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Perception of Intrinsic Formal Functionality: An Empirical Investigation of Mozart's Materials

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Background in music theory. Several music theorists have proposed that in the stylistically conventionalized music of the high classical period (c.1770–1810), a musical passage may convey a particular formal function—the temporal role of beginning, middle, or end—even when taken out of its original context (e.g., Agawu, 1991; Caplin, 1998; Kramer, 1988; Lochhead, 1979). However, a listener's ability to perceive such an out-of-context form-functional expression—henceforth termed *intrinsic formal functionality*—has never been examined thoroughly.
Background in music perception and cognition. Scholars in the field of music perception and cognition have studied the interaction between musical materials and temporal location (Clarke & Krumhansl, 1990; Krumhansl, 1996; Lalitte, Bigand, Poulin-Charronnat, McAdams, Delbé, and D'Adamo, 2004; Tillmann & Bigand, 1996, 2001). None, however, has conducted a systematic investigation of multiple formal functions.
Aims. This interdisciplinary study empirically addresses the perceptibility of intra-thematic intrinsic formal functionality by musicians and non-musicians and proposes hypotheses about function-defining musical parameters.
Main contribution. Two groups of participants—musicians and non-musicians—heard short excerpts (average 3.9 s) from Mozart's piano sonatas. The participants' primary task was to identify each excerpt as the beginning, middle, or end of a theme. The results show that both musicians and non-musicians were able to identify the intrinsic formal functionality of these musical excerpts.
Implications. This research brings empirical support to music theorists' claims about the perceptibility of intrinsic formal functionality. It also offers hypotheses about the perceptual relevance of individual musical parameters that music theorists associate with the expression of specific formal functions.

Keywords: Music theory, music perception and cognition, form, formal function, intrinsic formal functionality, musical parameters.

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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*. When applied to musical form, this idea is embodied 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 (Caplin, 1998, 2009).[1] 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 location. For instance, a passage may be easily identified as a beginning if it opens a movement or a piece. An *intrinsic* (i.e., out-of-context) 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 characteristics to specific formal functions.

An informal statement such as "this is an unusual beginning," for instance, depends on an intrinsic evaluation of formal functionality. Indeed, the "unusualness" of the (contextually defined) beginning is contingent upon evaluating its internal elements, which, on their own, may express a different temporality (i.e., a sense of being a "middle" or even an "end"). One might wonder, however, whether such an association between a passage's internal elements and a specific temporal location is possible based solely on aural information. 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*.[2]

Background in music theory

Music theorists have proposed that in the stylistically conventionalized music of the high classical period (c.1775–1810), a musical passage may convey a particular temporal location even when removed from its original context (Agawu, 1991; Caplin, 1998; Kramer, 1988; Lochhead, 1979).[3] They have argued that a high familiarity with the style's form-functional conventions—many of them definable through certain configurations of musical parameters such as harmony, melodic contour, texture, etc.—can enhance listeners' perception of temporality. Although theorists have assumed that listeners are capable of associating musical materials with different temporal locations (such as a 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 offered various ideas about which musical characteristics define formal functionality. Of the three functions of beginning, middle, and end, scholars have focused most attention on the latter, generally agreeing that end functions feature an authentic cadential progression concluding on a strong metrical position and, typically, supporting a descending melodic contour.[4] Caplin (1998) further proposes

explicit attributes of beginnings and middles. He describes typical beginnings as harmonically tonic-prolongational (with a special emphasis on root-position tonic), rhythmically varied, and melodically ascending ("opening-up"). He characterizes middles as featuring phrase-structural fragmentation (i.e., grouping units that decrease in size), acceleration of harmonic rhythm, and increased surface rhythmic activity. These attributes of medial functionality are relational; that is, they depend on comparing the passage to what precedes it in order to determine, say, if the grouping structure decreases or the harmonies accelerate. Thus whereas 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). The consequences of this distinction for the perception of middle functions will be briefly addressed later.

