Pitch Dispersal and the Perception of Tonal Strength in Schoenberg’s Oeuvre

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The idea that listeners’ tonal/atonal sense represents a special case of multiple causation was examined, and the following hypothesis was tested: pitch dispersal (i.e., distance in pitch between successive tones) is a secondary determinant of tonality and atonality, the former being strengthened by low levels of pitch dispersal and the latter by high levels of pitch dispersal. A correlational study was conducted in which eight trained listeners judged the degree to which 78 melodies extracted from A. Schoenberg’s oeuvre convey a tonic. In line with the present hypothesis, results suggest that listeners’ judgments were influenced not only by consonance or pitch class distributions (i.e., by underlying “scales”), as expected from previous research, but also by pitch dispersal. Interestingly, it was also found that Schoenberg’s melodies became not only less diatonic over time, but also more dispersed, which suggests that the joint manipulation of pitch class distributions and pitch dispersal might have been a strategy on Schoenberg’s part to weaken the sense of tonality. Some of the key musical, theoretical, and psychological implications of these findings are discussed.

Received: January 8, 2016, accepted December 29, 2016.

Key words: tonality, atonality, multiple causation, pitch class-related factors, pitch-related factors

One of the key distinctions in Western music history is that between tonal and atonal. Choron (1817), who coined the term tonality, applied it to a range of musical styles, beginning with that of ancient Greece; various forms of tonality then flourished before the emergence of modern tonality, in which the major and minor modes (or scales) were given prominence and melodic structuring (i.e., tone succession) ceded importance to harmony (i.e., tone simultaneity). (For similar, more recent approaches to tonality, see Norton, 1984, and Réti, 1958; for a critical summary of different approaches, see Hyer, 2002). By contrast, the term atonal was applied to specific forms of avant-garde music composed from the early 1900s onwards, which were labeled as such precisely because they opposed the tonal traditions. According to Adorno (1984), for example, atonality is mainly a feature of the music of Arnold Schoenberg (1874-1951) and his followers, which, Adorno claims, broke the continuity of Western musical thought (p. 80), rejecting the major and minor modes in favor of the chromatic mode, and the traditional chords in favor of “non-diatonic” (or vieltönigen) harmonies (p. 57) (see also Haimo, 1997; Schoenberg, 1922/1978).

Interestingly, the distinction between tonal and atonal is grounded in music perception and psychology. Indeed, Choron (1817, pp. 36-37) himself first defined tonality as an auditory experience, in which one tone in the piece—the tonic (or tonique)—conveys a sense of completion (or paraître du terminaison) that no other tone does. Accordingly, the term atonality is generally confined to music that totally banishes any reference to a tonic (Apel, 1969: p. 62; see also Kennedy, Kennedy, & Rutherford-Johnson, 2013: p. 35). More recent psychomusical studies explored these conceptualizations further, aiming to determine how tonality and atonality influence on music listening. The insights provided by these studies are numerous.

For instance, when tonal stimuli are given, the sense of completion is strongest for the tonic, as Choron (1817) suggested, but also subtly different for the remaining tones, particularly in trained listeners (Krumhansl & Shepard, 1979). By contrast, atonal stimuli promote a sense of completion that relies more heavily on temporal factors (e.g., tone duration; Dibben, 1999; Esteve-Faubel, Francés-Luna, Stephens, & Bartel, 2016; see also Lerdahl, 2001). In addition, tonal pieces are judged as quite dissimilar to their (ad hoc generated) atonal versions despite having the same rhythms and form, which illustrates the impact that tonality/atonality may have on music perception. Furthermore, tonal (or atonal) pieces are judged as more similar to each other than to their atonal (or tonal) counterparts (Lalitte, Bigand, Kantor-Martynuska, & Delbé, 2009). On the other hand, in comparison with atonal (or tonally ambiguous) stimuli, tonal stimuli improve mistuning...
identification (Prince, Schmuckler, & Thompson, 2009; Umemoto, 1990), as well as tone recognition (Dewar, Cuddy, & Mewhort, 1977; Schulze, Dowling, & Tillmann, 2012; see also Cuddy & Lyons, 1981), and also strengthen melodic expectations—basically, for the tones of the scale (Schellenberg, 1996; see also Schellenberg, 1997, Table 1). In sum, tonal stimuli, as opposed to atonal stimuli, allow listeners to represent tones in highly hierarchical (oriented towards the tonic) and stable (across pieces) ways, usually referred to as tonal hierarchies or key profiles (see also below), and these profiles, in turn, are responsible for listener’s experiences related to tonalness as opposed to atonalness (Bharucha, 1984; Krumhansl & Cuddy, 2010; Lerdahl, 2001).

Given the importance that tonality and atonality have in the various fields of musical thought, and the experiential status these terms intrinsically have, a central question for music psychology relates to the causes of tonality and atonality. To put it simply, the question is: what are the objective properties of music that lead it to sound tonal or atonal? The present study addressed this question by asking listeners to judge how tonal or atonal the vocal parts of several pieces by A. Schoenberg sounded to them. As detailed below, the central prediction tested was that tonality and atonality are related not only to the pitch class structures music shows, as previously known (e.g., Krumhansl, 1990a; Lerdahl, 2001; Temperley, 2007a), but also to how dispersed successive tones are in the register, as recently suggested (Anta, 2015). In addition, the study was based on the idea that tonality and atonality represent not only two extremes of a single phenomenon, as suggested above (see also Larson, 1997, p. 117, and Lerdahl, 2001, p. 351), but also a special case of multiple causation, one in which a hierarchical gradation of determiners (e.g., pitch class-related and pitch-related factors) is operative. These ideas are developed in the next sections in order to provide the theoretical framework within which the present study was carried out.

**Tonal Strength and Multiple Causation**

As far as the author knows, there is little research on the question of what properties lead music to sound tonal or atonal. Rather, the focus has been on the question of why tonal stimuli sound in a particular tonality or key (e.g., C major), as opposed to other keys (e.g., D major) but not to “no key” (i.e., atonality). To put it more accurately, previous research has focused on the tonal implications of musical stimuli (i.e., the key/s they suggest), their tonal strength (i.e., the force with which each key is implied), or their tonal ambiguity/clarity (i.e., the difference in strength between implied keys; see Krumhansl, 1990a; Temperley, 2007b). These notions may be useful to address the question posed here. However, the most useful would be that of tonal strength, since low levels of tonal strength may be understood as indicating high levels of atonality, or vice versa. Further, the study reported in this paper did not test what key/s a given musical stimulus suggests, but whether or not it suggests any key, and if so, to what extent. Therefore, the research reviewed below is mostly restricted to that illuminating which musical properties affect tonal strength.

