

**Beethoven's last piano sonata and those who follow crocodiles:
Cross-domain mappings of auditory pitch in a musical context**

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ABSTRACT

Though auditory pitch is customarily mapped in Western cultures onto spatial verticality (high-low), both anthropological reports and cognitive studies suggest that pitch may be mapped onto a wide variety of other domains. In an ongoing study, we investigated how such pitch mappings are used and structured. In particular, we inquired (1) how Western subjects apply non-Western pitch mappings (2) whether mappings of "high" and "low" pitch derive from associations with spatial verticality, (3) whether mappings reported for simple auditory stimuli are similarly applied by listeners to actual music (4) what, if any, general dimensions underlie the cross-domain mappings of pitch.

In Experiment 1, participants received a list of 29 antonym pairs, including several non-Western metaphors, and circled the term of a pair that they associated with either high or low pitch. In addition, they rated the appropriateness of the pair as a metaphor for pitch. A control group performed the same tasks with regard to spatial verticality. In Experiment 2, participants rated on a bipolar scale the appropriateness of 36 antonyms, including all antonyms

used in Experiment 1, to two segments from Beethoven's op. 111 that differed mainly in pitch register.

Results show significant matches with high or low pitch for 26 out of 29 pairs. In 10 pairs, including thin-thick, happy-sad, alert-sleepy, fast-slow, light-dark, sharp-blunt, young-old, and light-heavy, there was more than 90% consensus among participants. Mappings of "high" and "low" pitch significantly differed from those of high and low spatial position in 15 metaphor pairs. Notably, physical size and quantity were associated in opposite ways with pitch "height" and spatial verticality. Results of Experiment 2 concurred with the results of Experiment 1, this concurrence suggesting that cross-domain mapping of pitch may provide relevant insights into music cognition and expression. In both experiments, participants always employed metaphors originating in non-Western cultures in agreement with their original uses.

These results suggest that diverse and strong cross-domain mappings for pitch exist latently besides the common verticality metaphor. Such mappings, as indicated by the "correct" identification of non-Western pitch metaphors by Western participants, are not based solely on culture-specific conventions, but may draw upon basic interactions with the physical environment, in particular the natural correlates of sound production. Furthermore, the ubiquity of the verticality metaphor in Western usage notwithstanding, results imply that cross-domain pitch mappings are largely independent of that metaphor, and seem to be based upon different underlying dimensions. The most important of these dimensions, as revealed by factor analysis, is a composite component linking size, mass, and visual lightness.

Keywords

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Pitch register, metaphor, weak synesthesia, cross-domain mappings,

INTRODUCTION

To a large extent, discourse concerning auditory phenomena, and music specifically, applies metaphorical language, mapping terms originating in diverse realms of human experience onto auditory and musical domains. Thus, we habitually speak of high and low (or ascending and descending) pitches, bright and dark sounds, or heavy or light-footed rhythms. A large number of empirical studies have shown that such cross-domain mappings are not merely convenient figures of speech, but relate to characteristics of auditory perception and cognition, such as selected attention, object discrimination, and similarity perception (see Marks, 2000, 2004, for summaries).

Auditory pitch in particular possesses a wide variety of cross-domain connotations, some of which are already apparent in perception at a very early age. The central cross-domain association of pitch in Western culture, matching “high” and “low” pitch with the corresponding spatial poles (the “verticality” metaphor) has been shown to relate even to infants’ attention (Wagner, Winner, Cichetti, & Gardner, 1981). However, several other types of pitch mappings are strong as well. For adults, pitch is strongly associated with size, brightness, colour lightness, sharpness, speed, and activity, as shown by experiments based on Stroop and speeded discrimination paradigms (Walker & Smith, 1984, 86; Marks, 1982, 1987). Pitch is also associated with spatial or spatio-kinetic dimensions other than verticality. In music imagery experiments, pitch “rise” has been associated with spatial rise, acceleration and distancing, and pitch “fall” with spatial fall, approaching, and turning left (Eitan & Granot, 2006).

The origin of these matches – to what extent pitch mappings are based on physical experience, on symbolic or linguistic associations, or rather on low-level perceptual associations – is still in dispute (Marks, 2004). Some associations seem to be active earlier in a child’s development than others. For instance, four-year old children consistently match pitch with brightness, but not pitch with visual size, while 12-year old children do consistently apply the latter mapping (Marks, Hammael, & Bernstein, 1987). This suggests that some mappings may be learned, through experience or language, while others might be inborn.

