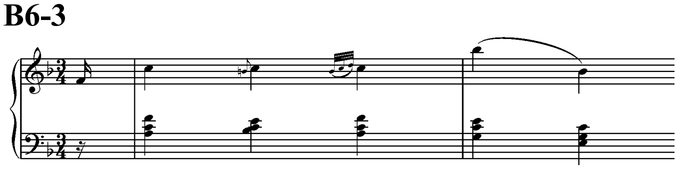
	B	M	E
mu	14	5	1
nm	6	11	3

B6-2



	B	M	E
mu	14	6	0
nm	6	12	2

B6-3



	B	M	E
mu	13	6	1
nm	7	5	8

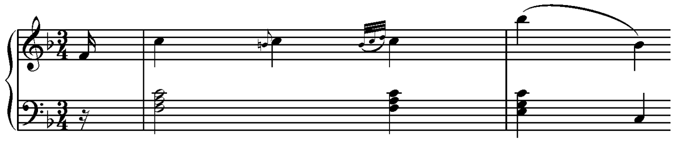
B6-4

	B	M	E
mu	15	5	0
nm	6	13	1

B6-5

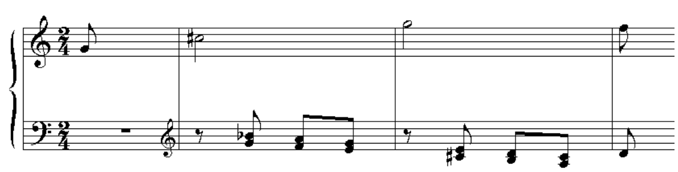
	B	M	E
mu	12	7	1
nm	8	11	1

B6-6



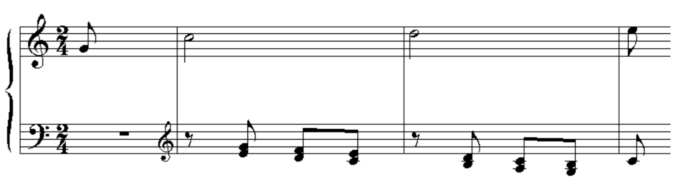
	B	M	E
mu	17	3	0
nm	12	6	2

B7-1



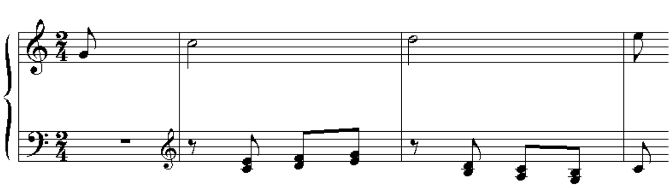
	B	M	E
mu	1	18	1
nm	5	13	2

B7-2



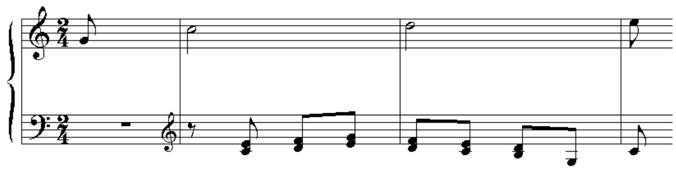
	B	M	E
mu	7	13	0
nm	4	10	6

B7-3



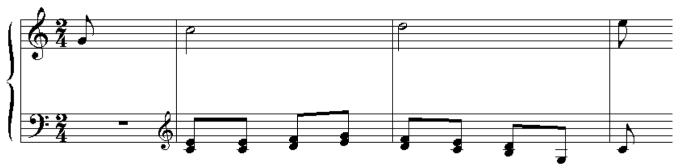
	B	M	E
mu	13	7	0
nm	10	8	2

B7-4



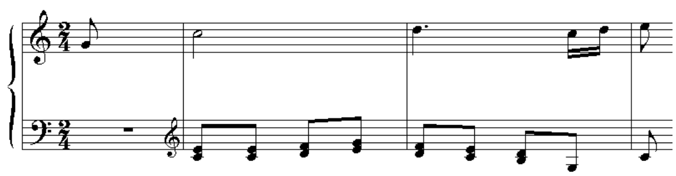
	B	M	E
mu	12	8	0
nm	12	5	3

B7-5



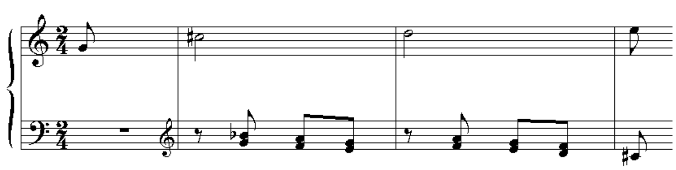
	B	M	E
mu	16	4	0
nm	14	5	1

B7-6



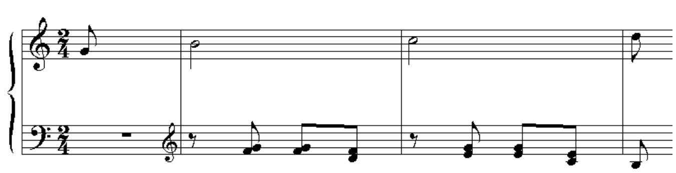
	B	M	E
mu	16	4	0
nm	10	9	1

B7-7



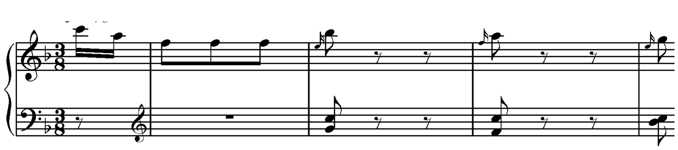
	B	M	E
mu	2	18	0
nm	6	13	1

B7-8



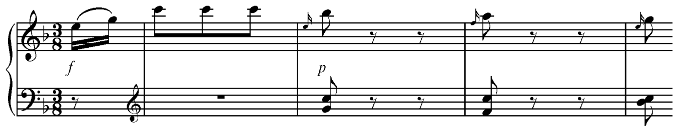
	B	M	E
mu	1	18	1
nm	9	10	1

B8. Piano Sonata in F major, K. 280, iii, 1−4



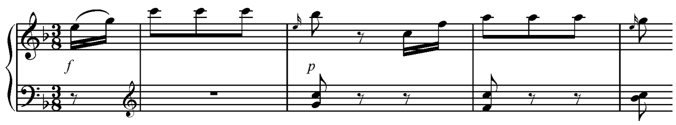
	B	M	E
mu	15	5	0
nm	8	1	11

B8-1



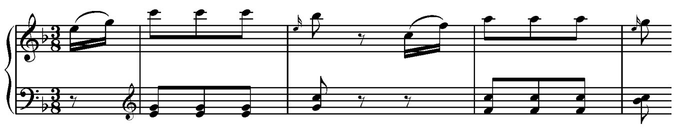
	B	M	E
mu	2	17	1
nm	8	6	6

B8-2



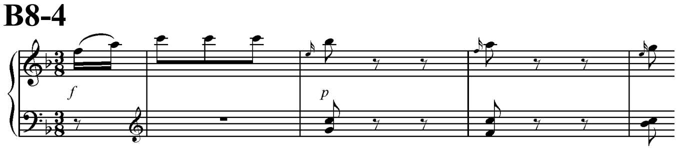
	B	M	E
mu	6	13	1
nm	13	5	2

B8-3



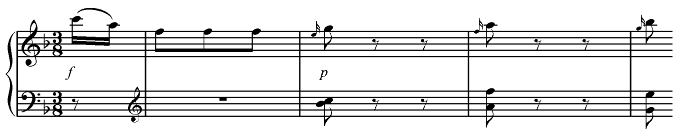
	B	M	E
mu	4	16	0
nm	7	12	1

B8-4



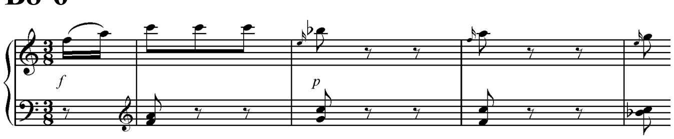
	B	M	E
mu	13	7	0
nm	7	5	8

B8-5



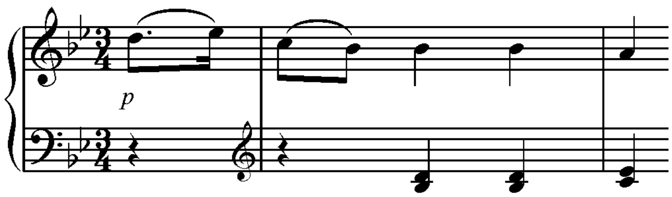
	B	M	E
mu	16	4	0
nm	7	5	8

B8-6



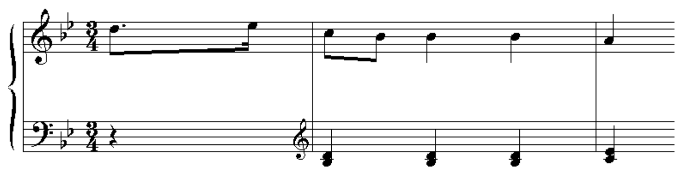
	B	M	E
mu	10	10	0
nm	9	6	5

B9-1



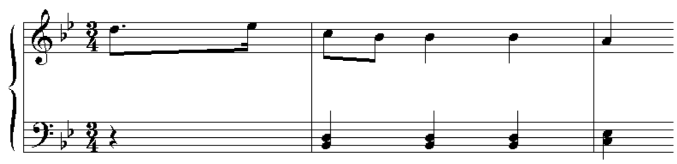
	B	M	E
mu	16	4	0
nm	11	4	5

B9-2



	B	M	E
mu	20	0	0
nm	12	4	4

B9-3

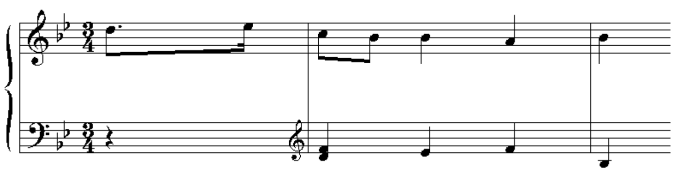


	B	M	E
mu	17	3	0
nm	8	10	2

B9-4

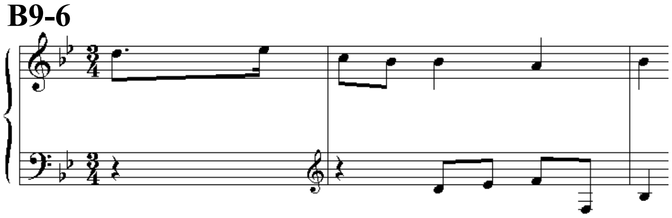
	B	M	E
mu	2	1	17
nm	0	0	20

B9-5



	B	M	E
mu	2	0	18
nm	1	1	18

B9-6



	B	M	E
mu	2	0	18
nm	2	2	16

B10-1

	B	M	E
mu	16	4	0
nm	18	2	0

B10-2

	B	M	E
mu	16	4	0
nm	19	1	0

B10-3

	B	M	E
mu	14	5	1
nm	18	2	0

B10-4

	B	M	E
mu	16	4	0
nm	18	1	1

B10-5

	B	M	E
mu	7	12	1
nm	17	2	1

B10-6

	B	M	E
mu	17	3	0
nm	14	6	0

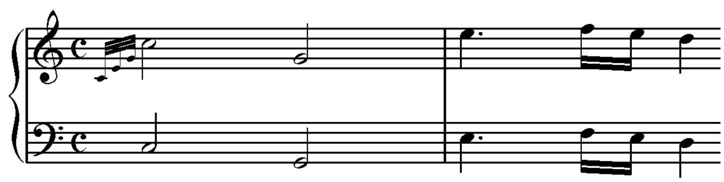
B10-7

	B	M	E
mu	8	12	0
nm	3	15	2

B10-8

	B	M	E
mu	7	11	2
nm	1	18	1

B11-1

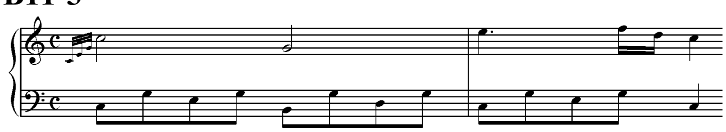


	B	M	E
mu	17	2	1
nm	8	7	5

B11-2

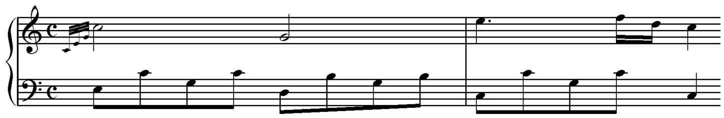
	B	M	E
mu	17	1	2
nm	3	16	1

B11-3



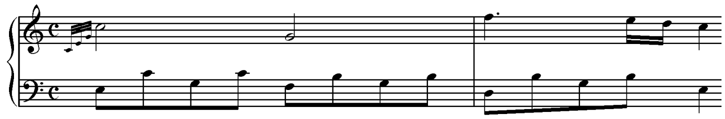
	B	M	E
mu	17	2	1
nm	5	9	6

B11-4



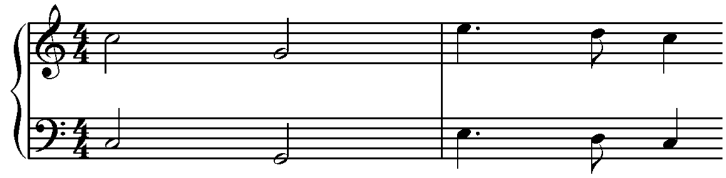
	B	M	E
mu	12	5	3
nm	7	6	7

B11-5



	B	M	E
mu	10	8	2
nm	1	15	4

B11-6



	B	M	E
mu	19	1	0
nm	7	10	3

B12-1

	B	M	E
mu	8	12	0
nm	2	16	2

B12-2

	B	M	E
mu	1	18	1
nm	1	17	2

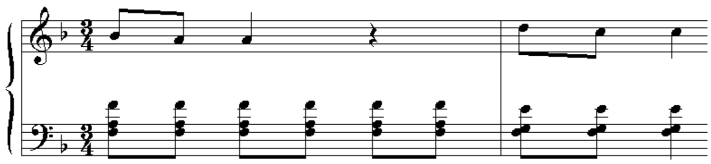
B12-3

	B	M	E
mu	5	12	3
nm	1	16	3

B12-4 (30% faster than original)