(For more on tonal implication and related issues, the interested reader may consult Chew, 2014, and Temperley, 2007a). This review will survey the pitch class related factors on which previous research concentrates and from which the present research departs.

Perhaps the most fruitful models of tonal strength are those referred to as distributional (see Temperley, 2007a). According to these models, there are four steps in tonal perception. First, the pitch-related information of the piece is compressed into pitch classes (categories of pitches one or more octaves apart). Second, the distribution of pitch classes in the piece is computed according to some factor; in particular, the duration accumulated by each pitch class (e.g., Krumhansl, 1990a; Smith & Schmuckler, 2004) or their frequencies of occurrence (e.g., Bharucha, 1987; Temperley & Marvin, 2008; Tillmann, Bharucha, & Bigand, 2000). Third, the pitch class distribution observed in the piece is compared with those distributions usually observed in tonal repertoires, which would be stored in memory as relative (i.e., in scale degree terms) and schematic entities, the above mentioned key profiles. Two key profiles are proposed, one for major keys and one for minor keys. The between-distributions comparison process is usually thought of as correlational, as was done here (see below), but other approaches (e.g., a probabilistic one, in the works by Temperley and his colleagues) have been developed as well. Finally, the maximum correlation coefficient (in a correlational approach) between either of the key profiles and the pitch class distribution of the piece indicates its (main) tonal implication, whereas the magnitude of the coefficient indicates its tonal strength.

Figure 1 illustrates the way in which distributional models work, and the problems they may have in dealing with tonality or atonality. The vocal parts (i.e., the leading melodies) of two pieces (Opuses 1-1 and 22-4) by A. Schoenberg were analyzed. These pieces are usually understood as tonal and atonal, respectively (e.g., Frisch, 2010; Simms, 2000; cf. Haimo, 2006; see below). The frequency-based pitch class distributions of the melodies are shown in Figure 1 (right side panels). The
frequency-based key profiles suggested by Temperley and Marvin (2008) were used in the analysis; these profiles were chosen because they were originally formulated as proportions, which facilitates comparison between distributions. The major and minor key profiles are also shown in Figure 1 (left side panels). In the case of Op. 1-1, the maximum correlation was found with the major key profile oriented to D (i.e., being D the tonic), and the correlation coefficient was \( r(12) = .75, \ p < .01 \). Thus, according to the model the melody implies the key of D major, and with a relatively high level of tonal strength. Interestingly, D major is the key suggested by Schoenberg in the score (through the key signature), which highlights the predictive power distributional models may have. In the case of Op. 22-4, the maximum correlation was found with the minor key profile oriented to A, and the correlation coefficient was \( r(12) = .61, \ p < .05 \), which means that A minor would be the implied key, with a moderate tonal strength. Finally, note that the model predicates that the tonal strength is lower in Op. 22-4 than in Op. 1-1, which also highlights its predictive power. However, it also predicates that Op. 22-4 confidently implies a key, which strongly contradicts conventional musicological wisdom; further, the predicted level of tonal strength is not as low as one would expect for a melody supposedly atonal.

Alternatively, tonal strength may be examined using functional models (e.g., Brown, 1988; Brown & Butler, 1981). Like distributional models, these models rely on the notion of classes of sonorities. However, this notion is applied not only to pitches, but also to pitch intervals (i.e., to the distance in pitch between tones); thus, for example, the intervals B4-C5 and B4-C4, which respectively comprise 1 and 11 semitones, are thought of as two instances of the interval class 1.\(^1\) Next, the interval class vector (i.e., a vector encoding the number of occurrences of each interval class) inferred from the piece would be compared with the vectors inferred from the diatonic sets (i.e., from the major and minor scales). Finally, the piece would be tonal if its vector matches either vector of these sets; otherwise, it would be weakly tonal, and even atonal (see Brown, 1987). Indeed, tonal strength is thought of as varying with vectors’ entries.

\(^1\) Interval classes are referred to by numbers indicating the shortest theoretical distance between the pitch classes with which they are made (see Forte, 1973).
Specifically, in determining a tonal center, the listener would rely more on rarer than on common interval classes—those that unambiguously correlate with a single diatonic set—and more so when their pitches appear in temporal orderings implying goal-oriented motions (see also Brown, Butler, & Jones, 1994). However, as useful as these models are, they suffer from some important drawbacks. For instance, musical stimuli that depart slightly from diatonic sets (in the sense of being slightly chromatic) would necessarily yield a degraded tonal percept, which at least intuitively does not appear to be so. On the other hand, no definite diatonic set (and hence no definite interval class vector) is assigned to pieces in minor keys, which makes it difficult to estimate their tonal strength. Finally, this difficulty also arises from tonal music lacking in rarest intervals of the diatonic sets (see Anta, 2015; Krumhansl, 1990b).

In any case, the fact that the sense of tonality and atonality may be affected not only by pitch class distributions but also by rare interval classes and/or pitch class orderings suggests that tonal experience is to be understood in terms of multiple causation. As defined by Bunge (2009), multiple causation refers to situations in which two or more factors determine an effect; for only one factor, the term simple causation is applied. Multiple causation may be disjunctive or conjunctive. In the former case, two or more factors may alternately (i.e., one or another) produce an effect; in the latter the effect is produced by the joint action (i.e., one plus another) of two or more factors. Given this distinction, then tonal experience may be understood as a case of disjunctive multiple causation insofar as, for example, either duration-based pitch class distributions (as documented for example in Krumhansl, 1990a) or interval class vectors (as documented, for example, in Brown & Butler, 1981) may trigger tonal implications and regulate tonal strength. Further, disjunctive multiple causation might explain why within the distributional framework there is evidence of either duration-based or frequency-based strategies of tonality perception (as documented, for example, in Smith & Schmuckler, 2004, and Temperley & Marvin, 2008, respectively).