Cross-culturally, a rich vocabulary exists for pitch height. As Zbikowski (1998) notes, the verticality metaphor for pitch is far from being universal. In different cultures and historical eras, pitch polarity was designated as “sharpness” and “heaviness” (ancient Greek music theory), “small” and “large” (Bali and Java), or “young” and “old” (Suyá people of the Amazon basin). Pitch vocabulary often seems to derive strongly from specific cultural practices. For instance, the pitch classification for the Shona mbira (Zimbabwe) includes the opposition of the “croco-

dile” (low pitch) with “those who follow crocodiles” (high), and “Stable (person) who holds the piece together” (low) vs. “mad person” (high) (Berliner, 1971, discussed in Ashley, 2004). In the Gbaya xylophone (Central African Republic) notes are arranged genealogically, and include (from low to high) grandmother, mother, father, son and daughter (Ashley, 2004, after Arom & Voisin, 1998). This cross-cultural diversity seems to suggest that many of the mappings are learned and dependent on acculturation. However, this does not necessarily mean that the structure underlying diverse pitch-metaphors shows equal diversity. Instead, metaphors may be retraced to a limited set of underlying mappings, perhaps stemming (as Lakoff & Johnson, 1980, suggest) from basic bodily experiences and interactions with the physical environment.

This article reports two experiments that are part of an ongoing study aimed at investigating the cognitive structure and origins of pitch metaphors and the relevance of such metaphors to music listening. Experiment 1 is an exploratory conceptual investigation, in which participants matched 29 antonym metaphor pairs to two pitch poles (high-low). The pairs were mostly collected from results of previous perceptual and cognitive studies from cross-cultural data. In addition, a control group applied the same antonyms to the poles of spatial verticality (high-low). Experiment 2 investigated how the same antonyms are applied to an actual musical context.

Several questions underlay these experiments. First, we examine whether pitch mappings not generally used in participants’ language and culture are nevertheless consistently applied. Specifically, we examine how Western subjects apply non-Western pitch mappings. Second, we examine whether mappings of “high” and “low” pitch primarily derive from associations with spatial high and low, either through the longstanding use of verticality terms for pitch in Western languages, or perhaps, as Lakoff & Johnson (1980) suggest, through a conceptual metaphor, “up is more,” shared by both domains. Third, we examine whether conceptual pitch mappings (Experiment 1) are similarly applied by listeners to actual music (Experiment 2). Finally, we investigate, using factor analysis of the results of Experiment 2, whether the diverse metaphors used for pitch can be reduced to a limited number of underlying dimensions.¹

¹ Experiment 1 also examined some additional issues, not discussed here due to space limitations. These include the effects of musical training and linguistic background on the application of pitch metaphors (the latter examined by a comparing results of Israeli participants to those of a group of American university students), and a comparison of the application of pitch metaphors to static (“high” and “low”) and dynamic (“ascending” and “descending”) pitch.

EXPERIMENT 1

Method (test group)

Participants

63 Tel Aviv University students (27 males, 36 females; mean age=26.3), native Hebrew speakers, 28 of them musically trained (>7 years of formal musical studies).

Materials

In the pre-test (see “procedure” below), 26 pairs of pitches (varying in register, duration, timbre, loudness and articulation), 13 rising and 13 falling, were created using pre-prepared instrumental sampled sounds of the *Sibelius 2* music software. Sounds were recorded on a CD and presented through loudspeakers. In the main test, no auditory stimulus was used.

Procedure

The session started with a *Pre-test*, administered to screen out participants with no clear percept of pitch direction. Participants heard the 26 pairs of pitches, presented in random order, with approximately 5 seconds between pairs, and were asked to mark on a form supplied to them which pitch in each pair is higher (or lower, in version B of the test; see “main test” below).

The *main test* took part after the pre-test, following a 5 minutes break. In **part 1** of the main test, participants received a list of 29 pairs of antonyms, and were asked to note which term in each pair is a better description or metaphor for high pitch (task 1), and mark on a scale of 1-5 how well does each pair of antonyms as a whole serve as a metaphor for auditory pitch (task 2). Antonyms were presented in 4 different random orderings, while the order of antonyms within pairs was counterbalanced among participants. Participants were given 10-15 minutes to complete the tasks, and 5 minutes break before proceeding to part 2. In **part 2**, participants received the same list of antonyms (presented in a different random ordering, but preserving ordering within pairs), and were asked to note which term in each antonym pair is a better description or metaphor for *low* pitch (task 1). Task 2 was identical to that in part 1. The order of parts 1 (high pitch) and 2 (low pitch) were counterbalanced among participants

The experiment was administered in groups of 10-15 people.