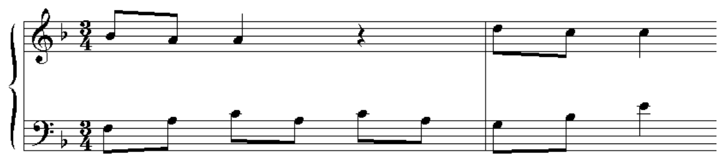
	B	M	E
mu	18	2	0
nm	8	10	2

M1-1



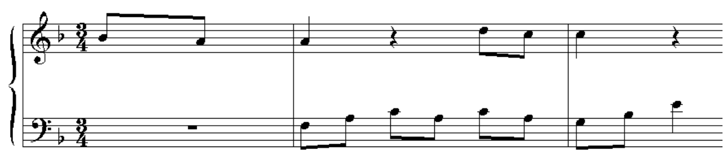
	B	M	E
mu	6	14	0
nm	0	19	1

M1-2



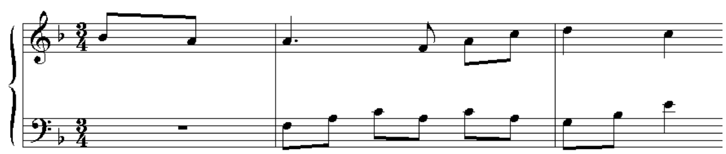
	B	M	E
mu	6	14	0
nm	7	13	0

M1-3



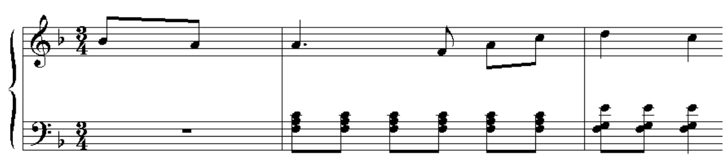
	B	M	E
mu	13	7	0
nm	15	5	0

M1-4



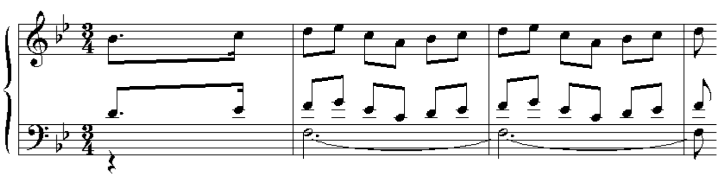
	B	M	E
mu	15	5	0
nm	12	6	2

M1-5



	B	M	E
mu	13	7	0
nm	12	7	1

M2-1

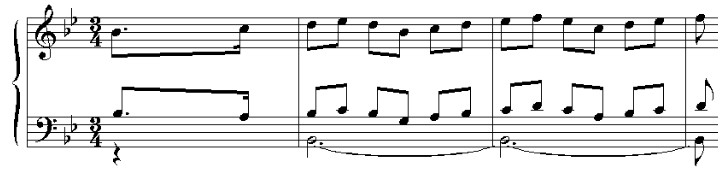


	B	M	E
mu	2	18	0
nm	7	11	2

M2-2

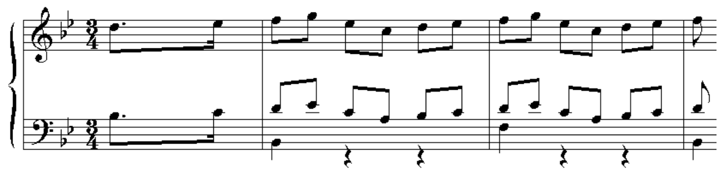
	B	M	E
mu	8	11	1
nm	4	13	3

M2-3



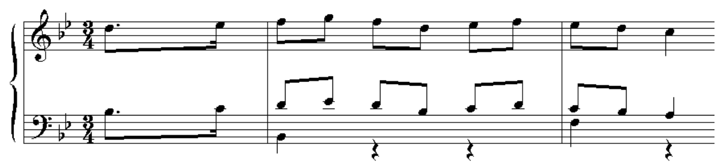
	B	M	E
mu	10	10	0
nm	10	10	0

M2-4



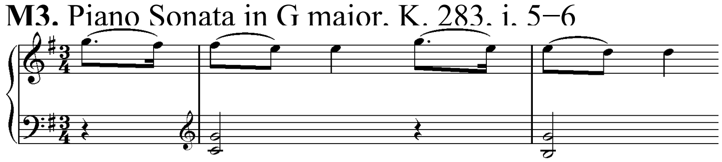
	B	M	E
mu	9	9	2
nm	3	13	4

M2-5



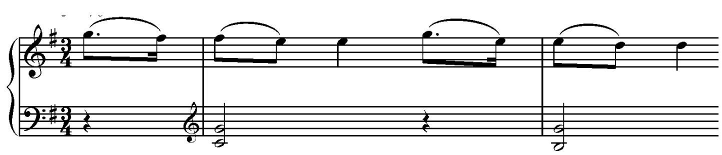
	B	M	E
mu	9	11	0
nm	11	8	1

M3. Piano Sonata in G major, K. 283, i. 5–6



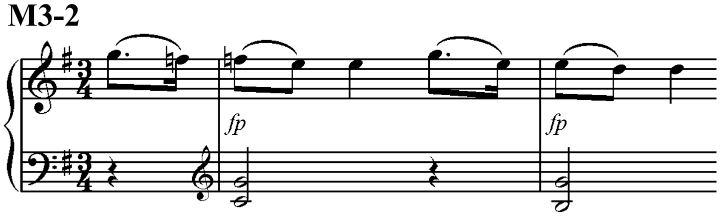
	B	M	E
mu	4	14	2
nm	13	7	0

M3-1 (28% slower than original)



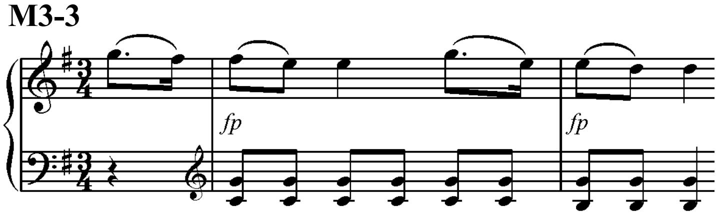
	B	M	E
mu	6	13	1
nm	13	4	3

M3-2



	B	M	E
mu	9	11	0
nm	14	4	2

M3-3

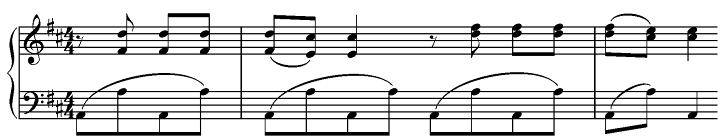


	B	M	E
mu	4	16	0
nm	12	8	0

M3-4

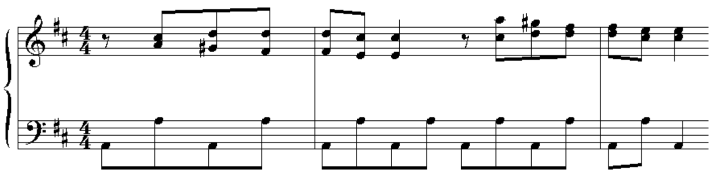
	B	M	E
mu	3	17	0
nm	8	12	0

M4. Piano Sonata in D major, K. 284, i, 5−6



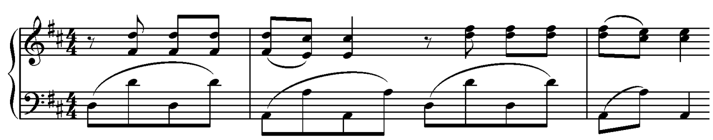
	B	M	E
mu	5	15	0
nm	2	17	1

M4-1



	B	M	E
mu	3	16	1
nm	6	14	0

M4-2



	B	M	E
mu	6	13	1
nm	3	16	1

M4-3

	B	M	E
mu	14	6	0
nm	5	15	0

M4-4

	B	M	E
mu	11	7	2
nm	9	11	0

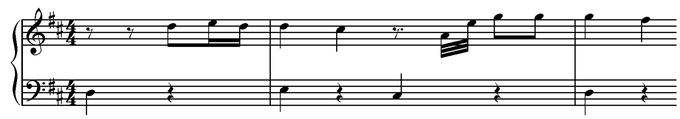
M4-5

	B	M	E
mu	14	6	0
nm	16	4	0

M4-6

	B	M	E
mu	12	8	0
nm	11	8	1

M4-7



	B	M	E
mu	17	3	0
nm	15	5	0

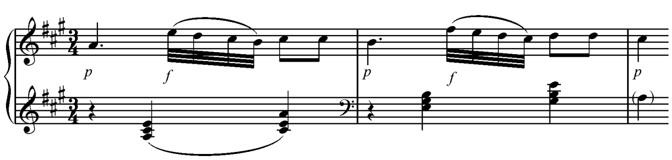
M5. Piano Sonata in D major, K. 284, ii, 5–7,

	B	M	E
mu	10	6	4
nm	8	4	8

M5-1

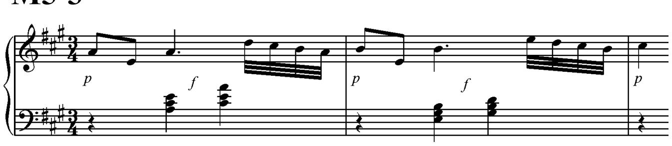
	B	M	E
mu	15	2	3
nm	9	4	7

M5-2



	B	M	E
mu	19	0	1
nm	12	6	2

M5-3



	B	M	E
mu	19	1	0
nm	18	2	0

M5-4

	B	M	E
mu	8	7	5
nm	7	0	13

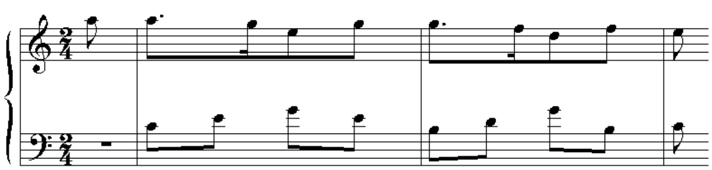
M5-5

	B	M	E
mu	8	5	7
nm	4	8	8

M6-1

	B	M	E
mu	7	13	0
nm	5	9	6

M6-2



	B	M	E
mu	10	7	3
nm	12	8	0

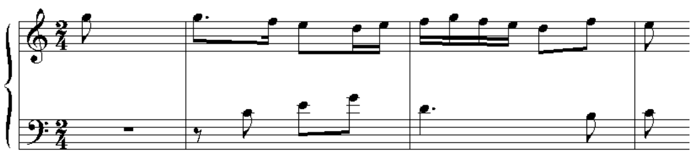
M6-3

	B	M	E
mu	9	10	1
nm	8	8	4

M6-4

	B	M	E
mu	19	0	1
nm	13	5	2

M6-5



	B	M	E
mu	13	5	2
nm	10	6	4

M6-6

	B	M	E
mu	0	17	3
nm	0	18	2

M6-7 (17% faster than original)