However, tonal experience might also constitute a case of conjunctive multiple causation. For instance, Huron and Parnscutt (1993) found that a combination of distributional and functional factors (briefly, the occurrence of pitch classes weighted by their recency in time) may explain listeners' tonal judgments better than either factor alone, particularly for chord sequences. Accordingly, the authors conclude that tonality perception might arise through separate diachronic (i.e., disjunctive) and synchronic (i.e., conjunctive) processes in which both structural and functional factors could be critical (see also Leman, 1995, 2000). In a different line of research, Abe and Okada (2004) reported that the key listeners infer from a tone sequence may vary if the pitch and rhythmic structures of the sequence are either in phase (original condition) or out of phase (shifted conditions), which suggests that tonal implications are jointly determined by pitch-related and time-related factors. In line with this, it has been theorized that phenomenal accents and/or metric cues may determine which tones listeners understand as tonally important (Lerdahl & Jackendoff, 1983; Narmour, 1990; see also Lerdahl, 2001). Finally, Boltz (1989) showed that, given a tonal sequence, listeners’ judgments of completion depend not only on the pitch class with which the sequence ends, but also on its temporal location (i.e., expected or unexpected), which suggests that time-related factors affect tonal strength as well (see also Schmuckler & Boltz, 1994).

In sum, the existing literature suggests that tonality represents an experiential system (involving tonal implications, sense of completion, expectedness, etc.), resisting explanations in terms of simple causation (e.g., pitch class distributions versus interval class vectors). Rather, it appears to be readily explained either in terms of disjunctive multiple causation (e.g., distributions or vectors) or in terms of conjunctive multiple causation (e.g., distributions and vectors). While this idea may not sound surprising given the complexity such a system would have, it forces one to carefully reflect on what factors may determine tonality, and how. In what follows the reflection focuses on pitch related factors, particularly on pitch dispersal, and on how this factor may act in determining listeners’ tonal experience.

**Tonal Strength, Hierarchical Multiple Causation, and Pitch Dispersal**

To understand tonality in terms of multiple causation does not mean to reject the critical role traditionally assigned to pitch classes in tonal determination. Recall that since Choron (1817), tonality has been linked to pitch class-related concepts such as tonic, scale, mode, or the like. Indeed, as Bunge (2009) explains, there may be instances of conjunctive multiple causation in which the causal complex can be analyzed into a hierarchical gradation. When such a gradation of causes is present, one may speak of the primary cause, a secondary determiner, a tertiary one, and so on. Thus, in the light of this
distinction between non-hierarchical and hierarchical multiple causation, tonality may be understood as determined by multiple factors of which pitch class-related factors would be the primary ones, and other factors (e.g., time-related factors) would be of secondary importance. But secondary importance should not be equated with unimportant. Although one cannot affirm, for example, that temporal factors are the (primary) cause of tonality, to neglect their role as (secondary) determiners seems unwise. Recall that temporal factors may alter tonal implications (e.g., Abe & Okada, 2004), and also tonal strength (e.g., Boltz, 1989). Further, there are action-reaction, systemic instances of conjunctive multiple causation in which the way factors act on each other may confer on them a function (i.e., a determinant status) particularly critical in certain situations (see also Franck, 2003). It appears that tonality is one of these instances of conjunctive multiple causation, and that pitch dispersal is one of the secondary factors that may become critical.

The term pitch dispersal is used here to refer to how close or distant successive—though not necessarily consecutive—tones are in the register. It is inspired by a recent study (Anta, 2015) suggesting that the splitting of tone sequences into different octaves alters not only their tonal implications, but also their tonal strength. More specifically, in that study participants were given either original melodic fragments extracted from the Western tonal repertoire, or distorted versions of them in which pitch class distribution was preserved but pitch class ordering, pitch contour (i.e., the pattern of ups and downs from one tone to the next), and/or pitch proximity (i.e., the distance in pitch between consecutive tones) were altered. Then, they were asked, first, to identify the tonic of each fragment/version, and second, to rate how confident they were in the tonic they identified. The results showed that although as a rule the tonics participants identified were those implied by pitch class-related factors (e.g., by pitch class distributions), responses differed significantly across conditions (original versus altered), even when only pitch dispersal was manipulated (i.e., when only pitch proximity was altered). Participants’ level of confidence also decreased with increased levels of pitch dispersal. Moreover, in the unordered conditions (i.e., when pitch class ordering was altered), low levels of pitch dispersal made participants more confident in the tonics they identified, but not more reluctant to change their decisions about which tonic to select.

In light of the discussion above, the importance of these findings is threefold. First, they support the idea that tonal implication and tonal strength are two different components of tonality; listeners may take one tone as a reference point, but also trust in the references it provides in different degrees. Second, they suggest that conjunctive multiple causation is a plausible explanation of how these components behave; otherwise, differences in participants’ responses across conditions would be hard to understand. And third, they suggest that pitch dispersal, a factor not often considered when discussing tonality (or atonality), is a secondary determiner of both tonal implications and tonal strength. In fact, in this last regard pitch dispersal would be particularly important. Seemingly, when tonal clues coming from temporal ordering are altered, by keeping tones close in the register some alternative clues are enhanced or preserved, which in turn reinforces the activation of whatever sort of representation of tonality (e.g., a given key profile) the listener may have. In contrast, by spreading tones in the register, tonal clues would be obscured or erased, which in turn would cause music to sound more atonal (see also Anta, 2015, Discussion section). Finally, taken together, these ideas lead to the hypothesis that pitch dispersal is a secondary determiner of a listener’s sense of tonality and atonality, the tonal sense being strengthened by low levels of pitch dispersal and the atonal sense by high levels of pitch dispersal. This hypothesis was examined in the study reported below.

**Method**

**PARTICIPANTS**

Two music professors and six undergraduate music students at the National University of La Plata (Argentina) volunteered for the study. Both professors had extensive experience (more than 25 years) in music theory and analysis; one of them was specialized in music performance, the other in music analysis. The students (mean age 25.7 years, SD = 1.6) had at least five years of formal music training within the past six years. All participants reported having taken courses in tonal and atonal music, and also having normal hearing. One student reported absolute pitch; however, since the correlations between participants’ responses were all significant (see below), differences between them were not examined further.