Method (control group)

Participants

58 Tel Aviv University students (19 males, 39 females; mean age=26.2), native Hebrew speakers.

Materials

In addition to using paper forms, participants heard two pairs of sampled sounds produced by the *Sibelius 2* music software. Sounds were recorded on a CD and presented through loudspeakers.

Procedure

Parts 1 & 2 of Experiment 1 (but not the pre-test) were repeated, but participants were asked to apply metaphors to *spatial elevation*². All antonyms used in the original test were applied. In addition, four pairs of verbal antonyms referring to sound and two pairs of actual sounds were added.

Results (Experiment 1)

Applying pitch metaphors

Results reveal striking agreement on the application of most metaphors presented. Chi-square tests indicate that for 23 of the 29 metaphors, choices of “high” or “low” deviate significantly (after FDR correction for multiple testing) from random choice (50%). As Table 1 reveals, agreement on the application of many metaphors nears consensus.

Importantly, the near-consensual metaphors include the pitch metaphors originating in non-Western cultures or historical cultures, such as small-large, sharp-heavy (the metaphor which received the strongest agreement!), young-old, granddaughter-grandmother, and thin-thick. They also include some mood related metaphors, such as happy-sad, tense-relaxed, and alert-sleepy. Note, however that there was no consensus on matching the antinomies pleasant-unpleasant and pretty-ugly with pitch, which suggests that **mood-related metaphors distinguishing high from low may be primarily based on activity, rather than valence.**

Of the 29 metaphors, only hard-soft, near-far, and pleasant-unpleasant were not significantly associated with either high or low pitch. Several metaphors were associated with one pitch pole only. Full, much, and wise were associated with low pitch (Task 2), while their opposites (empty, little, and foolish) were not associated with high pitch. Conversely, soft (sound), pretty, and weak were matched with high pitch (Task 1), while their opposites (loud, ugly, and strong) were not matched with low pitch.

Table 1. Strongest dyads for pitch height. First term is associated with high, second term with low.

| > 0.95 | > 0.90 | > 0.80 |
|-------------|-------------|-------------|
| Sharp-heavy | Light-dark | Female-male |
| Thin-thick | Sharp-blunt | Small-large |

². Note that since in Hebrew the same word (Gavoha) is used for both “tall” and “high,” participants were specifically instructed to apply metaphors to the dichotomy high-low, as distinguished from tall-small.

| | | |
|--------------|--------------|---------------|
| Happy-sad | Young-old | Tense-relaxed |
| Alert-sleepy | Grdaugh-Grma | Smooth-rough |
| Fast-slow | Light-heavy | Summer-winter |

Participants' decisive agreement on the application of most metaphors, however, contrasted sharply with their low appropriateness ratings for the very same metaphors. Only one average rating, for thin-thick, exceeded 3.5 (on a scale of 1-5). Particularly striking contrasts between high agreement on a metaphor's application and devaluation (low appropriateness ratings) of the metaphor itself were found for some of the non-Western or historical metaphors, such as sharp-heavy (100% consensus, but only 2.96 rating), or grandmother-daughter (92% consensus, 2.37 rating). Hence, while participants may find pitch metaphors such as "grandmother-daughter" odd and perhaps inappropriate, once forced to apply them, they reveal a consensus among themselves and agreement with the original use of such metaphors.

Pitch metaphors and metaphors for spatial elevation (control group)

As mentioned, the control group for Experiment 1 performed the same tasks with regard to *spatial* high and low, rather than auditory pitch. We thus aimed at examining whether cross-domain mappings of pitch "height" are derived from (or closely related to) those of spatial height.

By and large, the answer to this question is "no." Like the test group's participants, those in the control group strongly agree on the application of metaphors presented to them (above 0.70 for 23 out of 29 dyads). Their choices, however, were significantly different from those in the test group for 15 of the 29 metaphors presented.³ Furthermore, 8 pitch height judgments were not only significantly different but incongruent - opposite in direction - with judgments of spatial height (Table 2).