Background in music perception and cognition

Research on form in the field of music perception and cognition has mainly addressed issues of formal syntax (that is, the logical ordering of events) and the interaction between musical materials and form. Studies focusing on formal syntax at high or moderately high structural levels have established that listeners do not significantly prefer the original version of a piece over scrambled versions of the same piece (Karno & Konečni, 1992; Konečni, 1984; Tillmann & Bigand, 1996). 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). This research therefore suggests that an investigation 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).

Other experimental research has inquired into the link between specific musical characteristics and temporal positions. Priming studies (e.g., Tillmann, Bigand, and Pineau, 1998b; Tillmann & Bigand, 2001) have shown that both musically trained and untrained listeners develop expectancies for a passage's final tonic. Studies using segmentation tasks have investigated various types of interaction between musical materials and form (Clarke & Krumhansl, 1990; Krumhansl, 1996; Lalitte, Bigand, Poulin-Charronnat, McAdams, Delbé, and D'Adamo, 2004). None, however, has focused systematically on the expression of multiple formal functions.

Aims

This interdisciplinary project examined the perception of beginnings, middles, and ends of musical themes in the instrumental style of the high classical period. We posed the following two questions: (1) are musicians and non-musicians capable of correctly identifying the formal function of short, out-of-context, intra-thematic musical units? and (2) what are the specific musical characteristics that elicit musicians' and non-musicians' perception of beginnings, middles, and ends?[5]

To address the first question, 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 (1756-1791). 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.

To address the second 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 characteristics, 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.[6] 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.[7] All excerpts are reproduced in the Appendix. A conditioning phase preceding the experiment proper used the first 40 measures of Mozart's Piano Sonata in F major, KV 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.

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 the Appendix, next to each musical excerpt.

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.[8] The 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 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.[9] Table 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.

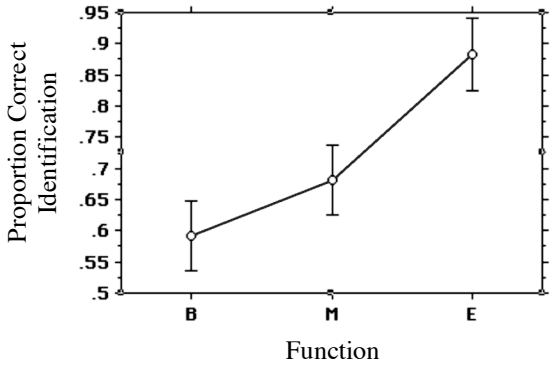

Figure 1. Accuracy of function identification for all participants. The overall mean proportion correct identification of the formal functions is shown for each function (B, M, E standing for beginning, middle, and end, respectively). The vertical bars indicate the 95% confidence interval about the mean.

Table 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.

Agreement. 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 *agreed upon*.

Table 2 shows the number of excerpts that were agreed upon for each formal function and expertise group (excerpts' labels are shown between parentheses). Among the set of 36 excerpts presented to participants, musicians agreed upon the conveyed function of 27 excerpts, of which 7, 8, and 12 were categorized as beginning, middle, and end functions, respectively. Participants in the non-musicians groups agreed upon the conveyed function of 15 excerpts, of which 2, 4, and 9 were categorized as beginning, middle, and end functions, respectively. Overall, excerpts agreed upon as 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. Excerpts that received a minimum of 15 identical functional judgments. The labels of agreed-upon 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 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 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

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

(b) Non-musicians

Response / Stimuli	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 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 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).[10] In contrast, the same error types are asymmetrically distributed in the non-musicians group (Table 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 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, $\chi^2(2) = 1.41$, $p = 0.49$), non-musicians' functional judgments differed significantly from a homogenous distribution (192 beginning, 297 middle, and 231 end judgments, $\chi^2(2) = 23.48$, $p < .0001$). 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, 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.