**STIMULI**

Stimuli were generated from 78 pieces by A. Schoenberg. Specifically, they were based on the vocal lines of all of Schoenberg’s works with opus number for solo voice and accompaniment between Op. 1 and Op. 22, and the vocal line of one of his songs without opus
number, *Am Strande* (see Appendix). These musical materials were chosen as a source for stimuli preparation for several reasons. First, as discussed above, the idea of “levels of pitch dispersal” applies to voice leading and melodic structure. Therefore, only melodic materials (from a traditionally monophonic instrument, the voice) were chosen. Second, according to musicological research, Schoenberg’s later works are either atonal (e.g., Simms, 2000) or at least less tonal (e.g., Haimo, 1997, 2006) than his earlier ones; furthermore, the works composed around 1908 (Frisch, 1993; Haimo, 2006; Simms, 2000; see also Adorno, 1984), and particularly the song *Am Strande* (Forte, 1978, 1981; see also Maegaard, 1977) would represent a critical step towards the consolidation of the tonal/atonal differentiation. This being so, the present musical selection (ranging from 1898 to 1916; see Appendix) would comprise both tonal and atonal musical materials which in turn would allow one to examine the impact pitch dispersal may have on listeners’ sense of tonality and atonality. Finally, the third reason is that Schoenberg’s atonal pieces are among the first and most influential of the repertoire. Recall that, for example, according to Adorno (1984), atonality is mainly represented by Schoenberg’s oeuvre. Further, Schoenberg’s explorations with atonality appeared first in his vocal works (Frisch, 10; Simms, 2000). Thus, by focusing on Schoenberg’s vocal repertoire one also examines, basically, which musical features initially led music to sound atonal.

Once selected, Schoenberg’s melodies were modified in two ways. First, the original rhythms were replaced by an isochronous rhythm without rests in which each tone lasted 500 ms. Second, the original pitches were transposed as needed in such a way that the median pitch of each melody (i.e., the pitch that was equidistant from the lowest and highest pitches in the melody) was the same. In order to avoid extremely high or low pitches, C4 was taken as median pitch. (When, due to non-integer values, this was not possible, the median pitch of the melody was set as close as possible to C4—i.e., a quarter tone higher or lower). Finally, musical materials were coded as MIDI files using Finale® 2010, generated as sound tracks with Garritan Instruments for Finale® set to the Steinway Piano timbre, and recorded as MP3 files. These files were used as stimuli in each test session, as described below (see Procedure).

**APPARATUS**

Stimuli (hereafter also referred to as melody 1-1, melody 1-2, etc. in relation to Schoenberg’s opus from which they were respectively generated) were presented via Shure® SRH840 headphones connected to a laptop computer used for stimuli presentation (see Procedure). A netbook computer was used for recording participants’ responses. In this netbook, the mouse recorder software Ghost Mouse® (version 3.2.3) was run (in the background) during each individual session, while the participants listened to each of the stimulus melodies. In addition, the netbook’s screen displayed a white page with a horizontal line in it: the numbers 0 and 10 appeared at the left and right extremes of this line, respectively, with the rest of the integers numbers (from 1 to 9) equally spaced between them, and three short, equally spaced horizontal lines appeared in between each consecutive pair of numbers (e.g., between 0 and 1). Finally, a Genius® Micro Traveler mouse was connected to the netbook, which was manipulated by participants and whose movements and clicks were recorded with the abovementioned software. In sum, through the netbook real time, continuous responses (i.e., the slide and clicks of the mouse) were recorded from each participant in each session.

**PROCEDURE**

Participants were told that they would hear several melodies and that their task was to judge how tonal or atonal each melody sounded to them. Next, they were informed that there were a relatively large number of melodies and that because of this, during the study they would be asked two times if a rest was needed (after hearing trials 26 and 52; this was not told to the participants beforehand). In addition, they were told that short breaks between melodies were allowed if necessary. Participants then sat in front of the netbook and were given the following instructions: 1) to locate the mouse arrow on number zero; 2) to (left) double-click on zero as soon as the beginning of the melody was heard; 3) to slide the mouse arrow to the right, along the horizontal line, if a tonic tone is identified, and as much as needed, from 0 to 10, to reflect how certain they were that a given tone was indeed the tonic; 4) to slide the mouse to the left or to the right as the melody flows to reflect whether the sense of tonality (i.e., the sense that there is a tonic) was weakened or strengthened, respectively; 5) to stop moving and double-click the mouse as soon as the end of the melody was heard; 6) to provide a single score.
between 0 and 10, summarizing how weak or strong the sense of tonality was while listening the melody; and 7) to locate the mouse arrow again on zero, and to be ready to do the same with the next melody (i.e., to restart from instruction 2).

The study was administered individually to participants in a sound attenuated classroom, with the exception of one of the professors, whose session took place in her office. The experimenter sat next to participants, in front of the laptop, giving instructions and administering stimuli presentation. Each session started with a practice session in which participants heard two practice trials and were given an opportunity to ask questions and adjust volume. Practice trials were obtained by reproducing the second half of the melodies 6-8 and 21-2 backwards; these melodies were selected for practice randomly. Next, participants were asked if they felt comfortable with the apparatus and task; they all answered this question affirmatively. Then, they were asked to keep in mind that they should not rate how stable the melodies sounded in a tonal sense, but rather if—and to what extent—they felt that, at any given moment, the melodies had a tonic. In particular, they were asked not to slide the mouse, for example, if the melody moved from the tonic to the dominant, passed through a non-diatonic tone, or modulated (i.e., if one tonic was replaced by another), but only if their sense that there was a perceptual reference point or tonic varied with melody's flow. Finally, participants were urged to use all the scores on the rating scale when giving their responses, limiting scores of 0 to atonality (or lack of tonic) and 10 to tonality (or absolute certainty that there is a tonic).

Before the test session began the experimenter said to participants the following alerting clause: "Mouse arrow on zero: are you ready?" Once the participant indicated that s/he was ready, the experimenter pressed play on the first test trial and the test session began. After listening to each test trial, participants provided a single score summarizing how tonal or atonal the trial sounded (see instruction 6 above). This score was registered by the experimenter in the laptop. Then, the experimenter repeated the alerting clause and, once the participant indicated that s/he was ready, the next trial began; this pattern preceded each test trial. Once the test session was completed, participants were asked if they recognized the melodies used as stimuli; all of them answered negatively. Finally, participants were asked to fill in a questionnaire on age, education, and hearing aptitudes. The entire study (i.e., the practice session and the test session) lasted approximately 130 min in duration. Within each session, the order of trials was random; in test sessions, the order of trials was different for each participant.

### Data Preparation

For the analyses, melodies’ tonal strength (hereafter referred to as *predicted tonal strength*) was determined with the duration-based distributional model developed by Krumhansl and Schmuckler (see Krumhansl, 1990a). This model was chosen for two reasons: first, it was not designed for any particular musical corpus, but was based on experimental perception data. And second, the key profiles it utilizes to assess the tonal content of musical materials came to be regarded as the most concise and robust psychological representations of modern, major-minor tonality (Parncutt, 2011). In addition, for each melody the following measures of pitch dispersal were estimated based on distances in pitch (measured in semitones) between both consecutive and non-consecutive tones: *local dispersal, global dispersal*, and *balance*. Local dispersal was defined as the average distance between each pair of consecutive tones. Global dispersal refers to the standard deviation from the mean pitch of the melody. Finally, balance was defined as the absolute average distance (expressed in negative numbers) between tones and the modal (i.e., most frequently occurring) tone.