Table 2. Metaphors applied differently for pitch and spatial elevation ($p < 0.01$). Larger font size signifies stronger agreement on a metaphor's application.*

| High pitch | High elevation | Low pitch | Low elevation |
|--------------|----------------|-----------|-----------------|
| Feminine | Masculine*** | Masculine | Feminine*** |
| Grd-daughter | Grd-ma*** | Grd-ma | Grd-daughter*** |
| Small | Large*** | Large | Small*** |
| Beginning | End*** | End | Beginning*** |
| Little | Much*** | Much | Little*** |

³ Choices were significantly different for both "high" and "low" for 11 metaphors.

| | | | |
|-------|-------------|-------|---------------|
| N. P. | Pleasant*** | N. P. | Unpleasant*** |
| N. P. | Wise*** | N.P. | Fool*** |
| - | - | N.P. | Weak*** |
| - | - | N.P. | Soft** |
| - | - | N.P. | Ugly** |
| Far | Far*** | - | - |
| Thin | Thin*** | - | - |
| Young | Young*** | - | - |

*** $p < 0.001$, ** $p < 0.01$; N.P. indicates no significant preference for either pole.

These comparisons highlight two general differences between connotations of pitch height and those of spatial elevation. First, while spatial elevation is positively correlated with physical size and mass (large/small, much/little, thick/thin, full/empty; and indirectly, masculine/feminine, old/young, and grandmother/daughter) pitch "height" is negatively correlated with both. Second, while spatial elevation is strongly associated with diverse aspects of valence (pleasant/unpleasant, wise/fool, pretty/ugly), the associating of pitch height with valence is considerably weaker.

If judgments of spatial height are used to predict judgments of pitch height, the explained variance varies between 0.26 and 0.37, depending on the variables that are compared (e.g., agreement in choosing one pole or the other, or appropriateness ratings for high or for low). This suggests that judgments of spatial elevation are poor predictors for judgments of pitch height.

In addition to the pairs used for the judgments of pitch height, judgments for spatial elevation also included four pairs of sound terms, and a pair of actual pitches. All of these showed significant agreement (above 0.70) with the highest agreement for scream-sigh, soprano-bass, and for the pitch pair (above 0.95) and lower agreements for shout-whisper and sneeze-cough (0.87 and 0.74, respectively). Notably, average applicability ratings for the terms "soprano-bass" and for the actual sounds was the highest of all ratings for elevation metaphors (4.0 and 3.9), suggesting that while pitch metaphors and metaphors for spatial elevation differ considerably, auditory pitch itself is judged to be a strong metaphor for spatial elevation.

EXPERIMENT 2

Method

Participants

63 Tel Aviv University students (28 males, 35 females; mean age=29.9), native Hebrew speakers, 36 of them musically trained (>7 years of formal musical studies).

Materials

Two segments from the 2nd movement (*Arietta*) of Beethoven's piano sonata, op. 111 (mm. 65-72, and 73-80) were used. These segments function analogously in a variation form. They share underlying structure and are similar in rhythm and texture, but contrast in pitch register (high vs. low). Both segments were taken from Daniel Barenboim's recording of Beethoven's piano sonatas (EMI Classical CZS5729122).

Procedure

Participants were tested in groups of 10-15. They received a list of 35 antonyms (including all antonyms used in Experiment 1, and six additional polar terms). Different random orderings of the 35 pairs were used, and the order of words within pairs was randomized and counterbalanced over participants.

Participants listened once to each of the two musical segments (presented in counterbalanced order). Immediately following each listening, they marked on a 1-5 bipolar scale how appropriate were the terms as a metaphoric descriptions of the music (1- the term to the right is very appropriate; 5 – the term to the left is very appropriate). We assumed that if participants strongly associate one pole with high or low pitch, the results should show significant differences between ratings for the high and low segments.

Results (Experiment 2)

Applying metaphors to high and low register segments

As mentioned above, the difference between the ratings of pairs for the high fragment and for the low fragment was calculated. The size of the difference is an indication for the variability of the pair with the music. For 27 out of 35 pairs, this difference between the ratings of the high fragment and low fragment was significantly different from 0 ($p < 0.05$ after FDR correction). As in Experiment 1, these terms include all but one (crazy-sane) of the metaphor pairs derived from ethnographical or historical sources (including the mbira "crocodile" antonym). Pairs showing highly significant differences between ratings for high and low are listed in Table 3.