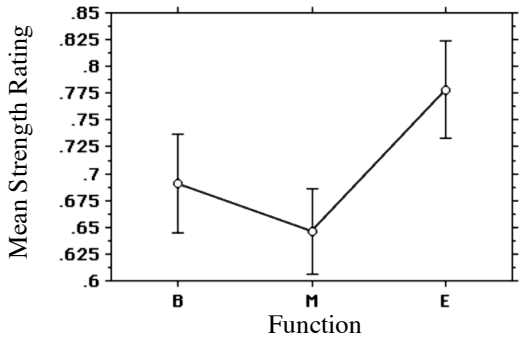

Figure 2. Mean rated strength of function (all participants). The mean strength-of-function conveyed is shown for each formal function. The vertical bars indicate the 95% confidence interval about the mean.

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 paper.

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).[11] 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 two 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 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. Moreover, the relatively high proportion correct identification of middles showed that this function can be expressed intrinsically, even though music-theoretic discourse emphasizes mostly its contextual attributes.[12]

Form-defining musical characteristics

The second goal of this project was to formulate hypotheses with respect to the various musical characteristics that led participants to their form-functional decisions. Such features were determined by collating the excerpts' characteristics with the results of the functional-identification task. These observations, however, form a corpus of preliminary hypotheses that will eventually require further, more systematic testing. 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.[13] Thus, excerpts featuring several characteristics that we defined as appropriate to a given function were likely to generate functional agreement (within a given group of listeners), while excerpts that presented competing characteristics (i.e., proper to different functions) were more likely to generate disagreement.[14]

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 "agreed upon"); (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' agreed-upon 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),[15] six were identified as beginnings by 15 or more musicians—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.[16] Of all musicians' agreed-upon 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 agreed-upon middles (see excerpts M1–4, M8, M9).[17]

Rhythmic variety was also likely to affect musicians' perception of beginning function, whereas rhythmic uniformity tended to prompt the identification of a middle function.[18] 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).[19] On the other hand, four of the five beginnings that were not agreed upon (and thus absent from the Beginning column of Table 2) exhibited a low or relatively low level of rhythmic variety (excerpts B1, B5, B6, and B7).[20]

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).[21] 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 agreed upon).[22] Likewise, three of the five middles in which the right hand enters before the left hand—M3, M5,[23] and M6—were categorized the most often as beginnings.[24]

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 agreed-upon middles were in fact those that exhibited the lowest emphasis on the tonic harmony (see Table 2).[25] 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.

Middles: non-musicians. Rhythmic uniformity also influenced non-musicians' perception of middles. It seems, however, that non-musicians alone associated two specific characteristics 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.[26] Indeed, three of the four beginnings that accumulated the highest number of middle judgments (B2, B4, B5) display the highest levels of onset density.[27] 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 agreed upon as a middle by both groups of expertise. We propose that such an unexpected outcome exemplifies the perceptual influence of rhythmic uniformity—a middle feature.[28] The 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.[29] Second, excerpts E1, E8, and E12 were the only ends that were *not* agreed upon by non-musicians; 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.[30] 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 ones from non-musicians. Apart from its high onset density, this excerpt exhibits another characteristic that non-musicians 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., Tillmann et al, 1998b).[31] The above discussion hints, however, at one difference between musicians and non-musicians. For musicians, a perfect authentic cadence guaranteed an agreed-upon 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.

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. 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.[32] In other words, they 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" (cited at the opening of this paper), 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 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.[33] 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 one-bar units. Within their placement in the original themes, these units follow directly upon a passage containing two-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 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 evidenced by our experimental results. 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 agreed upon as 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.

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.[34] 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.[35] 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 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. 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.[36]

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

(i.e., out-of-context) 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).

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 conclusively 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.[37]

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). The results of our forthcoming research, in conjunction with those presented here, will deepen our understanding of how formal functions are expressed

through musical materials and consequently perceived by musicians and non-musicians alike.

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[1] 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, it is beyond the scope of this paper to provide a detailed account of the differences between these two types of functionality.

[2] The terms *perception* and *cognition* are often considered as referring to distinct, complementary processes, the former being associated with the apprehension and transformation of the acoustic signal by the sensory organs and the latter with the mental representation of the incoming sensory information, attention to it, and its storage and retrieval from memory. We believe, however, that this distinction is irrelevant to the purposes of the current study, particularly given that the feedback of higher-level functions onto lower-level ones is ubiquitous in music perception and cognition. For the sake of simplicity, we use exclusively the substantive *perception* and its related verb forms.