	B	M	E
mu	6	11	3
nm	5	13	2

M7-1

	B	M	E
mu	14	6	0
nm	9	10	1

M7-2

	B	M	E
mu	3	15	2
nm	3	17	0

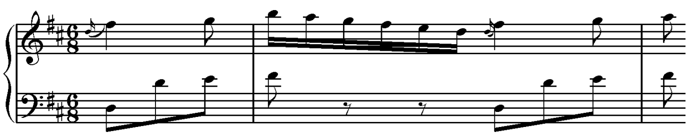
M7-3

	B	M	E
mu	1	19	0
nm	4	16	0

M7-4

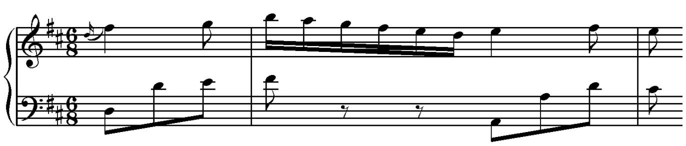
	B	M	E
mu	1	17	2
nm	0	16	4

M7-5



	B	M	E
mu	9	10	1
nm	7	13	0

M7-6



	B	M	E
mu	9	11	0
nm	9	11	0

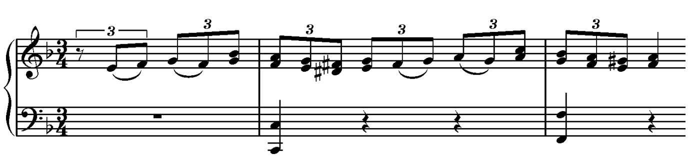
M7-7

	B	M	E
mu	11	9	0
nm	8	12	0

M7-8

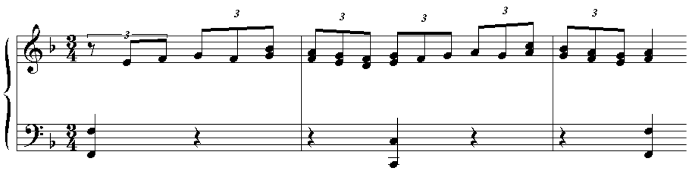
	B	M	E
mu	12	8	0
nm	6	14	0

M9-1



	B	M	E
mu	3	17	0
nm	7	13	0

M9-2

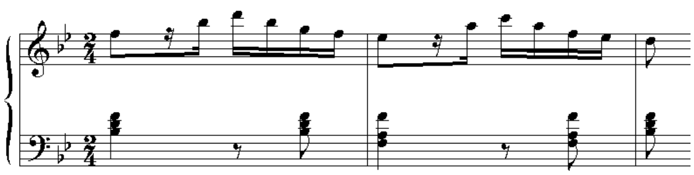


	B	M	E
mu	8	11	1
nm	5	9	6

M10-1

	B	M	E
mu	10	10	0
nm	8	12	0

M10-2

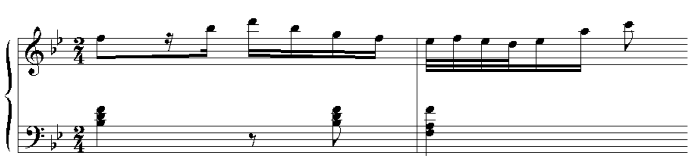


	B	M	E
mu	9	9	2
nm	11	6	3

M10-3

	B	M	E
mu	15	2	3
nm	13	4	3

M10-4



	B	M	E
mu	10	9	1
nm	18	2	0

M11-1

	B	M	E
mu	0	12	8
nm	3	11	6

M11-2

	B	M	E
mu	0	15	5
nm	0	10	10

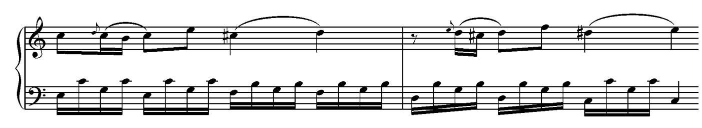
M11-3

	B	M	E
mu	0	1	19
nm	0	1	19

M11-4

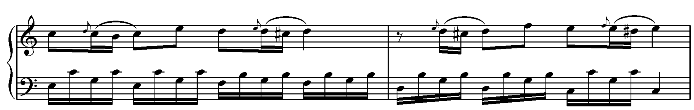
	B	M	E
mu	1	15	4
nm	1	14	5

M12-1



	B	M	E
mu	11	9	0
nm	0	19	1

M12-2

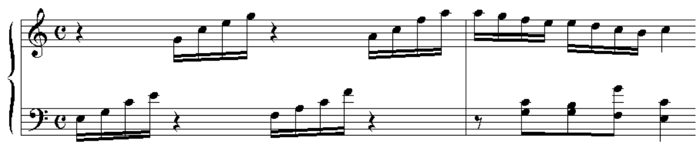


	B	M	E
mu	11	8	1
nm	4	16	0

M12-3

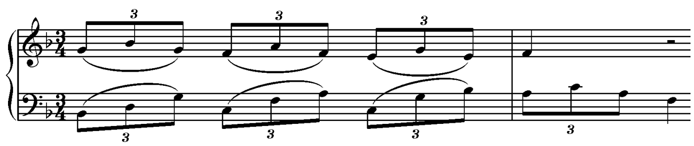
	B	M	E
mu	5	14	1
nm	10	10	0

E1-1



	B	M	E
mu	0	2	18
nm	0	2	18

E2. Piano Sonata in C major, K. 279, ii, 5–6

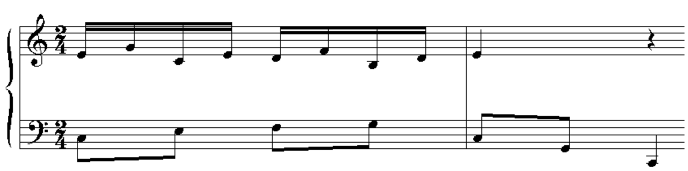


	B	M	E
mu	0	2	18
nm	1	2	17

E3-1

	B	M	E
mu	1	0	19
nm	0	2	18

E3-2

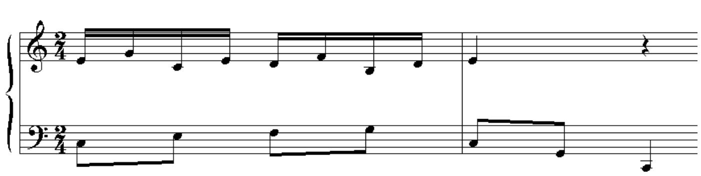


	B	M	E
mu	1	1	18
nm	0	2	18

E3-3

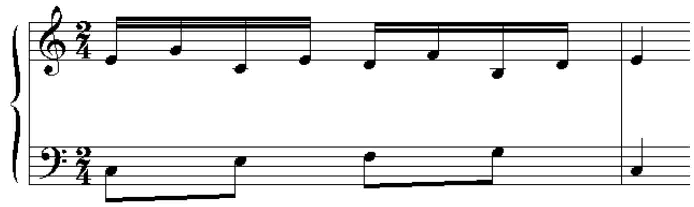
	B	M	E
mu	1	1	18
nm	0	2	18

E3-4



	B	M	E
mu	0	2	18
nm	0	0	20

E3-5



	B	M	E
mu	0	9	11
nm	0	10	10

E4. Piano Sonata in F major, K. 280, i, 12–13

	B	M	E
mu	0	1	19
nm	0	2	18

E5-1

	B	M	E
mu	1	1	18
nm	2	5	13

E5-2

	B	M	E
mu	1	17	2
nm	1	9	10

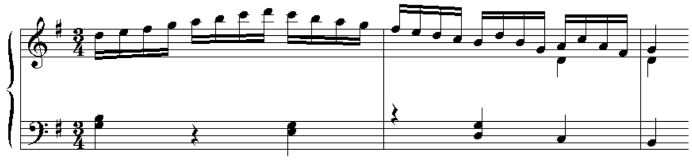
E5-3

	B	M	E
mu	0	9	11
nm	0	9	11

E6. Piano Sonata in B-flat major, K. 281, iii, 6–8

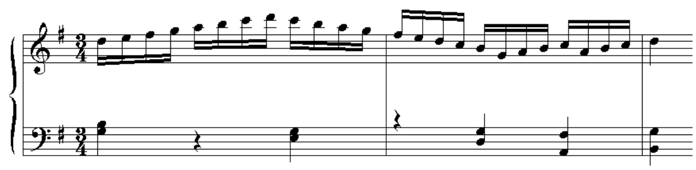
	B	M	E
mu	0	2	18
nm	1	2	17

E7-1



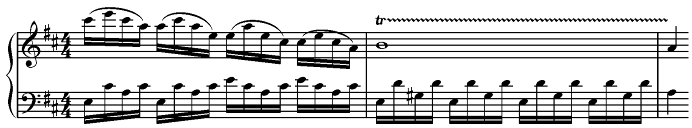
	B	M	E
mu	1	5	14
nm	4	6	10

E7-2



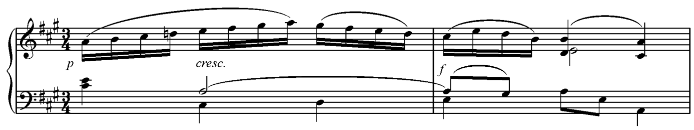
	B	M	E
mu	3	16	1
nm	2	17	1

E8. Piano Sonata in D major, K. 284, i, 48–50



	B	M	E
mu	0	1	19
nm	1	6	13

E9. Piano Sonata in D major, K. 284, ii, 15–16

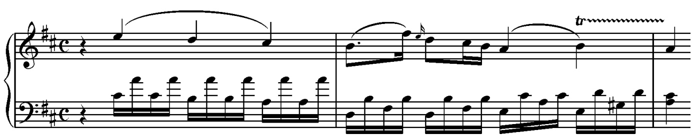


	B	M	E
mu	0	2	18
nm	3	1	16

E10. Piano Sonata in C major, K. 309, iii, 18–19

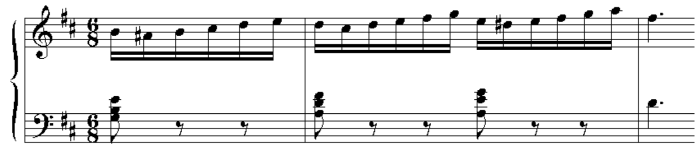
	B	M	E
mu	0	0	20
nm	0	1	19

E11. Piano Sonata in D major, K. 311, i, 30–32



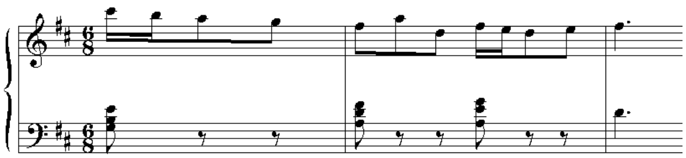
	B	M	E
mu	0	1	19
nm	2	5	13

E12-1



	B	M	E
mu	1	8	11
nm	3	11	6

E12-2



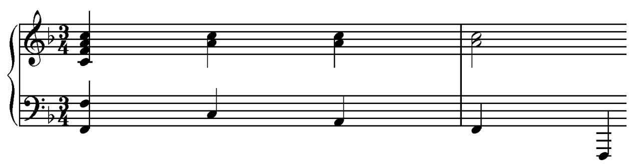
	B	M	E
mu	0	12	8
nm	0	10	10

B, M, and E stand for beginning, middle, and end, respectively; 'mu' and 'nm' stand for musicians and non-musicians.

Appendix C

Experiment 3: Musical excerpts and form-functional judgment distributions[1]

B1. Piano Sonata in F major, K. 270, i, 1−2

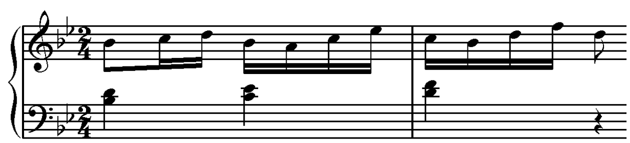


	1st time			2nd time		
	B	M	E	B	M	E
mu	3	1	16	4	0	16
nm	2	3	15	1	1	18

B1-1

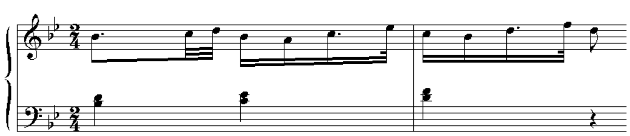
	B	M	E
mu	2	1	17
nm	0	4	16

B2-3



	B	M	E
mu	6	14	0
nm	6	12	2

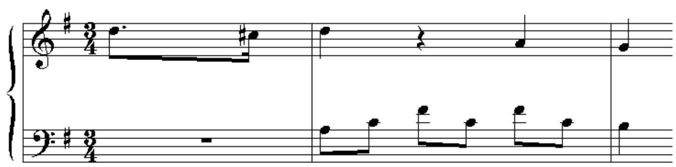
B2-3-1



	B	M	E
mu	13	7	0
nm	8	12	0

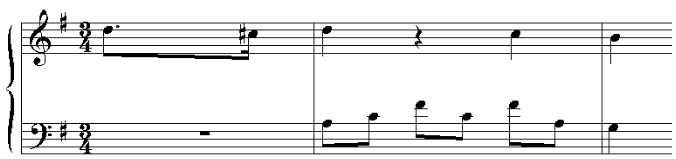
[1] Excerpts already used in Experiments 1 and 2 were provided the same labels as in Appendices A and B. New modifications were numbered consecutively to the last modification of a given family in Appendix B. The same excerpt thus always has the same label in Appendices A–C and different excerpts have necessarily different labels in all of the Appendices.