Table 3. Terms associated with pitch register in Experiment 2. In each pair, terms associated with high pitch are listed first.

| $A > 2^{**}$ | $A > 1.5^{**}$ | $A > 1.2^{**}$ | $A > .9^{**}$ | $A > .65^*$ |
|--------------|----------------|----------------|---------------|---------------------|
| Light-dark | Female-Male | Clean-Dirty | Alert-sleepy | Followers-crocodile |
| Thin-thick | Summer-winter | Happy-Sad | Soft-Hard | Weak- Strong |
| Light-heavy | Sharp-blunt | Fast-Slow | Good-Bad | Pleasant-unpleasant |
| Young-old | Sharp-heavy | Begin.-end | Pretty-Ugly | Soft-loud |

| Grd.dau-Grd.ma | Small-large | Sparse-dense | Empty-Full | Little-much |
|----------------|--------------|--------------|------------|-------------|
| | Sweet-sour | | | |
| | Smooth-rough | | | |

** $p < 0.0001$, * $p < 0.01$.

Abstract vs. musical tasks

Comparison between Tables 1 and 3 shows that most of the strongest associations are shared by both experiments – Experiment 1, using abstract judgments without musical context, and Experiment 2, where an actual musical context was applied. To compare the results of the two experiments more systematically, two analyses were applied. First, a regression analysis was run, taking results of Experiment 1 as predictor for results of Experiment 2. Before regression, the respective data was averaged over participants. Table 4 shows an overview of the resulting explained variances. The explained variances of 0.56 based on judgments of pitch height indicate quite a strong agreement between judgments in a musical context and in an abstract conceptual context. In contrast, the two model fits for spatial height were not significant.

Second, we specifically examined whether results in the two experiments concur with regard to each of the 29 term pairs used in both experiments. We first coded in Experiment 2, for each participant, the direction of the difference between high and low; cases in which the difference was 0 were excluded from the analysis. For Experiment 1, choices for low and high pitch were combined, and contradictory choices (e.g., "light" for both high and low) were not included in the analysed data. We then compared, using chi-square analysis, the proportion of participants who associated each metaphor with high and low pitch.

Table 4. Explained variance of judgments from Experiment 1 predicting judgments from Experiment 2.

| Predicting variable Exp1 | Predicted variable Exp2 | R^2 |
|--------------------------|-------------------------|-------------|
| Pitch high | Difference rating | 0.56 |
| Pitch low | Difference rating | 0.57 |
| Spatial elevation high | Difference rating | 0.08 (n.s.) |
| Spatial elevation low | Difference rating | 0.12 (n.s.) |

Table 5. Metaphors applied differently in abstract (Experiment 1) and music-related (Experiment 2) tasks. The terms presented were associated with high pitch.

| Experiment 1 | Experiment 2 |
|--------------|--------------|
| Tense | Relaxed*** |
| Loud | Soft*** |

| | |
|-------|--------------------|
| N.P. | Soft (not hard)*** |
| N.P. | Strong*** |
| N.P. | Pleasant** |
| Alert | Alert** |

*** $p < 0.001$, ** $p < 0.01$, Chi-square two tailed. N.P. indicates no significant preference for either pole.

As Table 5 shows, only 6 of the 29 pairs differed significantly between experiments, and of these, only 2 present opposite directions. For these metaphors, apparently, variables other than pitch may have played a role in this process. Specifically, while both high and low segments apply a dense texture, in the lower register of the piano this density (due to the thicker sound, richer in partials) might have generated an impression of a tenser, “harder” and louder impression, which was absent in the acontextual judgments of Experiment 1.

Factor analysis

To highlight groupings of correlated responses, the differences between the ratings for high and low of Experiment 2 were subjected to a factor analysis, which included all data of individual participants. First, a principle component analysis was run on the data. Only the data for the 27 pairs that showed a significant difference between ratings of high and low were included. This resulted in 8 components with an eigenvalue greater than 1. The four main components were selected for inclusion in factor rotation. Table 6 shows the variables that correlated most strongly with each factor ($r > 0.60$). Additionally, the position of the pair Crocodile – those who follow crocodiles is indicated (correlation with Factor 4 was 0.51).

This list suggests a number of separate dimensions shaping pitch metaphors in musical contexts. Three of the four dimensions (F2, F3, and F4) correspond respectively with the dimensions of potency, valence (evaluation) and activity known from Osgood’s semantic differential analyses (Osgood, Succi, & Tannenbaum, 1957). The first dimension, (F1), a combination of brightness, sharpness, physical size, age and gender, is more intriguing, and its possible significance will be discussed below.