Continuous data collected from the mouse movements each participant made during each test trial (i.e., in between double clicks) were averaged and, for each participant, the correlation between average continuous data and summary scores (i.e., those given after listening each test trial) were estimated using Pearson’s correlation tests. These correlations were all positive and statistically significant (mean $r = .85$; min-max = .68-.94; $SD = .10$; $p < .001$), suggesting that the online tonal/atonal experience the listeners had while listening to each test trial was vivid enough as to be satisfactorily stored and largely retrievable. Given this, and to avoid data duplication, only continuous responses were taken into account in subsequent analyses. Next, average continuous responses from each participant were correlated with those from every other participant. All 28 of the pairwise inter-participant correlations were statistically significant (mean $r = .49$; min-max = .23-.74; $SD = .14$; $p < .05$). Given the consistency between participants’ responses, average continuous responses were averaged across participants. Thus, for each of the 78 melodies an average score for all 8 listeners was calculated. These average scores (hereafter referred to as *observed tonal strength*) were used in the analyses reported below.

### Results

First, the simple correlations between observed tonal strength, predicted tonal strength, and the measures of
Table 1. Correlation Coefficients Between Observed Tonal Strength and the Independent Variables Examined in the Present Study (N = 78)

<table>
<thead>
<tr>
<th></th>
<th>P-Tonal strength</th>
<th>Local dispersal</th>
<th>Global dispersal</th>
<th>Balance</th>
<th>Opus chron</th>
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<tbody>
<tr>
<td>O-Tonal strength</td>
<td>.56**</td>
<td>−.40**</td>
<td>−.51**</td>
<td>.22†</td>
<td>−.74**</td>
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<tr>
<td>P-Tonal strength</td>
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<tr>
<td>Local dispersal</td>
<td></td>
<td></td>
<td>−.26*</td>
<td>.03</td>
<td>−.41**</td>
</tr>
<tr>
<td>Global dispersal</td>
<td></td>
<td>.65**</td>
<td></td>
<td>−.11</td>
<td>.55**</td>
</tr>
<tr>
<td>Balance</td>
<td></td>
<td></td>
<td>−.28*</td>
<td>.56**</td>
<td>−.20*</td>
</tr>
</tbody>
</table>

Note: O-Tonal strength = observed tonal strength; P-Tonal strength = predicted tonal strength; Opus chron = opus chronology. For tests involving opus chronology, Spearman’s coefficients are reported; for the remaining tests, Pearson’s coefficients are reported instead. *p < .06 *p < .05 **p < .001

Pitch dispersal described above were examined. The results of these analyses are shown in Table 1. As expected from previous research, there was a positive correlation between observed and predicted tonal strength; that is, the more similar the melodies’ pitch class distributions were to the schematic tonal distributions, the stronger the listener’s experience of “tonalness”. More importantly, there was a negative correlation between observed tonal strength and both local and global dispersal, and also a positive (marginally significant) correlation between observed tonal strength and balance. This suggests that listeners’ tonal sense became weaker as melodies became more dispersed, or less balanced.

Table 1 also shows that there was a negative correlation between predicted tonal strength and global dispersal, which suggests that Schonberg manipulated these factors jointly to avoid tonality. In order to explore this issue farther, the independent variable opus chronology was designed, which coded melodies from 1 to 78 according to the date in which musical pieces were finished. When two or more dates were the same, or when the date was unknown (e.g., Op. 8-6), ordering was based on opus numbers; the final ordering is shown in the Appendix. Finally, the Spearman rank order correlation coefficients between opus chronology and the remaining variables were estimated. The results of these analyses are also shown in Table 1 (right side column).

As may be seen, predicted tonal strength decreases as opus chronology increases, whereas global dispersal increases; that is, Schoenberg’s melodies became both less diatonic and more dispersed over time. This supports the long standing idea that atonality is related to an increasing chromaticism (see, for example, Schoenberg, 1922/1978), and also suggests that the joint manipulation of pitch class distributions and pitch dispersal might have been a strategy on Schoenberg’s part to weaken the sense of tonality. In line with this, note that local dispersal also increases with opus chronology, whereas balance decreases. More importantly, observed tonal strength decreases, which confirms that Schoenberg’s melodies became increasingly atonal. The specific functional form underlying this decrement was investigated via the Loess procedure. Loess (an acronym for “local regression”) is a nonparametric curve-fitting procedure that summarizes the central tendency of the variable Y at different locations of the variable X (see Jacoby, 2000).

Here, it was implemented by taking opus chronology as the variable X, and observed tonal strength as the variable Y. The results of these analyses are depicted in Figure 2. A quadratic relationship was

4 Loess works by performing a series of local regressions on specific subsets of the total data based on a zero-or-higher order regression equation: data subsets’ size is defined by a parameter called α, specified as a value between 0 and 1, whereas the regression equation is specified by a parameter called λ, in which 1 means linear, 2 means quadratic, etc. Additionally, Loess can incorporate a robust estimation procedure in order to reduce the influence of unusual data points. Here, Loess curves were fitted with α = .5, λ = 1, and robustness iterations.

5 In the Loess analyses, “opus chronology” was treated as a quantitative variable—and not as an ordinal variable, as in the Spearman’s correlation analyses. Thus, it was assumed that the stylistic changes Schoenberg’s music suffered from one opus to the next are roughly equal, or at least comparatively similar in scope. Although, as far as I know, there is no definite evidence as to whether this is so, the assumption of “roughly equal changes” is supported by the literature that stresses the continuously transforming nature of Schoenberg’s oeuvre—e.g., Haimo (1997, 2006), Simms (2000); see text.

Note: Dates of composition used throughout this paper are those reported by the Schoenberg Center Institute (http://www.schoenberg.at/index.php/de/archiv/musik).
found between observed tonal strength and opus chronology, with a smooth transition from more tonal to more atonal melodies. Interestingly, the idea of smooth transition is also applied in the musicological literature to this portion of Schoenberg’s oeuvre, being the year 1908 usually claimed as a critical period towards differentiation (e.g., Frisch, 1993; Haimo, 2006; Simms, 2000; see also Adorno, 1984). The present results support these claims.