B3-1



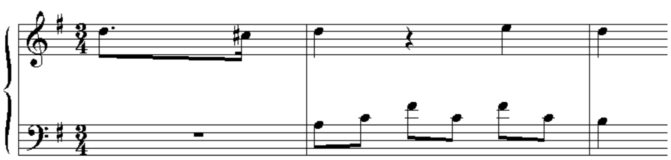
	1st time			2nd time		
	B	M	E	B	M	E
mu	4	13	3	2	10	8
nm	8	9	3	3	14	3

B3-1-1



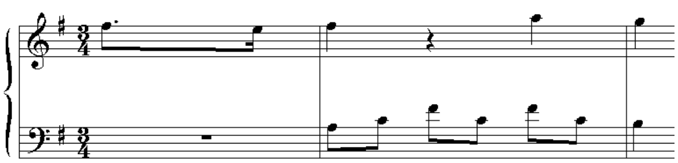
	B	M	E
mu	3	14	3
nm	4	12	4

B3-2



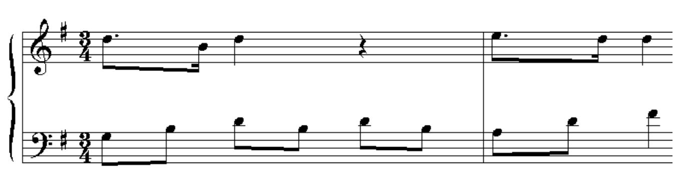
	B	M	E
mu	5	15	0
nm	9	11	0

B3-2-1



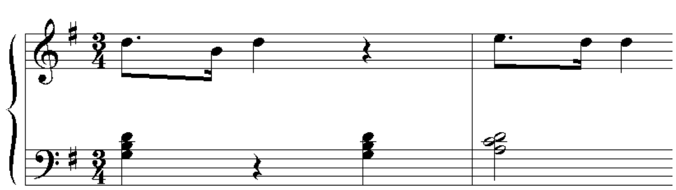
	B	M	E
mu	1	15	4
nm	8	5	7

B3-7



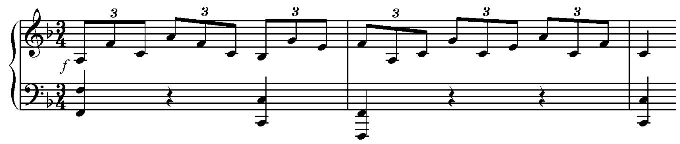
	B	M	E
mu	9	11	0
nm	5	14	1

B3-7-1



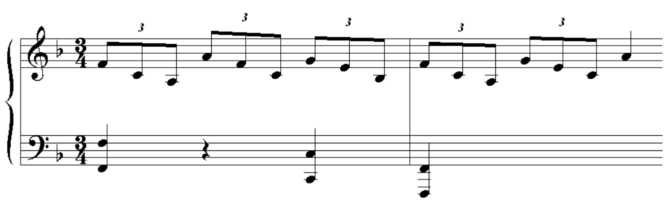
	B	M	E
mu	11	9	0
nm	9	8	3

B5. Piano Sonata in F major, K. 280, i, 13−15



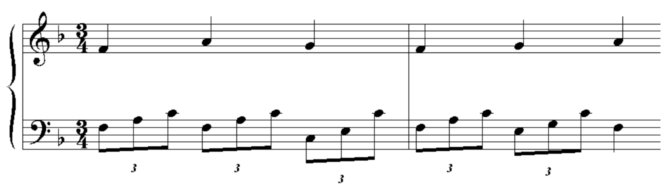
	B	M	E
mu	7	13	0
nm	2	15	3

B5-4-1



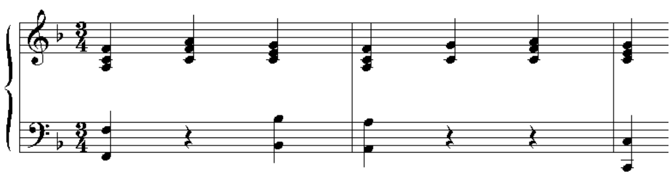
	B	M	E
mu	9	11	0
nm	3	17	0

B5-4-2



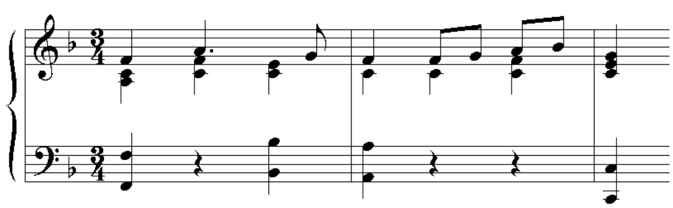
	B	M	E
mu	11	9	0
nm	4	14	2

B5-6



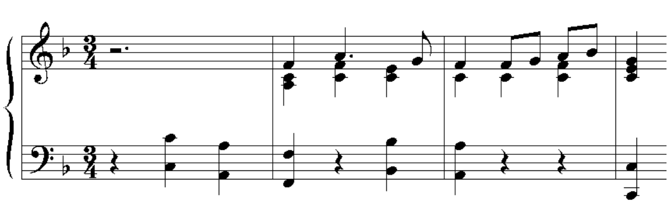
	1st time			2nd time		
	B	M	E	B	M	E
mu	12	8	0	12	8	0
nm	5	11	4	4	12	4