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

[4] The authentic cadence requires a dominant-to-tonic harmonic progression, with both harmonies in root position. The half cadence also constitutes a formal end, though it is a weaker end-marker than the authentic cadence.

[5] 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.

[6] KV 279 (C major), KV 280 (F major), KV 281 (B major), KV 282 (E-flat major), KV 283 (G major), KV 284 (D major), KV 309 (C major), KV 311 (D major), KV 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.

[7] 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.

[8] 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.

[9] Chance level is 33.3%.

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

[11] Since the level of familiarity and the rating values are inversely proportional, a lower numerical score indicates a higher degree of familiarity.
[12] This claim, however, must be somewhat qualified due to non-musicians' relatively high rate of confusion involving the middle function (see Table 3b).
[13] 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. See also Barsalou (1992).
[14] *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 strongly agreed upon its conveyed formal function) while causing a high level of confusion (i.e., most participants mistakenly categorized this beginning excerpt as a middle excerpt).
[15] 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 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.
[16] M7 and M5 were identified as beginnings by 14 and 13 musicians, respectively; therefore these middle excerpts almost made it into the category of agreed-upon beginnings.
[17] Excerpt M11 was the only agreed-upon middle that opened with a tonic harmony.
[18] 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.
[19] 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 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.
[20] 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.
[21] Excerpts M4 and M6 are exceptions to this tendency.
[22] 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.
[23] 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.
[24] Excerpts M8 and M9, although identified as beginnings by 5 and 6 non-musicians, respectively, are exceptions to this tendency.
[25] M12 is an exception to that rule. This excerpt was not agreed upon as a middle despite its lesser emphasis on the tonic harmony than some of the agreed-upon 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.
[26] Because the unit of time being measured is absolute, the perceived onset density depends on the tempo of the performance.
[27] B6 is an exception to this tendency.
[28] 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.
[29] 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.

[30] 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.

[31] These studies showed that listeners—both with and without musical training—expect the tonic harmony to close a musical passage.

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

[33] We nevertheless established 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.

[34] Further testing is necessary to confirm or reject our hypotheses about participants' decision-making processes.

[35] 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 was *agreed upon* as expressing any other formal function than an end.

[36] Excerpts B5 and M2 may be considered as other representatives from this category, since they were both agreed upon as middles by both expertise groups.

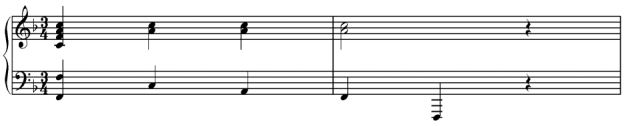
[37] In other words, there was no significant interaction between musicianship and accuracy of identification, and between musicianship and strength-of-function rating.

Appendix

Musical excerpts and form-functional judgment distributions

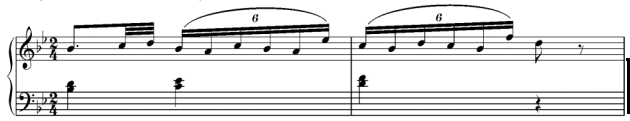
Beginnings:

B1 (K. 280, i, mm. 1-2)



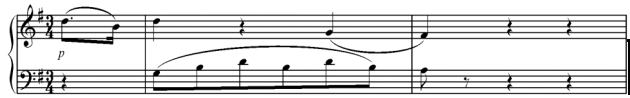
	B	M	E
Mu.	9	2	9
N-mu.	5	5	10

B2 (K. 281, i, mm. 1-2)



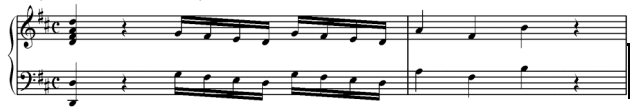
	B	M	E
Mu.	17	3	0
N-mu.	7	12	1

B3 (K. 283, i, mm. 1-2)