Next, the plausibility of multiple causation as an explanation for the observed tonal strength and, in particular, the plausibility of a causal complex in which pitch dispersal takes part, was assessed via hierarchical regression procedures. Hierarchical regression is a useful and particularly safe tool to examine the multivariate structure of a response variable when the joint influence that several factors have on it is initially explored (Ho, 2006), as was the case here. Briefly, in a hierarchical regression predictors are entered into the equation in blocks or steps based on previous research. As a general rule, known predictors are entered first, and new predictors are entered next. They then are evaluated in terms of what they add to the explanation beyond that afforded by the known predictors already entered.

In the present study, predictor variables were entered in three steps. In the first step, the predictor consonance was entered. Consonance refers to the proportions of tone repetitions (i.e., unisons) and consonant skips (i.e., perfect fourths, fifths, and octaves—not compound) in each melody. This predictor was entered for two reasons: 1) to control for the influence that consonance (i.e., sensory stability) could have had on participants’ judgments, and 2) because consonance is also thought of as a determinant of listeners’ sense of tonality (e.g., Leman, 1995; Parnon, 1989; see also Schoenberg, 1922/1978). In the second step, predicted tonal strength was entered. Finally, in the third step the predictors related to pitch dispersal—local dispersal, global dispersal, and balance—were entered. In addition, at steps 1 and 2 the “forced entry” method was used, which means that predictors were entered into the model by default. In step 3, however, the stepwise method was used, which means that predictors were entered one at a time if they significantly improved the ability of the model to explain the data, and deleted at any step if they no longer contributed significantly. (Routines for checking multiple regression’s assumptions suggested that data from melody 2-4 exerted an undue influence over the model; hence, these data were excluded from the analyses reported here). The results are summarized in Table 2.

The most important results in Table 2 are those shown under the subheading Step 3. There, the predictor variables that provided the best fit to the data are detailed, and also the values reflecting either the degree to which each predictor affects the outcome (see the β, standardized beta values), or the specific contribution each predictor made (see the sr², or squared semipartial correlation values) to the overall fit of the model (see Total R²). Focusing on Step 3, the first point to make is that the final model includes the predictor variables consonance and predicted tonal strength—as expected from past research—but also global dispersal. This indicates that a measure of pitch dispersal is needed to better explain participants’ responses. In fact, if global dispersal is removed from the regression analysis, balance is entered instead (i.e., the model is not left without a predictor based on pitch dispersal; results not shown in the table). The second point to make relates to the hierarchical structure of the model. Notice that the β and sr² values vary markedly across predictors

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**TABLE 2. Summary of Hierarchical Regression Model Fit to Observed Tonal Strength**

<table>
<thead>
<tr>
<th></th>
<th>∆R²</th>
<th>Total R²</th>
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<th>sr²</th>
<th>tolerance</th>
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<td>.44**</td>
<td>.66**</td>
<td>.44**</td>
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<td>.54**</td>
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<td>.45**</td>
<td>.15**</td>
<td>.76</td>
</tr>
</tbody>
</table>

Note: Only the predictor variables included at each step of the analysis are shown in the table. *p < .01 **p < .001

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6 It is worth mentioning that two other factors were entered into the regression equation to control for extraneous sources of variance in the data, chromaticism and dissonant skips. They respectively quantified the proportion of intervals of 1 ST (characteristic of the chromatic scale; see Schoenberg, 1922/1978) and of 3 or more ST (once consonant skips—perfect fourths, fifth, and octaves—were excluded) between consecutive tones in each melody. None of these factors contributed significantly to the model.
particularly between consonance and the remaining two predictors. Notice also that the lowest values are those of global dispersal. As the reader may realize, this gradation in predictors’ parameters fits well with the idea posited here—that listeners’ sense of tonality and atonality is triggered by a graded causal complex in which pitch dispersal is a secondary determinant.

Finally, there are two other points in Table 2 that deserve special attention. First, though there is redundancy in the model (i.e., though predictors retained in Step 3 are collinear; see also Table 1), multicollinearity does not appear to be a problem. The tolerance values are informative in this respect. Briefly, these values indicate the percentage of variance in each predictor that cannot be accounted for by the other predictors and, then, whether multicollinearity between predictors is problematic. Roughly, tolerance values below .20 indicate a potential problem (Menard, 2002; see also Ho, 2006): as shown in the Table 3, all the tolerance values are above this limit. Second, the model in Step 3 is not only accurate or unbiased (in the sense of meeting the assumptions of linear regression) but also appears to be generalizable. If a model can be generalized, then it must be capable of accurately predicting the same outcome in other samples from the same population. One way to examine this issue is by applying the formula proposed by Stein (1960). This formula is a cross-validity estimator that was found to outperform alternative statistical procedures in the context of best subset (of predictors) regression analyses like that implemented here (see Kennedy, 1988). Applied to the model summarized in Step 3, Stein’s formula yields a squared cross-validity coefficient, \( R^2_x = .54 \). This value is very similar to the observed value of \( R^2 \) (.58), indicating that the cross validity of the model is good.

**Discussion & Conclusions**

The distinction between tonal and atonal is one of the most important in Western music history. Accordingly, a central question in music psychology is what causes music to sound tonal or atonal. In a recent study (Anta, 2015), evidence was found that this distinction stems not only from differences in the pitch class structures music shows, as previously known (e.g., Krumhansl, 1990a; Lerdahl, 2001; Temperley, 2007a; see also Forte, 1973), but also from differences regarding how dispersed pitches are in the register. Based on this evidence, the following hypothesis was formulated: pitch dispersal is a secondary determinant of listener’s sense of tonality and atonality, the tonal sense being strengthened by low levels of pitch dispersal and the atonal sense by high levels of pitch dispersal. Consistent with this hypothesis, the present study shows, first, that overall the levels of pitch dispersal are lower in Schoenberg’s tonal melodies than in his (free-)atonal melodies; and second, that these properties of melodic structuring are linked to listeners’ judgments of tonalness and atonalness, respectively. Although much research is needed, together this study and the one that precedes it (Anta, 2015) make a strong case that pitch dispersal may play a substantial role in experiencing music as more or less tonal or atonal. In fact, given the musicological importance of Schoenberg’s oeuvre in the history of tonality and atonality, one could think of the present study as a more ecologically valid test of this issue (see Demorest, 1995). This notwithstanding, the findings reported here rest on some critical assumptions that need to be discussed. This will be done next. Finally, some of the implications they have for various fields of music research will be addressed.