B5-6-1



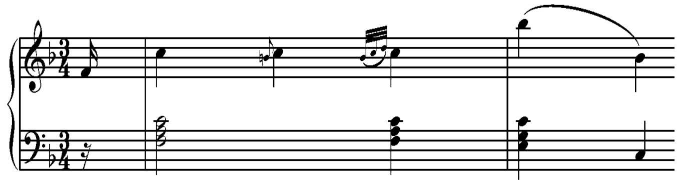
	B	M	E
mu	12	7	1
nm	11	7	2

B5-6-2



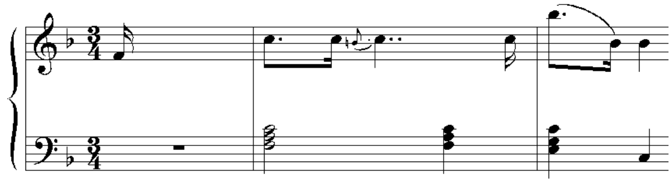
	B	M	E
mu	17	3	0
nm	9	9	2

B6-7



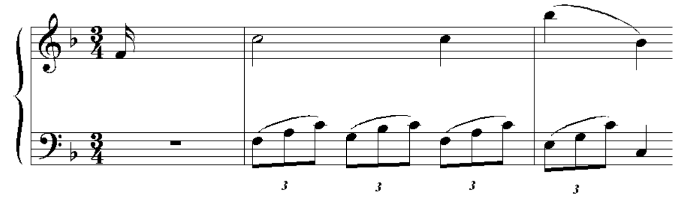
	B	M	E
mu	16	4	0
nm	11	8	1

B6-7-1



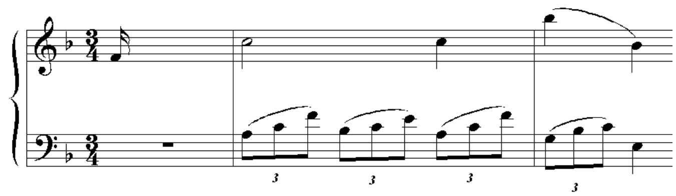
	B	M	E
mu	17	3	0
nm	7	12	1

B6-8



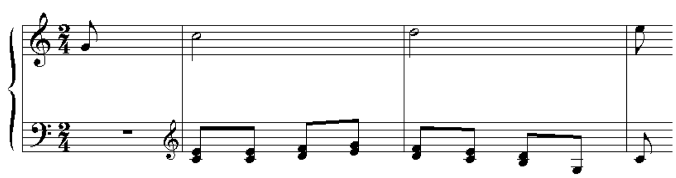
	B	M	E
mu	10	10	0
nm	11	8	1

B6-8-1



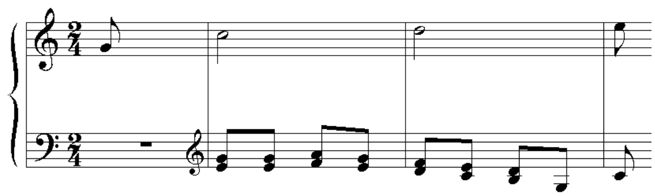
	B	M	E
mu	8	12	0
nm	7	10	3

B7-5



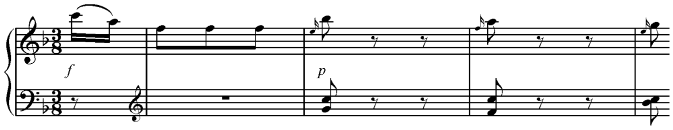
	B	M	E
mu	15	4	1
nm	8	9	3

B7-5-1



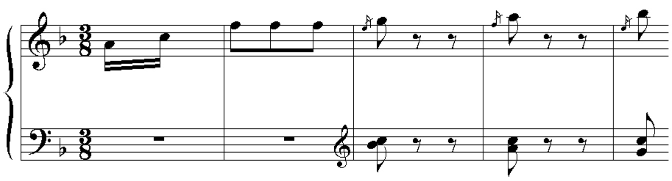
	B	M	E
mu	12	8	0
nm	4	14	2

B8. Piano Sonata in F major, K. 280, iii, 1−4



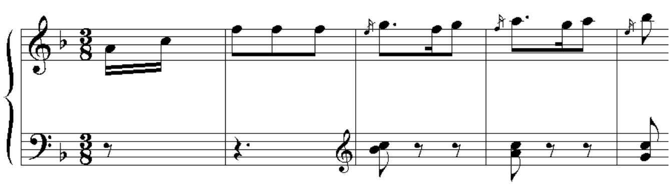
	B	M	E
mu	5	15	0
nm	6	5	9

B8-7



	B	M	E
mu	10	9	1
nm	6	9	5

B8-7-1



	B	M	E
mu	13	7	0
nm	9	7	4

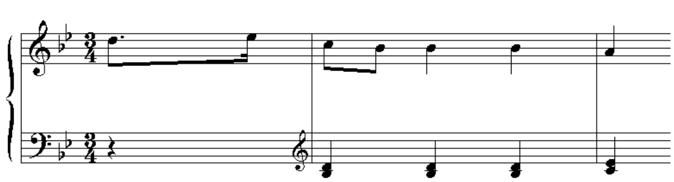
B8-7-2

	B	M	E
mu	17	3	0
nm	8	9	3

B9. Piano Sonata in F major, K. 282, ii, 1−2

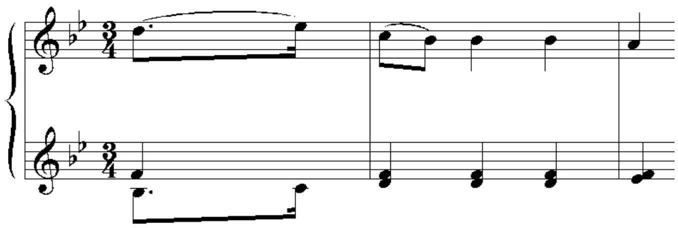
	B	M	E
mu	16	4	0
nm	8	10	2

B9-2



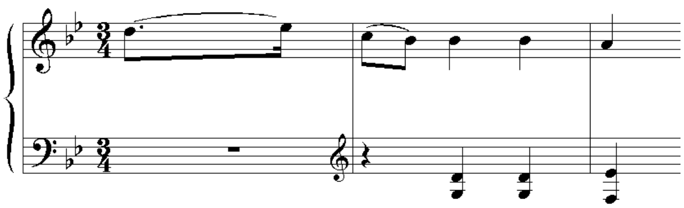
	B	M	E
mu	14	6	0
nm	13	5	2

B9-2-1



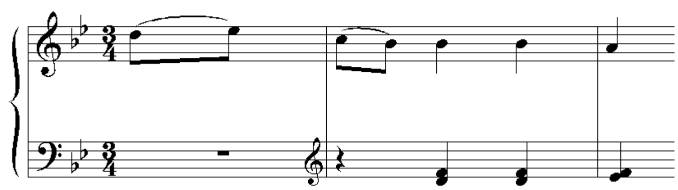
	B	M	E
mu	10	10	0
nm	6	14	0

B9-7



	B	M	E
mu	5	15	0
nm	6	9	5

B9-8



	B	M	E
mu	11	9	0
nm	7	12	1

B10. Piano Sonata in D major, K. 284, iii, 1−3

	1st time			2nd time		
	B	M	E	B	M	E
mu	18	2	0	19	1	0
nm	16	3	1	11	7	2

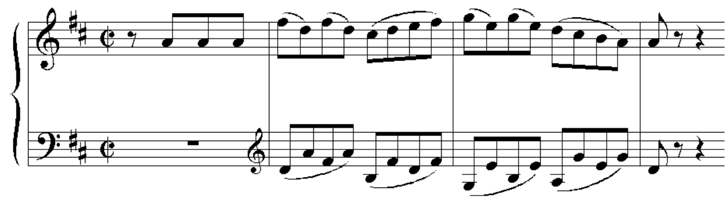
B10-6

	B	M	E
mu	16	4	0
nm	9	8	3

B10-9

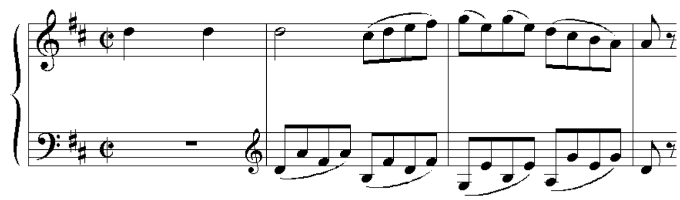
	B	M	E
mu	11	8	1
nm	9	8	3

B10-10



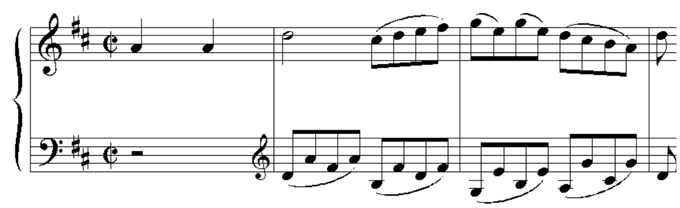
	B	M	E
mu	10	10	0
nm	11	7	2

B10-11



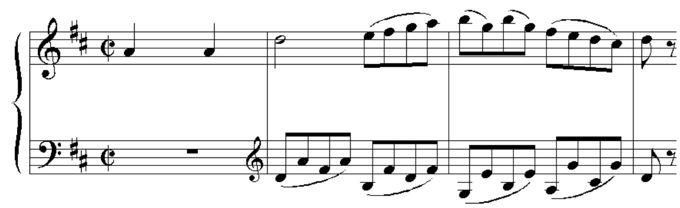
	B	M	E
mu	16	4	0
nm	12	5	3

B10-12



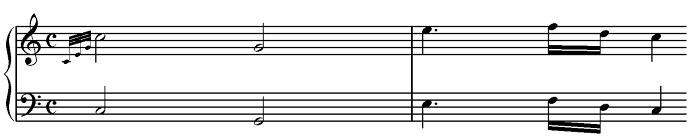
	B	M	E
mu	13	4	3
nm	12	4	4

B10-13



	B	M	E
m	7	4	9
nm	12	4	4

B11. Piano Sonata in C major, K. 309, i, 1−2

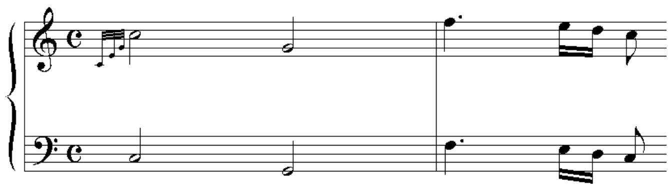


	B	M	E
mu	13	2	5
nm	4	8	8

B11-1

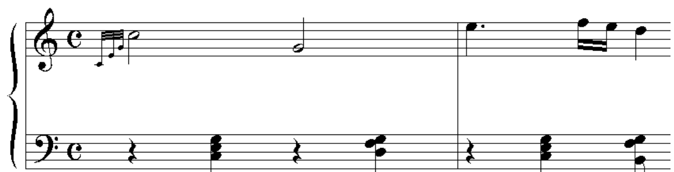
	B	M	E
mu	13	7	0
nm	6	10	4

B11-7



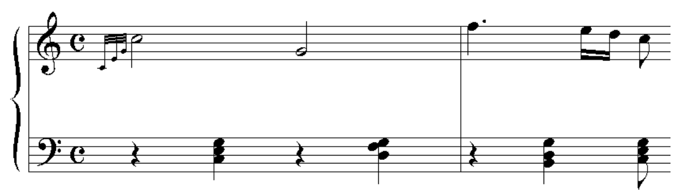
	B	M	E
mu	13	4	3
nm	1	7	12

B11-8



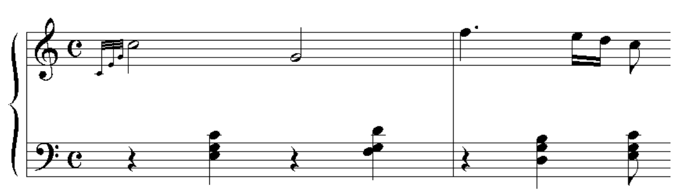
	B	M	E
mu	13	7	0
nm	7	12	1

B11-9



	B	M	E
mu	9	3	8
nm	6	5	9

B11-10



	B	M	E
mu	7	7	6
nm	2	10	8

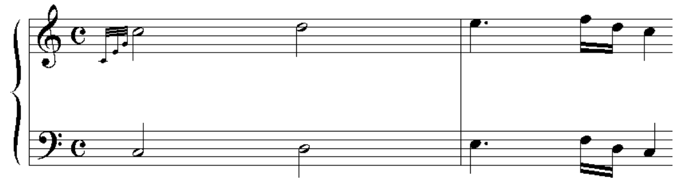
B11-11

	B	M	E
mu	13	6	1
nm	3	14	3

B11-12

	B	M	E
mu	9	10	1
nm	4	14	2

B11-13

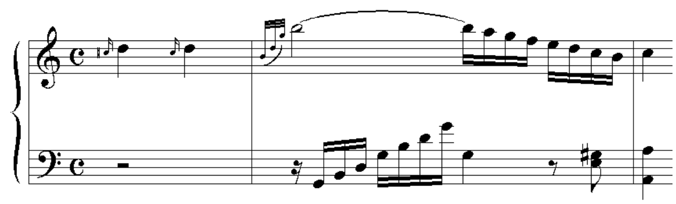


	B	M	E
mu	10	6	4
nm	4	10	6

B13. Piano Sonata in C major, K. 279, i, 17–18

	B	M	E
mu	2	17	1
nm	14	6	0

B13-1

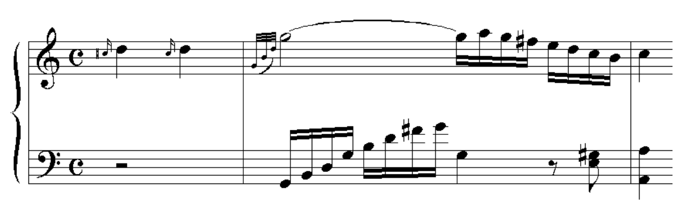


	B	M	E
mu	16	4	0
nm	15	5	0

B13-2

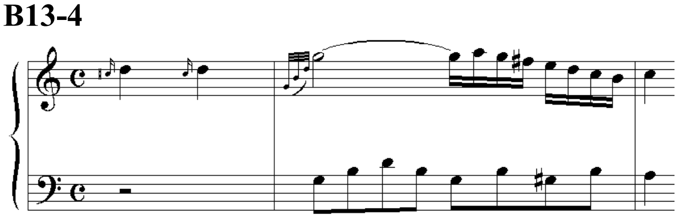
	B	M	E
mu	14	6	0
nm	16	4	0

B13-3



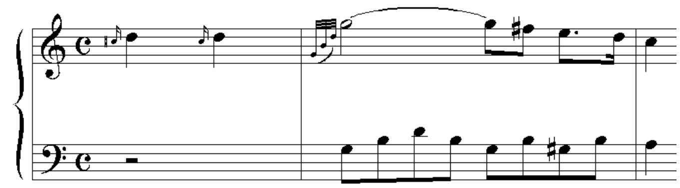
	B	M	E
mu	15	5	0
nm	17	3	0

B13-4



	B	M	E
mu	18	2	0
nm	15	5	0

B13-5

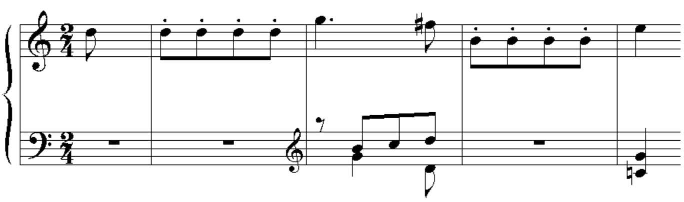


	1st time			2nd time		
	B	M	E	B	M	E
mu	14	6	0	16	4	0
nm	17	3	0	17	3	0

B14. Piano Sonata in C major, K. 279, iii, 27–30

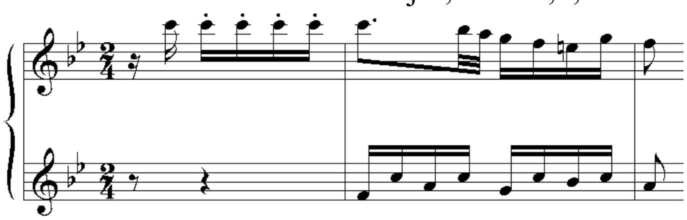
	B	M	E
mu	5	15	0
nm	17	2	1

B14-1



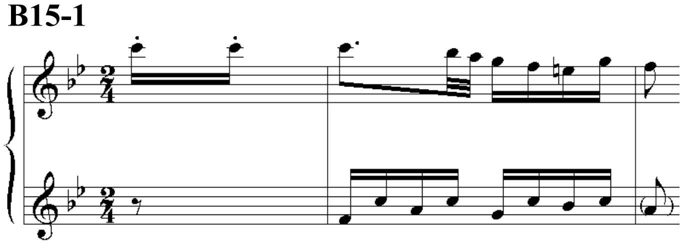
	B	M	E
mu	10	10	0
nm	14	5	1

B15. Piano Sonata in B-flat major, K. 281, i, 18–19



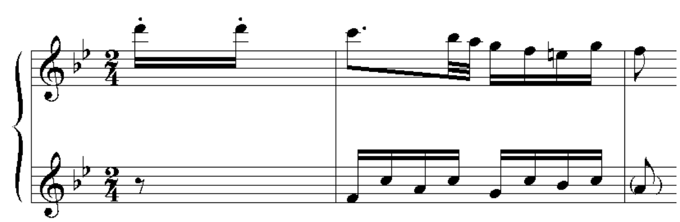
	B	M	E
mu	13	4	3
nm	15	1	4

B15-1



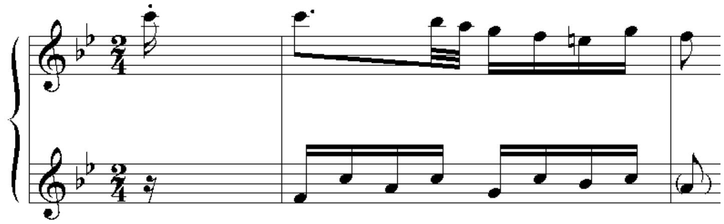
	B	M	E
mu	12	4	4
nm	6	5	9

B15-2



	B	M	E
mu	7	6	7
nm	6	6	8

B15-3

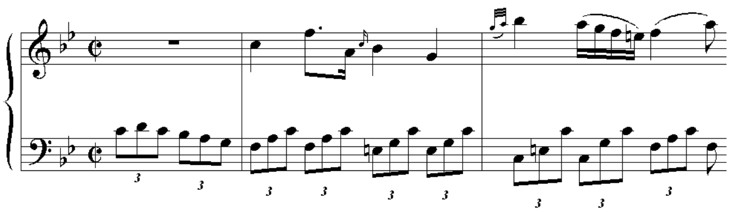


	B	M	E
mu	7	5	8
nm	8	7	5

B16. Piano Sonata in B-flat major, K. 281, iii, 18–19

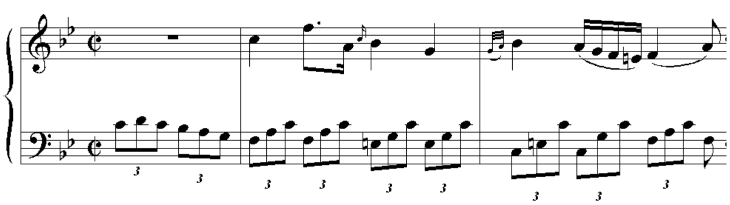