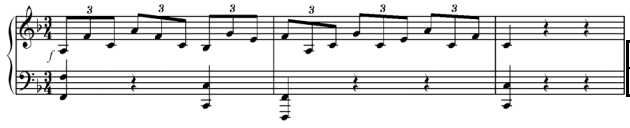
	B	M	E
Mu.	20	0	0
N-mu.	17	3	0

B4 (K. 284, i, mm. 1-2)



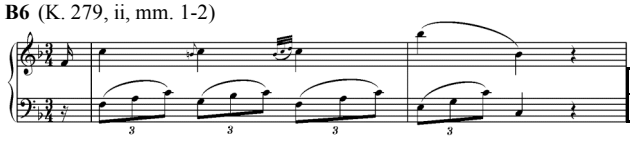
	B	M	E
Mu.	17	3	0
N-mu.	7	12	1

B5 (K. 280, i, mm. 13-15)



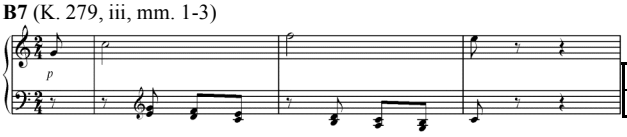
	B	M	E
Mu.	2	18	0
N-mu.	3	15	2

B6 (K. 279, ii, mm. 1-2)



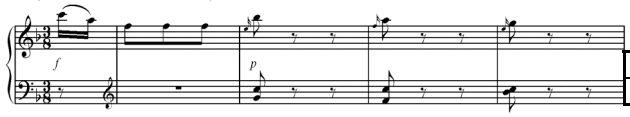
	B	M	E
Mu.	13	7	0
N-mu.	6	13	1

B7 (K. 279, iii, mm. 1-3)



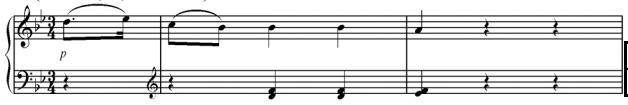
	B	M	E
Mu.	8	11	1
N-mu.	12	7	1

B8 (K. 280, iii, mm. 1-4)



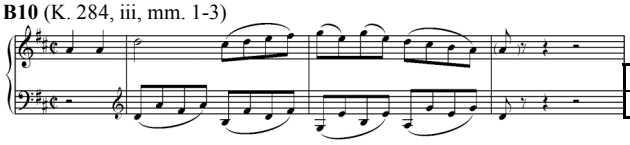
	B	M	E
Mu.	10	8	2
N-mu.	8	9	3

B9 (K. 282, ii, mm. 1-2)



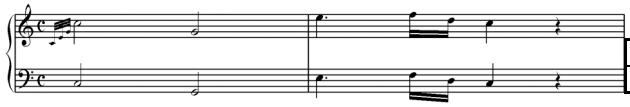
	B	M	E
Mu.	17	2	1
N-mu.	13	6	1

B10 (K. 284, iii, mm. 1-3)



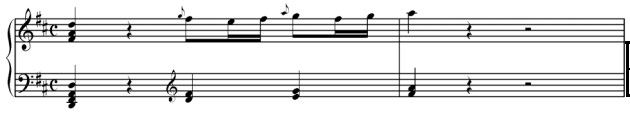
	B	M	E
Mu.	18	2	0
N-mu.	16	3	1

B11 (K. 309, i, mm. 1-2)



	B	M	E
Mu.	19	0	1
N-mu.	7	8	5

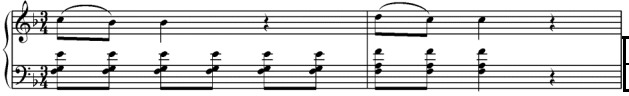
B12 (K. 311, i, mm. 1-2)



	B	M	E
Mu.	19	1	0
N-mu.	14	6	0

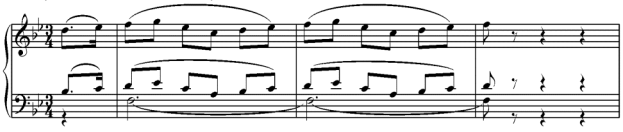
Middles:

M1 (K. 280, i, mm. 5-6)



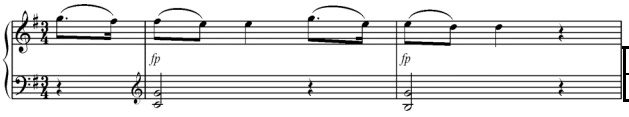
	B	M	E
Mu.	0	20	0
N-mu.	0	20	0

M2 (K. 282, ii, mm. 5-7)



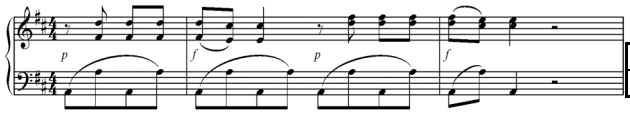
	B	M	E
Mu.	1	19	0
N-mu.	5	15	0

M3 (K. 283, i, mm. 5-6)



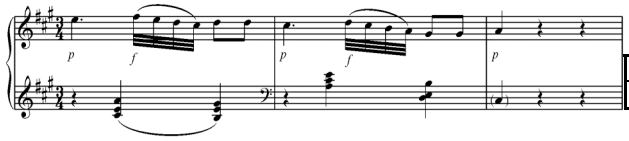
	B	M	E
Mu.	5	15	0
N-mu.	10	10	0

M4 (K. 284, i, mm. 5-6)



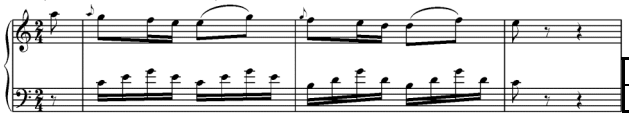
	B	M	E
Mu.	2	18	0
N-mu.	7	11	2

M5 (K. 284, ii, mm. 5-7)



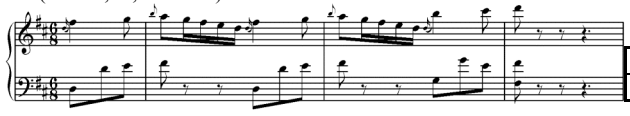
	B	M	E
Mu.	13	7	0
N-mu.	10	7	3

M6 (K. 309, iii, mm. 5-7)



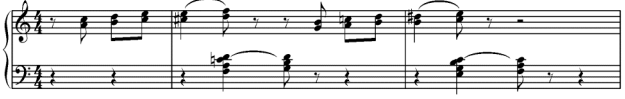
	B	M	E
Mu.	6	13	1
N-mu.	8	11	1

M7 (K. 311, iii, mm. 5-7)



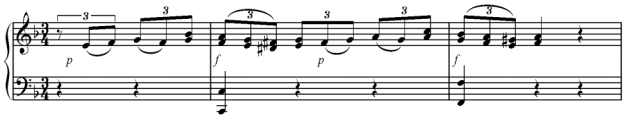
	B	M	E
Mu.	14	6	0
N-mu.	7	12	1

M8 (K. 310, i, mm. 6-7)



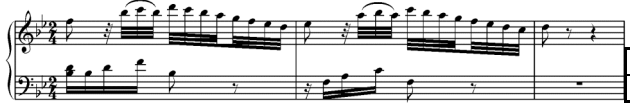
	B	M	E
Mu.	1	19	0
N-mu.	5	13	2

M9 (K. 279, ii, mm. 7-8)



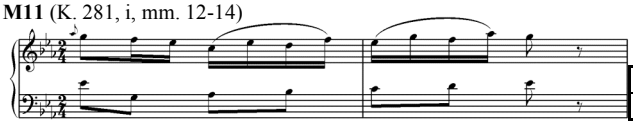
	B	M	E
Mu.	4	15	1
N-mu.	6	13	1

M10 (K. 281, ii, mm. 7-8)