Table 6. Pairs correlating strongly with first four factors. Terms associated with high pitch are listed first.

| F1 18% | F2 12% | F3 19% | F4 8.9% |
|-------------|-------------|---------------------|-----------------------|
| Thin-thick | Strong-weak | Pleasant-unpleasant | Alert-sleepy |
| Sharp-Blunt | Loud-soft | Good-bad | Fast-slow |
| Female-male | Much-little | Sweet-sour | (Followers-crocodile) |
| Sharp-Heavy | | Pretty-ugly | |
| Young-old | | Soft-Hard | |

| | | | |
|------------|--|--|--|
| Light-dark | | | |
|------------|--|--|--|

DISCUSSION

This study supports and broadens the notion, suggested by previous empirical research, that a web of connotations, encompassing diverse sensory modes as well as cognitive and social domains, are associated with the concept (and possibly the percept) of auditory pitch. In two different tasks, a conceptual, acontextual matching task and an adjective rating task using actual musical segments, participants associated pitch (often almost unanimously) with non-auditory physical domains such as size, mass, lightness and texture, with the socially-relevant domains of age and gender, with various evaluative measures, and with facets of activity and force. Thus, high pitches are interpreted, among other things, as small, visually light, lightweight, thin, sharp and smooth; as happy and alert; and as young and female. Given the overall high agreement among participants for these and other pitch metaphors (including non-Western metaphors), we may conclude that diverse and strong cross-domain mappings for pitch exist latently besides the common “high” and “low” metaphor.

While many of these mappings have been previously reported (see introduction), the present study examined several issues pertinent to the understanding of cross-domain mapping of auditory pitch which were barely explored before. First, we examined relationships between culturally-specific factors and broad cross-cultural ones, as expressed in cross-domain mapping of pitch. Western participants’ matching of non-Western pitch metaphors with high or low pitch (in both Experiment 1 and 2) was congruent with the original application of these metaphors. This congruence pertains not only to broad characteristics such as large-small or young-old, but also to seemingly idiosyncratic metaphors like sharp-heavy, grandmother-daughter, and crocodile-those who follow the crocodile. These results suggest that non-Western mappings of pitch, though using culture-specific associations, are also based on more general, cross-cultural connotations, which may stem from basic bodily experiences and interactions with the physical environment. Hence, such mappings may make intuitive sense, even though one might have never been aware of them. For instance, non-Western metaphors like “crocodile” or “grandmother,” which may sound odd to those outside their original cultural milieu, are still readily understood, since they are partially based on the general experiential correlation of pitch with size and mass.

Second, previous empirical studies concerning cross-domain mapping of pitch (see introduction) used very simple stimuli (typically, isolated synthesized pitches), far from the complexity of even the simplest musical segment. These stimuli, nevertheless, inevitably possessed qualities other than pitch (e.g., a specific duration and timbre), which might have interfered with participants’ judgments. Here, combined and compared two experiments. Experi-

ment 1 used a purely conceptual task, where participants were asked to apply metaphors to the concepts of high and low pitch, rather than to a specific sound presented to them. Experiment 2, in contrast, involved segments from an actual piece of music, which differed primarily in pitch register. Comparison between these two tasks suggests that abstract conceptual mappings of pitch generalize to a considerable extent to judgments for actual musical stimuli.

This finding (which should, of course, be supported by further studies, using a wide gamut of musical styles and characteristics) implies that the metaphorical web of pitch connotations investigated in the present study may supply an interesting tool for the analysis and criticism of music. For instance, expressive or programmatic connotations of “high” and “low” musical segments (as revealed by texts, programs, or listeners’ reactions) may be associated with such implicit, but widely-shared, metaphorical web associated with “high” and “low” pitch. Analysis of explicit or implicit cross-domain pitch mapping may also afford a better understanding of verbal discourse concerning music - from theoretical treatises through concert programmes to music-related prose and poetry. Finally, such connotations may help investigating, interpreting and perhaps discovering systematic phenomena concerning pitch register in music. The fact, for instance, that lower pitches are larger, heavier and “older,” may meaningfully relate (both ways) to the different rhythmic behaviour of pitch in different registers.