	B	M	E
mu	9	10	1
nm	3	14	3

B16-1



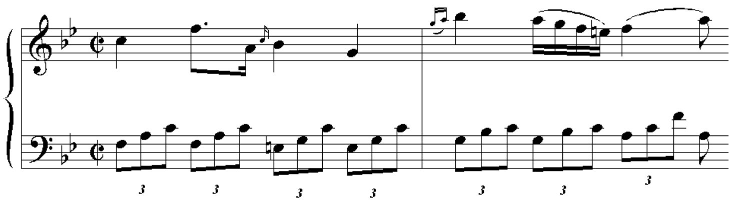
	B	M	E
mu	11	8	1
nm	3	15	2

B16-2



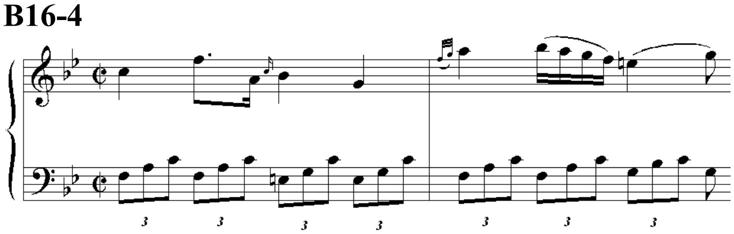
	B	M	E
mu	12	7	1
nm	4	15	1

B16-3



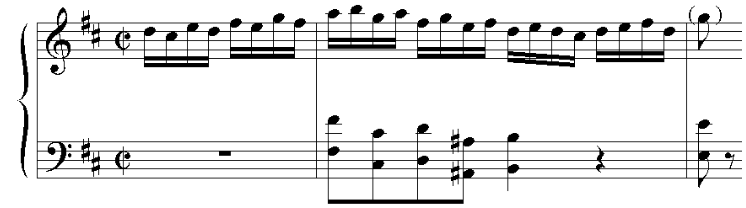
	B	M	E
mu	13	7	0
nm	1	18	1

B16-4



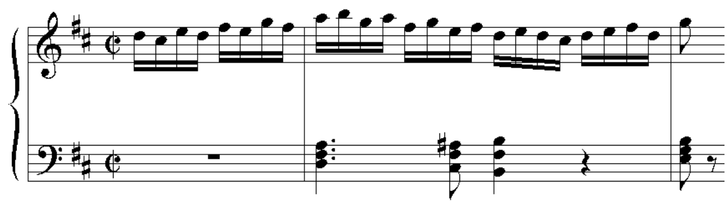
	B	M	E
mu	11	9	0
nm	3	16	1

B17. Piano Sonata in D major, K. 284, iii, Variation 3, 1–2



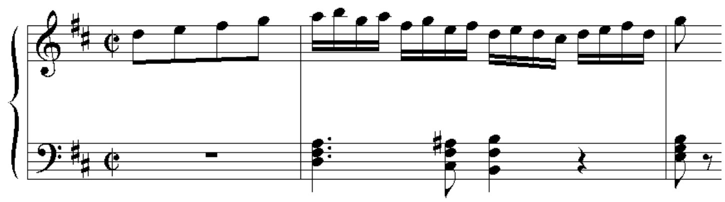
	B	M	E
mu	3	17	0
nm	2	17	1

B17-1



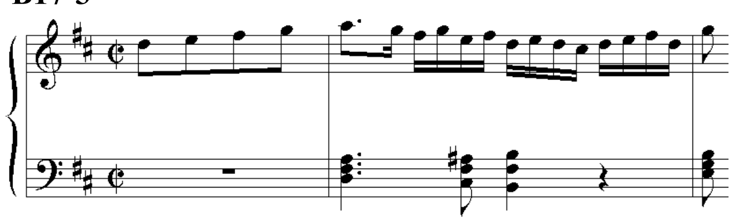
	B	M	E
mu	2	18	0
nm	4	15	1

B17-2



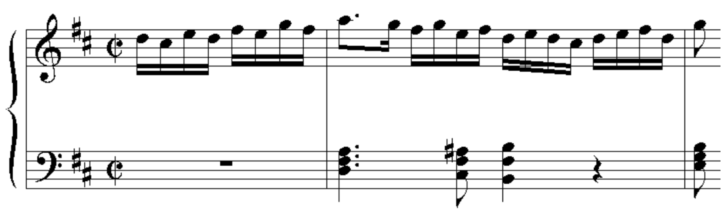
	B	M	E
mu	5	15	0
nm	15	4	1

B17-3



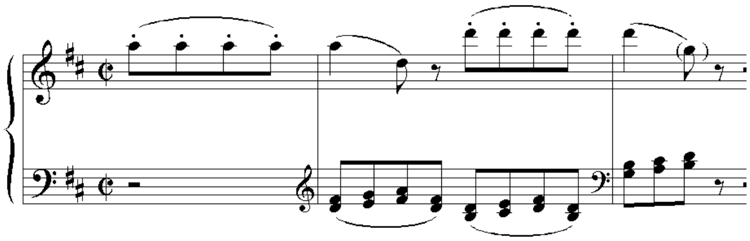
	B	M	E
mu	10	10	0
nm	8	11	1

B17-4



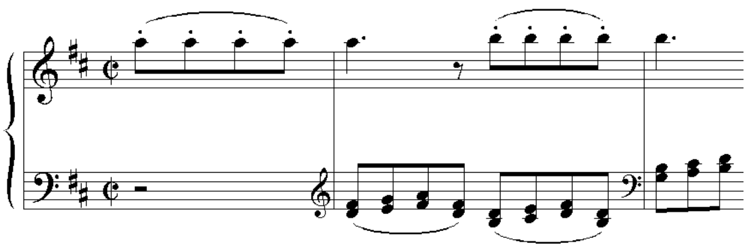
	B	M	E
mu	7	13	0
nm	3	13	4

B18. Piano Sonata in D major, K. 284, iii, Variation 5, 1–2



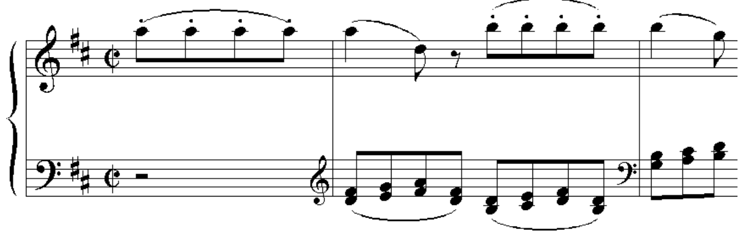
	B	M	E
mu	8	12	0
nm	17	3	0

B18-1



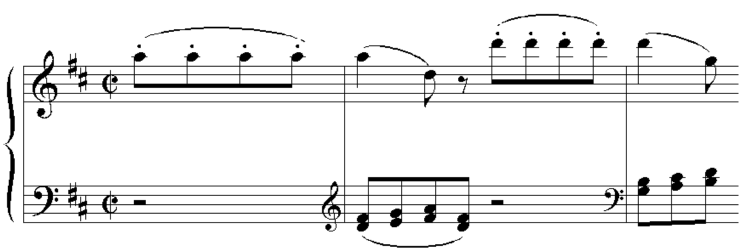
	B	M	E
mu	5	14	1
nm	15	5	0

B18-2



	B	M	E
mu	5	14	1
nm	13	7	0

B18-3

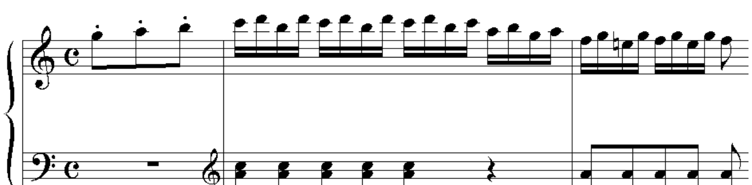


	B	M	E
mu	13	6	1
nm	12	8	0

B19. Piano Sonata in A minor, K. 310, i, 23–24

	B	M	E
mu	6	14	0
nm	12	8	0

B19-1



	B	M	E
mu	3	16	1
nm	8	12	0

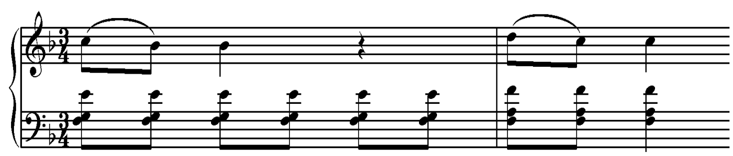
B20. Piano Sonata in C major, K. 309, iii, 1–2

	B	M	E
mu	8	12	0
nm	9	9	2

B20-1

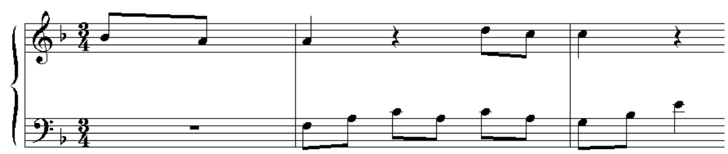
	B	M	E
mu	7	11	2
nm	7	12	1

M1. Piano Sonata in F major, K. 280, i, 5−6



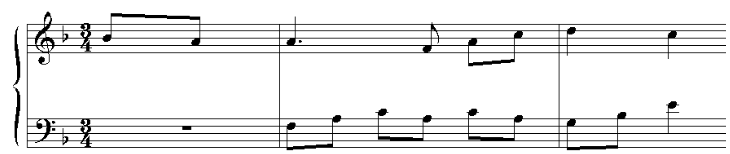
	1st time			2nd time		
	B	M	E	B	M	E
mu	1	19	0	1	19	0
nm	2	16	2	3	14	3

M1-3



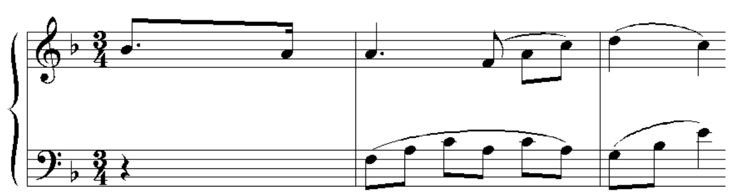
	B	M	E
mu	15	5	0
nm	10	9	1

M1-4



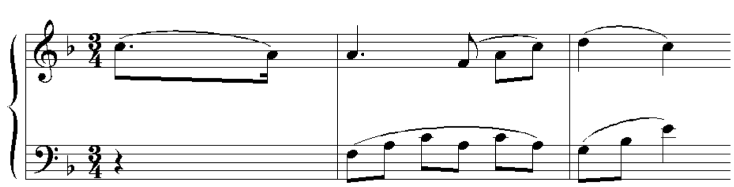
	B	M	E
mu	16	4	0
nm	13	7	0

M1-6



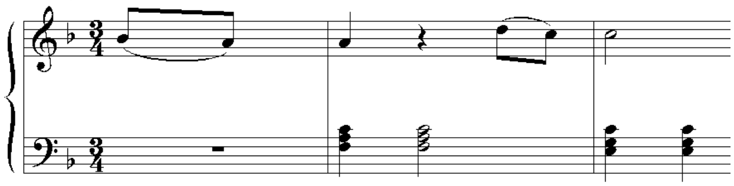
	B	M	E
mu	11	9	0
nm	10	10	0

M1-7



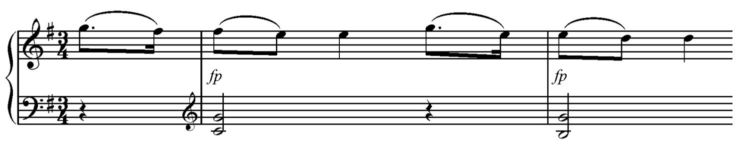
	B	M	E
mu	18	2	0
nm	10	10	0

M1-8



	B	M	E
mu	11	9	0
nm	8	10	1

M3. Piano Sonata in G major, K. 283, i, 5−6



	B	M	E
mu	4	15	1
nm	11	8	1

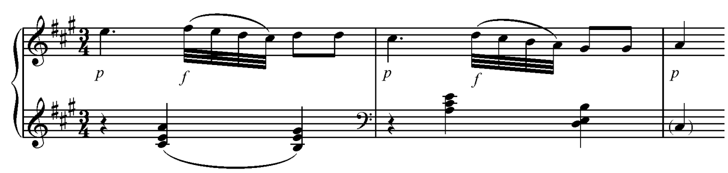
M3-2

	B	M	E
mu	4	16	0
nm	6	14	0

M3-3

	B	M	E
mu	11	9	0
nm	11	9	0

M5. Piano Sonata in D major, K. 284, ii, 5−7



	B	M	E
mu	14	6	0
nm	7	8	5

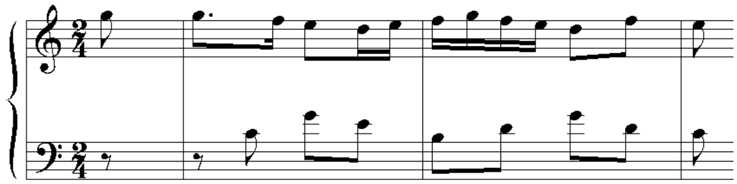
M5-6

	B	M	E
mu	7	10	3
nm	1	13	6

M6-4

	B	M	E
mu	11	7	2
nm	12	7	1

M6-4-1



	B	M	E
mu	13	5	2
nm	11	8	1

M6-4-2

	B	M	E
mu	13	5	2
nm	17	2	1

M6-4-3

	B	M	E
mu	11	7	2
nm	15	4	1

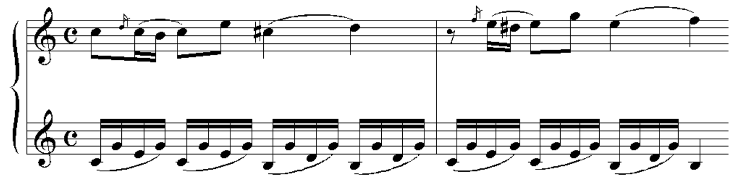
M7-3

	1st time			2nd time		
	B	**M**	**E**	**B**	**M**	**E**
mu	4	16	0	4	16	0
nm	2	18	0	1	19	0

M12. Piano Sonata in C major, K. 279, i, 5−6

	B	M	E
mu	13	7	0
nm	2	18	0

M12-4

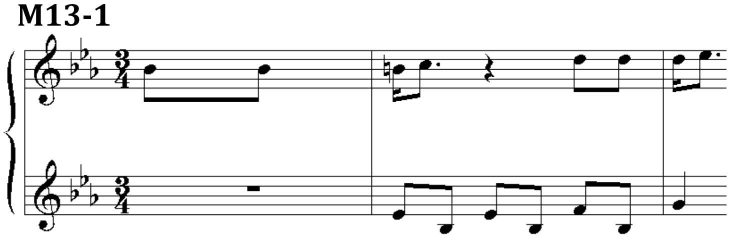


	B	M	E
mu	10	10	0
nm	3	16	1

M13. Piano Sonata in E-flat major, K. 282, i, 49–50

	B	M	E
mu	1	18	1
nm	3	15	2

M13-1



	B	M	E
mu	2	16	2
nm	9	10	1

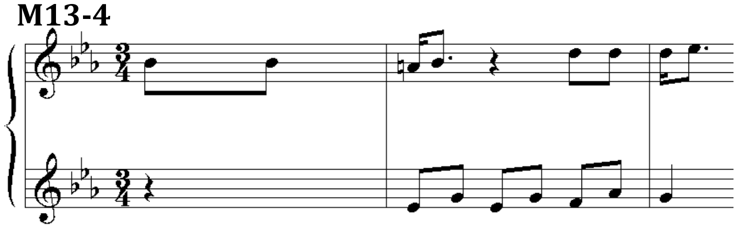
M13-2

	B	M	E
mu	3	12	5
nm	2	15	3

M13-3

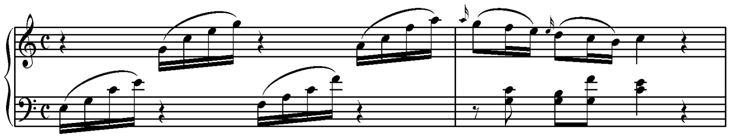
	B	M	E
mu	3	14	3
nm	1	16	3

M13-4



	B	M	E
mu	10	9	1
nm	4	16	0

E1. Piano Sonata in C major, K. 279, i, 11−12



	B	M	E
mu	0	1	19
nm	1	8	11

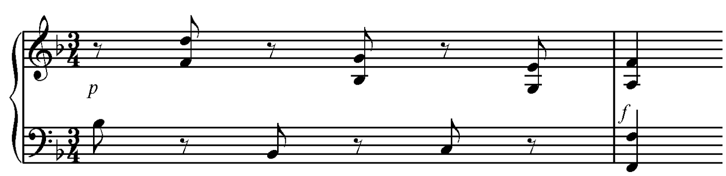
E2. Piano Sonata in C major, K. 279, ii, 5–6

	B	M	E
mu	0	2	18
nm	0	10	10

E3. Piano Sonata in C major, K. 279, iii, 9–10

	B	M	E
mu	0	1	19
nm	1	0	19

E4. Piano Sonata in F major, K. 280, i, 12–13

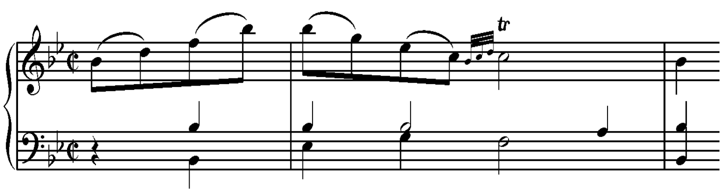


	1st time			2nd time		
	B	**M**	**E**	**B**	**M**	**E**
mu	0	0	20	0	0	20
nm	0	6	14	0	2	18