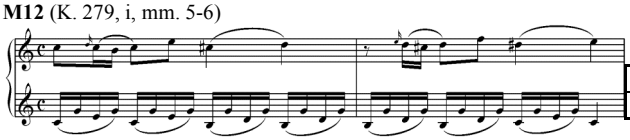
	B	M	E
Mu.	6	14	0
N-mu.	6	14	0

M11 (K. 281, i, mm. 12-14)



	B	M	E
Mu.	0	17	3
N-mu.	2	11	7

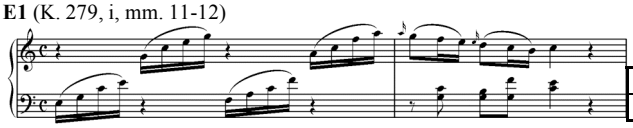
M12 (K. 279, i, mm. 5-6)



	B	M	E
Mu.	10	10	0
N-mu.	3	17	0

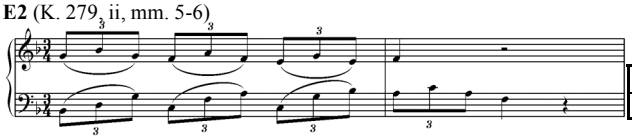
Ends:

E1 (K. 279, i, mm. 11-12)



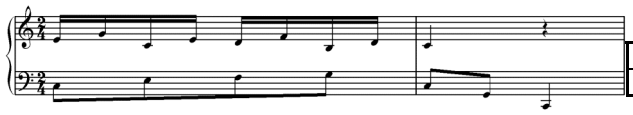
	B	M	E
Mu.	0	0	20
N-mu.	2	10	8

E2 (K. 279, ii, mm. 5-6)



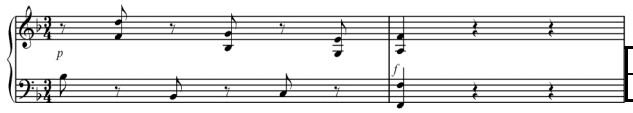
	B	M	E
Mu.	0	0	20
N-mu.	0	3	17

E3 (K. 279, iii, mm. 9-10)



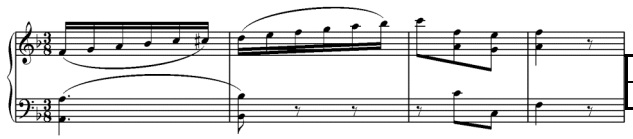
	B	M	E
Mu.	1	0	19
N-mu.	0	3	17

E4 (K. 280, i, mm. 12-13)



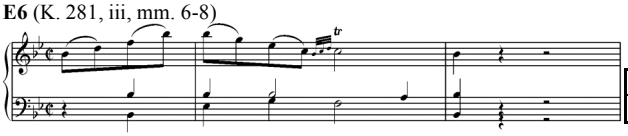
	B	M	E
Mu.	0	1	19
N-mu.	1	0	19

E5 (K. 280, iii, mm. 13-16)



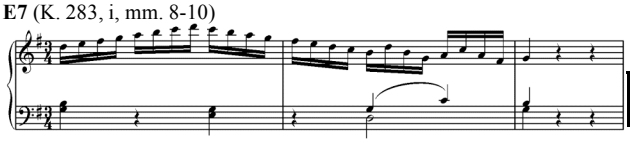
	B	M	E
Mu.	0	0	20
N-mu.	0	1	19

E6 (K. 281, iii, mm. 6-8)



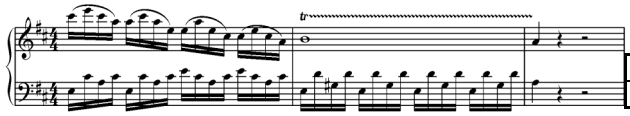
	B	M	E
Mu.	0	0	20
N-mu.	2	0	18

E7 (K. 283, i, mm. 8-10)