Perhaps the most critical assumption was that melodies’ tonal strength could be estimated with one single measurement of their pitch class distributions: that is, all the stimulus melodies were thought of as non-modulating (i.e., as not-changing substantially their pitch class distributions), or at least as having a main tonic/key whose strength was not exceeded by that of any other tonic/key. Contrary to this, one may argue that they might have had modulations that weakened the strength of the main key, but not that of the melody as a whole: if so, the measures of predicted tonal strength might not have been representative of the average tonal strength resulting from alternating tonics. Indeed, in some previous research (e.g., Krumhansl & Kessler, 1982; Schmuckler & Tomovski, 2005) the Krumhansl and Schmuckler’s model was applied vis-à-vis short musical materials to keep predictions in line with modulations. However, it must be noted that the single measurement assumption is problematic only in the case of tonal melodies: in the case of atonal melodies, modulations are excluded *ipso facto*, so the way in which tonal strength is measured should not be an issue. Further, if appropriate, values of predicted tonal strength should be low for atonal melodies. However, several values for the more atonal melodies were not: for example, the values (rescaled between 0 and 10) for melodies 75 to 78 were all higher than the corresponding values of observed tonal strength. This suggests that predicted tonal strength had errors not attributable to modulation. Accordingly, one may conclude that factors other than pitch class distributions need to be considered to predict the tonal strength of musical materials.
This leads one back to the starting point of the present research, where the focus was shifted from pitch class-related to pitch-related factors; that is, to pitch dispersal.

Another critical assumption was precisely that that shift can be done; that is, that the role of pitch dispersal in tonality/atonality perception can be properly examined in contexts in which only some critical factors (e.g., pitch class distributions) are taken into account. Recall, for example, that pitch class ordering may also be a primary determiner of tonality and atonality (e.g., Brown, 1988), and that there is some evidence that tonality perception may depend on how distributional and functional factors are set together (Huron & Parncutt, 1993). Thus, it may be the case that the associations between pitch dispersal and tonality or atonality observed here disappear when other pitch class-related factors are taken into consideration. As the reader may note, this possibility emerges from the idea that results may vary under different conditions, a standard caveat in science. However, this caveat is particularly important here, since tonality and atonality are thought of in the framework of hierarchical multiple causation—and a systemic approach to multiple causation is also thought of as plausible. Within this framework, it seems reasonable to suspect that some of the determiners of tonality and atonality—namely the secondary determiners—are particularly prone to lose their memberships in the causal structure. Given that pitch dispersal would be one of these secondary, “prone to vanish” determiners, to better characterize the contexts in which it is operative would be particularly relevant. The present findings shed some light on these contexts, but much further research is needed in this direction.

Regarding their implications, the first thing to be noted is that the present findings extend the musicological literature on Schoenberg’s oeuvre, and also suggest some avenues for further research. For instance, Haimo (2000, p. 115) stresses that Schoenberg’s pitch language evolution is a complicated and, as a norm, unexplored issue. The present study sheds light on this issue, at least in the period under consideration (i.e., 1898-1916; see Appendix). In addition, support was found for the idea that Schoenberg’s music does not represent a revolution or a break with the past (see, for example, Adorno, 1984), but a transition from tonal to atonal procedures (see, for example, Haimo, 1997, 2006; Simms, 2000). However, the results also suggest that his music implies a progressive reversal of several tonal principles, at least of those involved in voice leading and melodic structuring. Indeed, in tonal melodies tones tend to be proximate in pitch and centered in range (see, for example, Fucks, 1962; Huron, 2001; Thompson & Stainton, 1998; von Hippel, 2000; von Hippel & Huron, 2000; see also Piston 1959, pp. 13-23), whereas in Schoenberg’s melodies they tend to be increasingly distant and unbalanced (see Table 1). This means that the elaboration Schoenberg made of Western musical techniques was not positive and productive, so to speak, but negative and destructive, abolishing the rules upon which tonal melodies were built. (In line with this, see Huron’s, 2006, pp. 340-344, argument that Schoenberg’s serial oeuvre is ‘contratonal’ in nature.) This qualifies the idea that his atonal music is merely a product of evolution, and no more revolutionary than any other development in Western music history, as Schoenberg (1991, p. 151) himself claimed. Research in musicology might find it useful to develop this qualification.

The present findings also have implications for music theory. Specifically, they suggest that a (secondary) compositional condition for tonal music is a relatively low level of pitch dispersal, and that the opposite is the case for atonal music. This, in turn, implies that the terms tonality and atonality should be defined as to include these conditions. However, as a rule standard definitions refer to pitch class-related musical conditions, and not to pitch-related ones. For instance, in a recently published dictionary of music (Kennedy et al., 2013) ‘tonality’ (p. 859) is equated with ‘key’ (p. 452); that is, with the pitch classes of a given major/minor scale (for more on this, see, for example, Parncutt, 1989, p. 68). Admittedly, music theorists have offered more complex conceptualizations of tonality, and also broader definitions. Nonetheless, whether these definitions involve pitches is not as clear as it might be. For instance, Schachter (1999, p. 135) claims that a tonic results not only from using the tones of a scale, but also from other factors such as the presence of a diminished fifth or tritone. This leads one to think that tonality implies not only certain pitch class structures but also some specific pitch patterns. However, in the musical excerpt Schachter provides as illustration (Example 5.1) there is no tritone, and a class 6 interval of 18ST is pointed out as the diminished fifth, all of which leads one to conclude that tonality reduces to pitch classes. Although certain pitch class structures obviously favor tonality, the present findings suggest that this conclusion is misleading, and that some specific features of tonal and atonal pitch patterns should be taken into account to guarantee more comprehensive conceptualizations and definitions.

Last but not least, the present findings have psychological implications. First, it has to be noted that the way music theory conceptualizes tonality spills over into various fields of music research, particularly into music
psychology. Thus, as a rule, psychological studies on tonal perception also equate tonality with key, and then with some type of schematic representation about pitch classes (e.g., Bharucha, 1987; Brown, 1987; Butler & Brown, 1984; Krumhansl, 1979, 1990a; Krumhansl & Kessler, 1982; Tillmann et al., 2000; see also Butler & Brown, 1994). Moreover, tonality is usually defined as an independent psychological factor or representational dimension, different from distance between tones in the register, which would be represented in a dimension referred to as pitch height (see also Bigand, Parncutt, & Lerdahl, 1996; Krumhansl & Shepard, 1979; for theoretical perspectives on this issue, see also Bharucha, 1984; Krumhansl & Cuddy, 2010; Schmuckler, 2004). Thus, mutatis mutandis, what was stated about music theory, also applies here. That is, given that tonal music, as opposed to atonal music, may be compositionally (i.e., objectively) characterized not only by certain pitch class structures but also by some specific relationships between pitches, the present findings suggest that listeners’ representation of tonality might encode not only pitch class-related but also pitch-related features of musical patterns; in particular, those features based on—or emerging from—distance between pitches.