E5. Piano Sonata in F major, K. 280, iii, 13–16

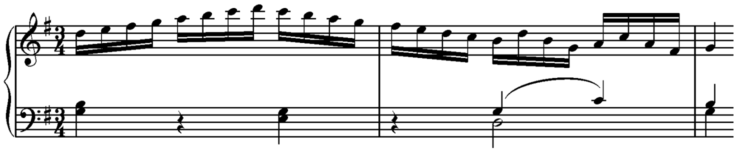
	B	M	E
mu	0	0	20
nm	0	5	15

E6. Piano Sonata in B-flat major, K. 281, iii, 6–8



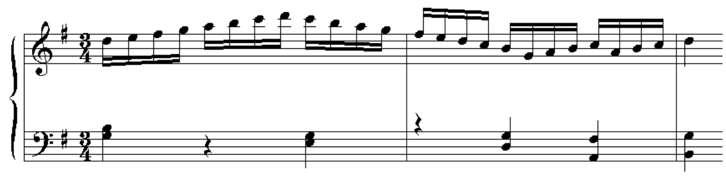
	B	M	E
mu	1	1	18
nm	0	4	16

E7. Piano Sonata in G major, K. 283, i, 8–10



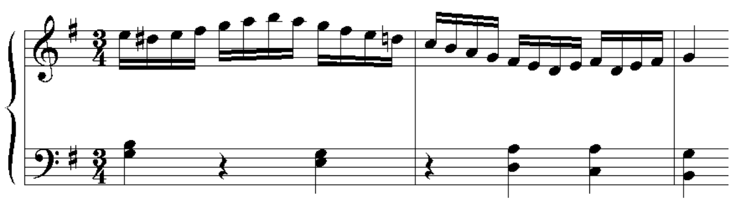
	B	M	E
mu	0	2	18
nm	1	4	15

E7-2



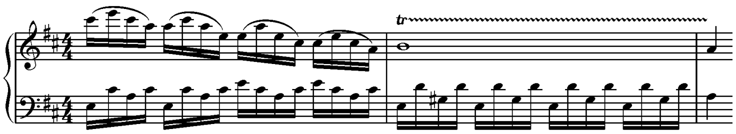
	B	M	E
mu	1	18	1
nm	2	13	5

E7-3



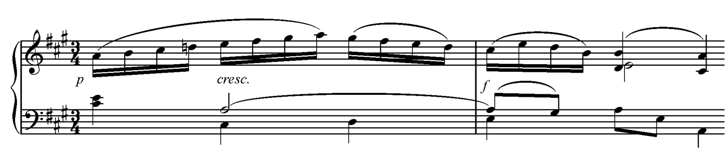
	B	M	E
mu	1	13	6
nm	1	9	10

E8. Piano Sonata in D major, K. 284, i, 48–50



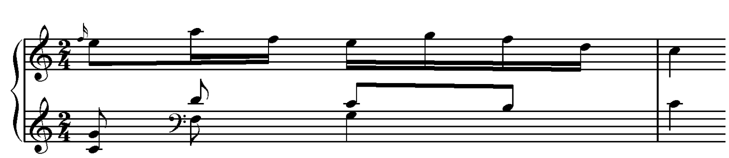
	1st time			2nd time		
	B	**M**	**E**	**B**	**M**	**E**
mu	0	1	19	1	0	19
nm	1	10	9	1	7	12

E9. Piano Sonata in D major, K. 284, ii, 15–16



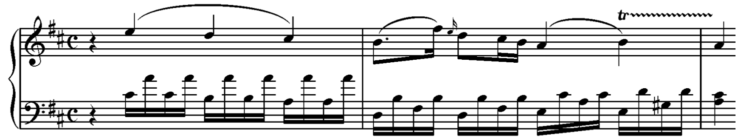
	B	M	E
mu	1	2	17
nm	0	6	14

E10. Piano Sonata in C major, K. 309, iii, 18–19



	B	M	E
mu	0	2	18
nm	0	5	15

E11. Piano Sonata in D major, K. 311, i, 30–32



	B	M	E
mu	0	4	16
nm	3	5	12

E12-3. Piano Sonata in D major, K. 311, iii, 15–16

	B	M	E
mu	0	3	17
nm	0	6	14

E12-1

	B	M	E
mu	0	15	5
nm	2	14	4

E12-3

	B	M	E
mu	0	19	1
nm	1	16	3

E12-4

	B	M	E
mu	0	14	6
nm	0	11	9

E13. Piano Sonata in A minor, K. 310, i, 8–9

	B	M	E
mu	0	20	0
nm	1	15	4

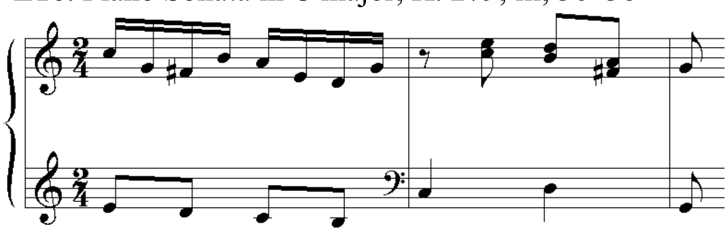
E14. Piano Sonata in C major, K. 279, i, 33–35

	B	M	E
mu	0	2	18
nm	3	9	8

E15. Piano Sonata in C major, K. 279, ii, 24–26

	B	M	E
mu	0	0	20
nm	0	12	8

E16. Piano Sonata in C major, K. 279, iii, 36–38

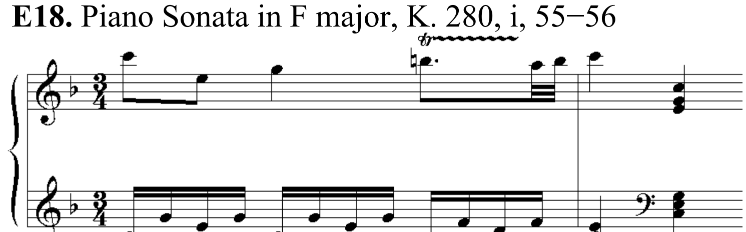


	B	M	E
mu	0	2	18
nm	0	8	12

E17. Piano Sonata in F major, K. 280, i, 52−54

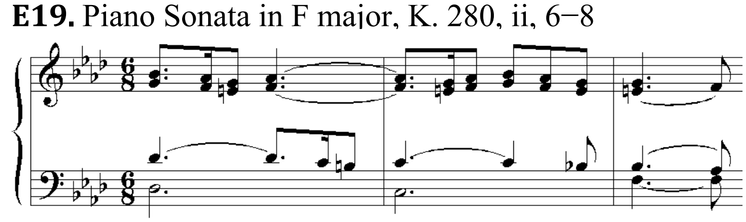
	B	M	E
mu	0	0	20
nm	2	2	16

E18. Piano Sonata in F major, K. 280, i, 55−56



	B	M	E
mu	0	1	19
nm	2	1	17

E19. Piano Sonata in F major, K. 280, ii, 6−8

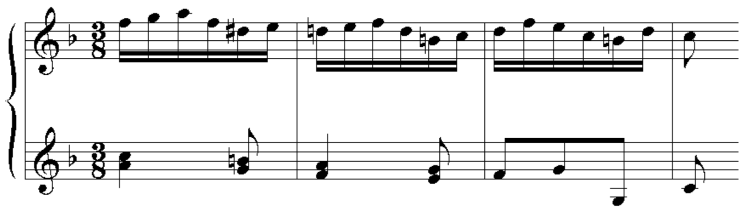


	B	M	E
mu	0	6	14
nm	3	10	7

E20. Piano Sonata in F major, K. 280, ii, 23−24

	B	M	E
mu	0	1	19
nm	0	3	17

E21. Piano Sonata in F major, K. 280, iii, 59−62



	B	M	E
mu	0	2	18
nm	0	10	10

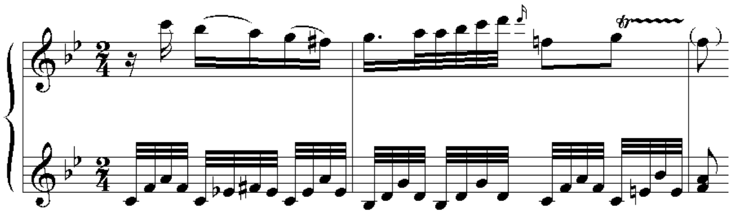
E22. Piano Sonata in B-flat major, K. 281, i, 3–4

	B	M	E
mu	1	5	14
nm	2	9	9

E23. Piano Sonata in B-flat major, K. 281, i, 7–8

	B	M	E
mu	0	0	20
nm	0	3	17

E24. Piano Sonata in B-flat major, K. 281, i, 33–34



	B	M	E
mu	0	2	18
nm	0	8	12

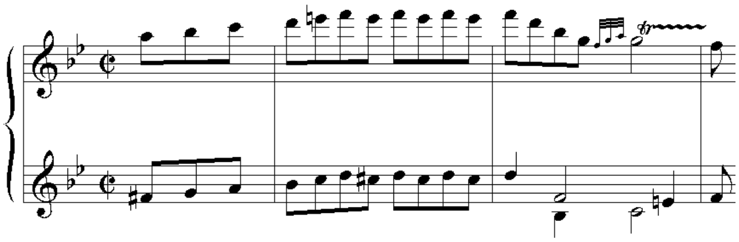
E25. Piano Sonata in B-flat major, K. 281, i, 36–38

	B	M	E
mu	0	2	18
nm	0	11	9

E26. Piano Sonata in B-flat major, K. 281, ii, 8–12

	B	M	E
mu	1	3	16
nm	6	5	9

E27. Piano Sonata in B-flat major, K. 281, iii, 37–39

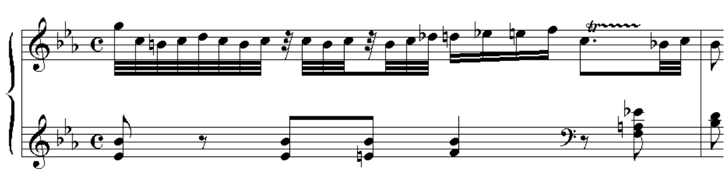


	B	M	E
mu	0	0	20
nm	0	9	11

E28. Piano Sonata in E-flat major, K. 282, i, 3–4

	B	M	E
mu	1	10	9
nm	1	12	7

E29. Piano Sonata in E-flat major, K. 282, i, 14–15

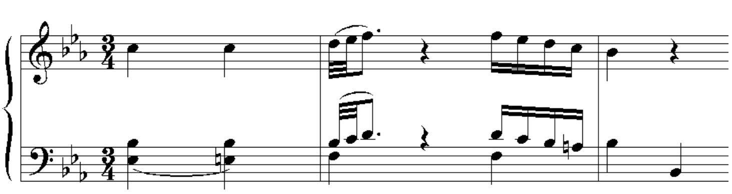


	B	M	E
mu	0	0	20
nm	1	3	16

E30. Piano Sonata in E-flat major, K. 282, ii, 31–32

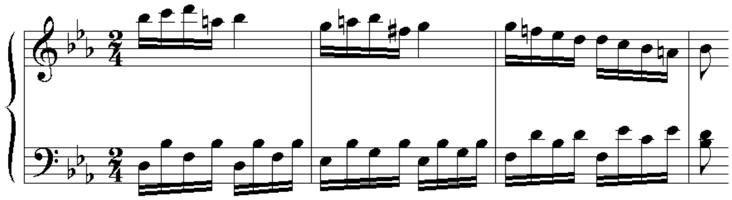
	B	M	E
mu	1	4	15
nm	1	8	11

E31. Piano Sonata in E-flat major, K. 282, ii, 47–48



	B	M	E
mu	0	1	19
nm	1	4	15

E32. Piano Sonata in E-flat major, K. 282, iii, 32–33



	B	M	E
mu	0	1	19
nm	1	12	7

E33. Piano Sonata in G major, K. 283, i, 46–48

	B	M	E
mu	0	1	19
nm	0	9	11

E34. Piano Sonata in G major, K. 283, ii, 13–15

	B	M	E
mu	0	0	20
nm	4	5	11

B, M, and E stand for beginning, middle, and end, respectively; ‘mu’ and ‘nm’ stand for musicians and non-musicians; ‘1^{st} time’ and ‘2^{nd} time’ stand for the first and second time duplicated excerpts were heard.

Appendix D

Table A. Functional-judgment distributions of pairs of referential excerpts, opening with tonic harmony, and comparative excerpts, opening with either a subdominant (IV), dominant (V), submediant, (vi), and secondary dominant ([V]) harmony. Values responsible for floor/ceiling effects are indicated with an asterisk (*).