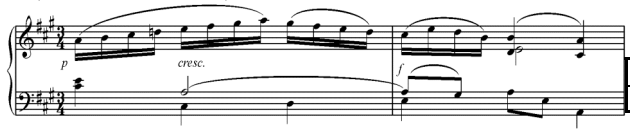
	B	M	E
Mu.	0	0	20
N-mu.	1	3	16

E8 (K. 284, i, mm. 48-50)



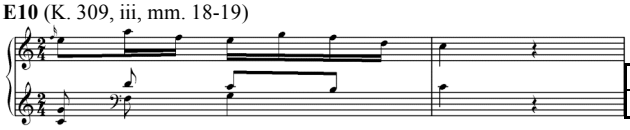
	B	M	E
Mu.	0	0	20
N-mu.	0	7	13

E9 (K. 284, ii, mm. 15-16)



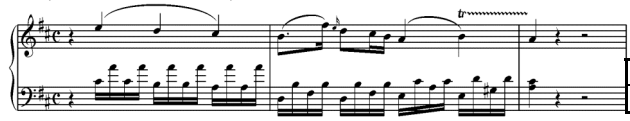
	B	M	E
Mu.	0	0	20
N-mu.	1	4	15

E10 (K. 309, iii, mm. 18-19)



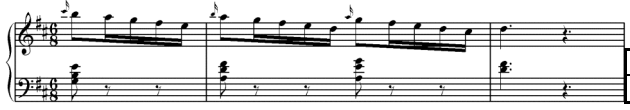
	B	M	E
Mu.	0	1	19
N-mu.	0	3	17

E11 (K. 311, i, mm. 30-32)



	B	M	E
Mu.	0	0	20
N-mu.	0	5	15

E12 (K. 311, iii, mm. 15-16)



	B	M	E
Mu.	0	1	19
N-mu.	1	5	14

B, M and E stand for beginning, middle, and end, respectively. 'Mu.' and 'N-mu.' stand for musicians and non-musicians. The formal function of every excerpt was identified by 20 musicians and 20 non-musicians.

Biographies

Michel Vallières studied performance (percussion) and composition at Université Laval in Quebec City before obtaining a Masters degree in Music Theory (McGill University, 2005). Currently a PhD candidate in Music Theory at McGill University, he focuses primarily on the perception of musical form, but his research covers a variety of topics, including popular music analysis and form in the early 18th century. He gave a keynote talk at the 2008 Conference on Interdisciplinary Musicology (CIM08) and has presented several papers at international conferences in North America, Europe, and Asia.

Daphne Tan obtained a Bachelors degree in Music Theory and Clarinet Performance, and a Masters degree in Music Theory from the Schulich School of Music, McGill University. She is currently pursuing a doctoral degree in Music Theory at the Eastman School of Music, University of Rochester. Her research interests include the perception of musical form, history of music psychology, and theoretical approaches to early-twentieth-century music.

William E. Caplin is James McGill Professor of Music Theory in the Schulich School of Music. His book *Classical Form* (1998) won the 1999 Wallace Berry Book Award from the Society for Music Theory. His recently published book, co-authored with James Hepokoski and James Webster, *Musical Form, Forms &* Formenlehre: *Three Methodological Reflections* (ed. Pieter Bergé) further develops the theoretical basis of his theory of formal functions. He has published other articles on musical form in the *Journal of the American Musicology Society*, *Eighteenth-Century Music*, *Beethoven Forum*, *Musiktheorie*, *The Journal of Musicological Research*, and *Tijdschrift voor Muziektheorie*. He served as President of the Society for Music Theory from 2005 to 2007.

Stephen McAdams studied music composition and theory at De Anza College in California before entering the realm of perceptual psychology (BSc, Psychology, McGill University, 1977; PhD, Hearing and Speech Sciences, Stanford University, 1984). In 1986, he founded the Music Perception and Cognition team at IRCAM in Paris. He was Research Scientist and then Senior Research Scientist in the French CNRS from 1989 to 2004. He has recently taken up residence at McGill University as Professor, Canada Research Chair in Music Perception and Cognition, and Director of the Centre for Interdisciplinary Research in Music Media and Technology (CIRMMT) in the Schulich School of Music.

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