Though pitch metaphors identified in the abstract are generalizable to actual music, this generalization is restricted by other musical features which may carry their own metaphorical web. Even when other features of the music (like texture, dynamics, or rhythmic complexity) are strictly controlled, these features may interact differently with pitch in different registers, and thus affect its cross-domain mappings. In the present experiment, interactions with features like textural and rhythmic density or perceived loudness (see results section) probably generated several differences between pitch connotations in the abstract context (Experiment 1) and in the context of Beethoven’s music (Experiment 2). The effect of such interactions on cross-domain mapping has hardly been studied empirically, and would certainly merit further research.

Third, our comparison of the results for pitch (Experiment 1, test group) and spatial elevation (control group) indicates that concepts related to spatial height can account for the latent metaphors for pitch to a limited extent only. Moreover, this limited relationship became non-significant when comparing judgments for spatial height with judgments for two musical fragments that differed mainly in overall pitch level (Experiment 2). Importantly, then, despite the long-standing, ubiquitous use of the verticality metaphor for pitch in the West (as well as the analogy of pitch and verticality in Western musical notation), the connotative web of

pitch, particularly musical pitch, seems largely independent of that metaphor, and primarily based on other factors.

The comparison of pitch and spatial elevation in Experiment 1 strongly suggests what one such factor may be. Spatial elevation is positively correlated with size and quantity. Indeed, “up is more” (or “greater is higher”) is one of the central conceptual metaphors discussed by Lakoff and Johnson (1980), providing basis for common expressions such as “higher salary” or “crime rate is up.” Recently, Cox (1999) suggested the “greater is higher” metaphor as a central source for mapping of pitch and spatial verticality. The present study, however, shows that the “up is more” relationship does not generalize to auditory pitch, where “upper” pitches are actually conceived as *lesser*, at least in physical qualities: they are small, thin, lightweight, and associated with “little” (as opposed to “much”).

This negative correlation of pitch “height” with quantity, size and mass – the “up is less” metaphor - is also reflected in the factor analysis of Experiment 2 (Table 5), an analysis that may shed some light on basic questions concerning the structure and origin of pitch metaphors. Of the four strongest factors revealed by the analysis, three closely resemble the three dimensions of Osgood’s semantic differential, valence (our F3) activity (F4) and potency (F2). These dimensions have been shown to underlie the connotations of varied concepts (Osgood, Succi, & Tannenbaum, 1957), and their detection as factors in pitch connotation is not surprising.

More intriguing, and perhaps more important, is the remaining factor (F1). This factor, one of two factors accounting for the largest percentage of the variance, also contains the strongest metaphors used in characterizing pitch, (those which presented the largest average difference between ratings for high and low register music in Experiment 2, and the widest agreement on their application to pitch in Experiment 1). While variables in the other three factors clearly relate to underlying concepts which were established empirically as semantic dimensions in numerous other contexts, this is not the case with F1. Indeed, with some interpretive effort, all but one of the stronger variables in this factor can be related to mass or size, either directly (thin-thick, heavy in “sharp-heavy”, sharp-blunt) or indirectly (female-male, young-old), representing the “up is less” correlation of pitch discussed earlier. Importantly, the above variables are experientially related to pitch, rather than just products of cultural convention. By and large, objects producing lower pitch indeed tend to be thicker (and thus not as sharp), heavier, older (adults as compared to children), and male.

What makes this dimension, however, harder to interpret as a “size” (or size+mass) factor, is the lightness (light/dark) variable strongly correlated with it (and rather surprisingly, not with valence, despite the metaphorical evaluative con-

notations of “dark” and “light”). Cross-domain mapping of pitch and lightness has been observed in a number of studies in adults (Hubbard, 1996; Marks, 1987; Walker & Smith, 1984), while brightness interacts with pitch even for 4-5 years old children (Marks, Hammeal, & Bornstein, 1987).⁴ Unlike the mapping of pitch and physical size, mapping lightness and pitch is not directly related to experience: painting a surface white, rather than black, or exposing it to sunlight, would not change its pitch. Its early development suggests that it is neither linguistic in origin.

Is there a unified cognitive dimension in which mass, size, and lightness – not subsumed under any specific verbal concept – are associated together with auditory pitch? Suggesting such an underlying cross-modal, non-verbal representation would, of course, be premature, given the limited scope of the present study. As this project progresses, we hope to further explore this intriguing pitch-related dimension.

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⁴ . Brightness and lightness are not identical dimensions. However, in Hebrew, used in this experiment, the same word (“bahir”) is used to denote both terms.