(a) Musicians, Experiment 2

Pair #	Referential (tonic)			Comparative ("off-tonic")			
	B	M	E	B	M	E	Harmony
1	19	1	0	4	15	1	V
2	17	3	0	7	13	0	V
3	16	4	0	7	12	1	V
4	14	6	0	5	15	0	V
5	13	7	0	2	17	1	V
6	12	8	0	1	19	0	V
7	9	11	0	4	14	2	IV
8	8	11	1	2	18	0	V
9	7	13	0	1	18	1	V
10	7	13	0	2	18	0	[V]
11	6	13	1	5	15	0	V
12	1*	17*	2	1	19	0	V

(b) Musicians, Experiments 2 and 3

Pair #	Expe-riment	Referential (tonic)			Comparative ("off-tonic")			
		B	M	E	B	M	E	Harmony
1	3	18	2	0	11	8	1	vi
2	3	16	4	0	2	17	1	[V]
3	3	16	4	0	5	15	0	IV
4	3	11	9	0	4	16	0	IV
5	3	10	10	0	5	15	0	vi
6	3	8	12	0	7	11	2	IV
7	3	6	14	0	3	16	1	vi
8	2 & 3	6	14	0	1	19	0	V
9	3	3*	14	3	3	12	5	V

(c) Non-musicians, Experiment 2

Pair #	Referential (tonic)			Comparative ("off-tonic")			
	B	M	E	B	M	E	Harmony
1	18	1	1	17	2	1	V
2	16	4	0	10	10	0	V
3	14	4	2	13	7	0	IV
4	12	7	1	14	5	1	V
5	7	5	8	8	6	6	V
6	7	12	1	5	14	1	V
7	5	15	0	2	17	1	V
8	4	13	3	7	11	2	V
9	4	10	6	9	10	1	V
10	4	10	6	6	13	1	[V]
11	3*	16	1	2	17	1	V
12	0*	16	4	4	16	0	V

(d) Non-musicians, Experiments 2 and 3

Pair #	**Expe-riment**	**Referential (tonic)**			**Comparative ("off-tonic")**			
		B	**M**	**E**	**B**	**M**	**E**	**Harmony**
1	3	16	3	1	9	8	3	vi
2	3	15	5	0	14	6	0	[V]
3	3	14	5	1	17	2	1	vi
4	3	12	8	0	8	12	0	vi
5	3	11	9	0	6	14	0	IV
6	3	9	9	2	7	12	1	IV
7	3	8	10	2	6	9	5	vi
8	3	1*	16	3	2	15	3	V
9	2 & 3	0*	19*	1	2	16	2	V

Table B. Functional-judgment distributions of excerpts in which the unaccompanied anacrusis was removed in the comparative excerpts.

(a) Musicians (Experiment 2)

Pair #	**Referential (anacrusis)**			**Comparative (no anacrusis)**		
	B	**M**	**E**	**B**	**M**	**E**
1	19	1	0	12	8	0
2	17	3	0	8	12	0
3	13	7	0	6	14	0
4	4	15	1	1	19	0

(b) Non-musicians (Experiment 2)

Pair #	**Referential (anacrusis)**			**Comparative (no anacrusis)**		
	B	**M**	**E**	**B**	**M**	**E**
1	16	4	0	7	12	1
2	15	5	0	7	13	0
3	14	6	0	3	15	2
4	10	10	0	5	14	1

Table C. Functional-judgment distributions of excerpts in which the unaccompanied anacrusis of the referential excerpt began on a scale degree belonging to the tonic chord and that of the comparative excerpt began "off tonic."

(a) Musicians (Experiment 3)

Pair #	**Referential (tonic)**			**Comparative ("off tonic")**		
	B	**M**	**E**	**B**	**M**	**E**
1	19	0	1	9	10	1
2	18	2	0	11	9	0
3	12	4	4	7	6	7

(b) Non-musicians (Experiment 3)

Pair #	**Referential (tonic)**			**Comparative ("off tonic")**		
	B	**M**	**E**	**B**	**M**	**E**
1	13	5	2	8	8	4
2	10	10	0	10	10	0
3	6	5	9	6	6	8

Table D. Functional-judgment distributions of excerpts in which the referential excerpt's *un*accompanied anacrusis was changed to an *accompanied* anacrusis in the comparative excerpt. Values responsible for floor/ceiling effects are indicated with an asterisk (*).

(a) Musicians (Experiment 3)

Pair #	**Referential (unaccompanied)**			**Comparative (accompanied)**		
	B	**M**	**E**	**B**	**M**	**E**
1	14	6	0	10	14	0
2	10	9	1	3	16	3
3	2*	16	2	1	15	2

(b) Non-musicians (Experiment 3)

Pair #	**Referential (unaccompanied)**			**Comparative (accompanied)**		
	B	**M**	**E**	**B**	**M**	**E**
1	13	5	2	16	14	0
2	9	10	1	3	15	2
3	4	16	0	1	16	3

Table E. Functional-judgment distributions of excerpts in which the unaccompanied anacrusis was reduced in the comparative excerpt.

(a) Musicians (Experiment 3)

Pair #	**Referential (unaccompanied)**			**Comparative (accompanied)**		
	B	**M**	**E**	**B**	**M**	**E**
1	13	5	2	11	7	2
2	13	4	3	12	4	4
3	13	4	3	7	5	8
4	11	7	2	13	5	2

(b) Non-musicians (Experiment 3)

Pair #	**Referential (unaccompanied)**			**Comparative (accompanied)**		
	B	**M**	**E**	**B**	**M**	**E**
1	17	2	1	12	7	1
2	15	4	1	11	8	1
3	15	1	4	6	5	9
4	15	1	4	8	7	5

Table F. Functional-judgment distributions of excerpts with relatively lower (referential) and higher (comparative) levels of rhythmic activity in the bass/accompaniment. Values responsible for floor/ceiling effects are indicated with an asterisk (*).

(a) Musicians, Experiment 2.

Pair #	Referential (lower rhythmic act.)			Comparative (higher rhythmic act.)		
	B	M	E	B	M	E
1	13	6	1	14	6	0
2	11	7	2	14	6	0
3	9	9	2	10	10	0
4	8	12	0	1	18	1
5	4	14	2	4	16	0
6	3*	15	2	1	19	0

(b) Musicians, Experiment 3.

Pair #	Referential (lower rhythmic act.)			Comparative (higher rhythmic act.)		
	B	M	E	B	M	E
1	14	6	0	7	8	5
2	13	2	5	4	8	8
3	11	9	0	9	8	3
4	11	9	0	9	10	1
5	9	3	8	6	5	9
6	4	15	1	11	8	1

(c) Non-musicians, Experiment 2.

Pair #	Referential (lower rhythmic act.)			Comparative (higher rhythmic act.)		
	B	M	E	B	M	E
1	13	7	0	12	8	0
2	11	6	3	8	12	0
3	9	11	0	5	15	0
4	7	5	8	6	12	2
5	3*	17*	0	4	16	0
6	2*	16	2	1	17	2

(d) Non-musicians, Experiment 3.

Pair #	Referential (lower rhythmic act.)			Comparative (higher rhythmic act.)		
	B	M	E	B	M	E
1	11	8	1	6	14	0
2	9	8	3	5	14	1
3	9	10	1	10	9	1
4	7	8	5	1	13	6
5	6	5	9	3	14	3
6	4	8	8	3	16	1

Table G. Functional-judgment distributions of excerpts with relatively lower (referential) and higher (comparative) levels of rhythmic activity either in the bass/accompaniment or in the melody. A separate column indicates the textural layer ('Text. layer'), either the the melody ('M') or the bass/accompaniment ('B/A'), involved in the modification.

(a) Musicians, Experiment 2.

Pair #	**Textural layer**	**Referential (lower rh. act.)**			**Comparative (higher rh. act.)**		
		B	**M**	**E**	**B**	**M**	**E**
1	M	17	3	0	12	8	0
2	M	16	4	0	16	4	0
3	M	14	6	0	3	15	2
4	B/A	13	6	1	14	6	0
5	M	12	8	0	14	6	0
6	B/A	11	7	2	14	6	0
7	B/A	9	9	2	10	10	0
8	B/A	8	12	0	1	18	1
9	M	4	14	2	3	17	0
10	B/A	4	14	2	4	16	0
11	B/A	3*	15	2	1	19	0

(b) Musicians, Experiments 2 and 3.

Pair #	**Expe-riment**	**Textural layer**	**Referential (lower rh. act.)**			**Comparative (higher rh. act.)**		
			B	**M**	**E**	**B**	**M**	**E**
1	3	M	18	2	0	16	4	0
2	3 & 2	M	18	2	0	17	3	0
3	3	B/A	14	6	0	7	10	3
4	3 & 2	B/A	13	2	5	17	1	2
5	3	M	12	7	1	12	8	0
6	3	B/A	11	9	0	9	11	0
7	3	B/A	11	9	0	15	5	0
8	3	B/A	9	3	8	13	6	1
9	3	B/A	4	15	1	4	16	0

(c) Non-musicians, Experiment 2.

Pair #	**Textural layer**	**Referential (lower rh. act.)**			**Comparative (higher rh. act.)**		
		B	**M**	**E**	**B**	**M**	**E**
1	M	15	5	0	11	8	1
2	M	13	7	0	8	12	0
3	B/A	13	7	0	12	8	0
4	M	11	8	1	16	4	0
5	B/A	11	6	3	8	12	0
6	M	10	9	1	14	5	1
7	M	9	10	1	3	17	0
8	B/A	9	11	0	5	15	0
9	B/A	7	5	8	14	6	0
10	B/A	3*	17*	0	4	16	0
11	B/A	2*	16	2	1	17	2

(d) Non-musicians, Experiments 2 and 3.

Pair #	Expe-riment	Textural layer	Referential (lower rh. act.)			Comparative (higher rh. act.)		
			B	**M**	**E**	**B**	**M**	**E**
1	3	M	16	3	1	9	8	3
2	3 & 2	M	16	3	1	14	6	0
3	3	M	11	7	2	5	11	4
4	3	B/A	11	8	1	6	14	0
5	3	B/A	9	8	3	5	14	1
6	3	B/A	9	10	1	10	9	1
7	3	B/A	7	8	5	1	13	6
8	3	B/A	6	5	9	3	14	3
9	3 & 2	B/A	4	8	8	3	16	1

Table H. Functional-judgment distributions of referential (opening root-position tonic) and comparative (opening first-inversion) excerpts.

(a) Musicians, Experiments 2 and 3.

Pair #	**Expe-riment**	**Referential (root-position tonic)**			**Comparative (first-inversion tonic)**		
		B	**M**	**E**	**B**	**M**	**E**
1	2	17	2	1	12	5	3
2	2 & 3	16	4	0	16	4	0
3	3	15	4	1	12	8	0
4	2	13	7	0	7	13	0
5	3	13	6	1	9	10	1
6	3	10	10	0	8	12	0
7	3	9	3	8	7	7	6

(b) Non-musicians, Experiments 2 and 3.

Pair #	**Expe-riment**	**Referential (root-position tonic)**			**Comparative (first-inversion tonic)**		
		B	**M**	**E**	**B**	**M**	**E**
1	2 & 3	11	4	5	8	10	2
2	3	11	8	1	7	10	3
3	2	10	8	2	4	10	3
4	3	8	9	3	4	14	2
5	3	6	5	9	2	10	8
6	2	5	9	6	7	6	7
7	3	3*	14	3	4	14	2

Table I. Functional-judgment distributions of referential excerpts closing with a perfect authentic cadence (PAC) and comparative excerpts in which the cadence has been modified.

(a) Musicians, Experiments 2 and 3.

Pair #	**Expe-riment**	**Referential (PAC)**			**Comparative (ruined PAC)**		
		B	**M**	**E**	**B**	**M**	**E**
1	2 & 3	0	0	20	1	17	2
2	2 & 3	2	0	18	16	4	0
3	2 & 3	2	0	18	16	4	0
4	2 & 3	2	1	17	16	4	0

(b) Non-musicians, Experiments 2 and 3.

Pair #	**Expe-riment**	**Referential (PAC)**			**Comparative (ruined PAC)**		
		B	**M**	**E**	**B**	**M**	**E**
1	2 & 3	0	0	20	8	10	2
2	2 & 3	1	1	18	8	10	2
3	2 & 3	2	2	16	8	10	2
4	2 & 3	0	5	15	1	9	10

Table J. Functional-judgment distributions of referential excerpts with melodies closing on the first scale degree and comparative excerpts with melodies ending on the fifth scale degree.

(a) Musicians, Experiments 2 and 3.

Pair #	**Expe-riment**	**Referential (first scale degree)**			**Comparative (fifth scale degree)**		
		B	**M**	**E**	**B**	**M**	**E**
1	3	0	3	17	0	14	6
2	3	7	4	9	18	2	0
3	2	4	8	8	7	13	0
4	3	1	13	6	1	18	1
5	3	1	15	4	5	15	0
6	3	13	4	3*	18	2	0
7	3	4	13	3*	5	15	0

(b) Non-musicians, Experiments 2 and 3.

Pair #	**Expe-riment**	**Referential (first scale degree)**			**Comparative (fifth scale degree)**		
		B	**M**	**E**	**B**	**M**	**E**
1	3	0	6	14	0	11	9
2	3	1	9	10	2	13	5
3	3	8	5	7	9	11	0
4	2	7	6	7	14	5	1
5	3	12	4	4	16	3	1
6	3	12	4	4	16	3	1
7	3	8	9	3*	9	11	0

Table K. Functional-judgment distributions of referential excerpts with melodies closing on the first scale degree and comparative excerpts with melodies closing on the second scale degree. Pair #4, featuring excerpts with an explicit harmonic setting, has been added for comparison with Pairs #3 (musicians) and #1 (non-musicians), which share the same melody without the explicit harmonic setting.

(a) Musicians, Experiments 2 and 3.

Pair #	**Expe-riment**	**Referential (first scale degree)**			**Comparative (second scale degree)**		
		B	**M**	**E**	**B**	**M**	**E**
1	3 & 2	13	2	5	17	2	1
2	3	13	2	5	13	7	0
3	3	13	4	3*	13	7	0
4	3	9	3	8	13	7	0

(b) Non-musicians, Experiments 2 and 3.

Pair #	**Expe-riment**	**Referential (first scale degree)**			**Comparative (second scale degree)**		
		B	**M**	**E**	**B**	**M**	**E**
1	3 & 2	1	7	12	6	10	4
2	3	4	8	8	8	7	5
3	3	4	8	8	6	10	4
4	3	6	5	9	7	12	1