Second and finally, by offering new insights into listeners’ representation of tonality, the present findings offer an opportunity to revisit the role of statistical learning in perceiving music as tonal or atonal. The hypothesis that the sense of tonality stems from statistical regularities in (tonal) music is one of the keystones of current research on the issue (see Krumhansl & Cuddy, 2010). Basically, the idea is that the key profiles described above are learned implicitly through repeated exposure to tonal repertoires: the pitch class distributions regularly found in tonal music would lead to schematic (or average) representations termed as tonality, and the lack of regularity (concerning pitch classes) in atonal music would lead to non-schematic representations termed as atonality. This idea has been used to account for various components of listeners’ musical experience, ranging from memory and similarity judgments to reaction time and expectations (see, for example, Huron, 2006; Temperley, 2007a; Tillmann et al., 2000). Furthermore, the analysis of how (objective) pitch class distributions varied in Western music in relation with the (subjective) key profiles proposed by Krumhansl and Schmuckler has recently been used to examine how the major/minor tonal system evolved over time (Albrecht & Huron, 2014; see also Fucks, 1962). In any case, given the present findings, one may wonder whether, in forming tonal schemas, listeners only assimilate regularities about pitch classes. Indeed, one may posit two alternative hypotheses about the nature of tonal schemas that depart from this assumption.

First, given that tonal music, as opposed to atonal music, is characterized not only by certain pitch class distributions (as documented, for example, by Albrecht & Huron, 2014; Krumhansl, 1990a; Temperley, 2007a; see also Forte, 1973) but also by lower levels of pitch dispersal (as documented here; see also Fucks, 1962; Huron, 2001; Thompson & Stainton, 1998), the schemas listeners develop to understand music as tonal might encode not only pitch class-related but also pitch-related musical regularities. The simplest way this might occur would be by encoding frequently occurring pitch class structures (in relative terms), plus proximity between pitches as a sequential restriction. Interestingly, this is in essence the proposal put forth by Deutsch and Feroe (1981; see also Deutsch, 2013). According to these researchers, listeners represent the pitch content of tonal music as a series of hierarchically structured pitch class alphabets (e.g., the diatonic major scale) that may be traversed in multiple but restricted ways: one restriction would be pitch proximity, which simply means that alphabets are to be traversed in a limited pitch range. In line with this, evidence was found here that the pitch ranges are more limited in tonal than in atonal melodies, and that this difference influences listeners’ sense of tonality and atonality.

Second, the possibility that tonal schemas encode only pitch-related regularities cannot be ruled out. If so, they would capture basically those intervallic patterns (e.g., a stepwise motion from 5-dominated to 1-tonic) occurring regularly in tonal repertoires. Interestingly, both music theory (e.g., Lerdahl, 2001; Meyer, 1973) and psychology (e.g., Huron, 2006; Larson, 1997-1998; see also Vos & Troost, 1989) report several intervallic patterns for characterizing tonal materials, which supports this possibility. Or alternatively, tonal schemas might encode only some portions of these patterns. For instance, Vos (1999) documented that when tonal pieces commence with an ascending perfect fourth, the second tone is usually the intended tonic, and Bharucha (1996) showed that, despite their perversiveness in tonal melodies, steps are largely confined to connect the tonally unstable tones to the tonally stable ones. Further, it is well known that tonal materials usually indicate finality by moving the leading tone (B, in the C major key) one step upwards to the tonic (see Boltz, 1989). Thus, for listeners it might suffice to schematize these regularities to judge music as tonal or atonal: briefly, a piece of music would be tonal if these regularities apply systematically in a given pitch set;
otherwise, it would be atonal. In any case, this does not mean to say that tonality can be fully appreciated without referring to pitch class-related data: these data would be necessary to ascertain whether a given tonic can be generalized throughout texture and form (Anta, 2015). Lastly, notice that since this model of tonal cognition relies on melody, it suggests that harmony is more a matter of consonance than of tonality (see also Leman, 1995; Parncutt, 1989). This would explain why certain types of ancient (e.g., Gregorian chants) and contemporary music (e.g., that of Debussy or Stravinsky) are understood as tonal even when they dispense with tonic (tertian-) chords and progressions (see Choron, 1817; Norton, 1984; Réti, 1958; Salzman, 1974).

In sum, in the present work tonality and atonality were thought of in terms of hierarchical multiple causation, and pitch dispersal was thought of as a secondary determiner. Consistent with this view, evidence was found: 1) that Schoenberg’s tonal melodies not only show some specific, particularly critical pitch class structures (e.g., some specific pitch class distributions), but also lower levels of pitch dispersal than his atonal melodies; and 2) that listeners are sensitive to this difference. In light of these findings, several issues were raised about Schoenberg’s music evolution. Further, the way in which tonality and atonality are defined, as well as the role of statistical learning in tonal/atonal perception, were discussed: basically, it was argued that not only pitch class-related but also pitch-related factors should be taken into account to provide appropriate definitions of tonality and atonality, as well as to properly describe their psychological representations. Further research is needed to determine the extent to which this is the case.

Author Note

This work was supported by Grant #PICT12-1852 from the National Agency for the Promotion of Science and Technology (ANPCyT) of Argentina. The author is grateful to Dr. David Temperley, Dr. Art Samplaski, and two anonymous reviewers for the careful reviewing of the manuscript and constructive comments.

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References


Appendix. List of the pieces by A. Schoenberg from which the melodic stimuli used in the present research were generated.

<table>
<thead>
<tr>
<th>Order</th>
<th>Opus/Title</th>
<th>Date Finished</th>
<th>Order</th>
<th>Opus/Title</th>
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</thead>
<tbody>
<tr>
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<td>op. 1–1</td>
<td>1898, Dec 31</td>
<td>10</td>
<td>op. 1–1</td>
<td>1909, Feb 08</td>
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<td>op. 1–2</td>
<td>1898, Dec 31</td>
<td>11</td>
<td>op. 1–2</td>
<td>1909, Feb 19</td>
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<tr>
<td>3</td>
<td>op. 2–1</td>
<td>1899, Aug 09</td>
<td>12</td>
<td>op. 2–1</td>
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<tr>
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<td>op. 2–3</td>
<td>1909, Mar 09</td>
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<td>op. 2–4</td>
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