Experiencing Groove Induced by Music: Consistency and Phenomenology

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There is a quality of music that makes people tap their feet, rock their head, and get up and dance. The consistency of this experience among listeners was examined, in terms of differences in ratings across 64 music examples taken from commercially available recordings. Results show that ratings of groove, operationally defined as "wanting to move some part of the body in relation to some aspect of the sound pattern," exhibited considerable interindividual consistency. Covariance patterns among the 14 rated words indicated four prominent factors, which could be labeled regular-irregular, groove, having swing, and flowing. Considering the wide range of music examples used, these factors are interpreted as reflecting psychological dimensions independent of musical genre and style.

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There is a quality of music that makes people tap their feet, rock their head, and get up and dance. For some music, such as jazz and various kinds of dance music, this is perhaps the most essential feature. Every musician with knowledge of these styles can have an opinion about the extent to which a given piece of music possesses this quality, and this is probably true for nonmusicians as well. In other words, it is well established in folk psychology.

However, agreed-upon terms or definitions are wanting. Here, I will refer to this experience as groove, operationally defined as "wanting to move some part of the body in relation to some aspect of the sound pattern." This definition leaves open the quality of the music that is presumed to induce it: At the present level of knowledge we can only be certain there exists such an experience (Madison, 2001, 2003), but there is no evidence that sound pattern properties actually induce it, that this induction is consistent among listeners, nor about which properties that might be. The present definition should be understood as describing the typical rather than being exclusive: It may be considered too open, for example that "some aspect" could be replaced by "the beat," that "in relation" could be replaced by "repetitively" or "in synchrony." However, such specifications raise further problems related to uncertainties about how to define beat, synchrony, and so forth. In any case, groove appears to be the most established term for this phenomenon (Iyer, 1998, 2002; Pressing, 2002; Schuller, 1989).

There is only a small number of papers addressing groove in psychology, musicology, and ethnomusicology (Iyer, 1998, 2002; Keil, 1995; Keil & Feld, 1994; Madison, 2001, 2003; Madison & Merker, 2003; Pressing, 2002; Prögler, 1995; Waadeland, 2001). Not even Grove's dictionary of music has an entry for *groove*, nor for any other term with similar meaning.

Many people surely associate groove with swing or with swing music. In fact, the closest synonym for groove in Swedish is *svängig*, which is equivalent to "having swing." However, Grove's entry for swing refers to musical performance and to musical structure but does not mention the experience of music. Swing refers to the structural property that the beat is subdivided into somehow unequal units—so-called swung notes—which is proposed to accentuate the beat (*Sohlmans Musiklexikon*, 1975). When measured on cymbal ostinato patterns in jazz performances, the duration of the long first note in pairs of swung notes was between 1.1 and 3.4 times longer than the short second note among a small number of drummers and performances (Friberg & Sundström, 1997). Across a range of tempi from 150 to 300 beats per minute (BPM) the short interval was constant (within 85–110 ms), which seems to be a lower limit for human temporal processing reflected both in maximum speed of movement and simple reaction time. Given that swung notes actually accentuate the beat in the sense of increasing its perceived salience, the critical property seems therefore not to be the ratio in itself, but rather that

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elements on the metrical level below the beat are perceptually distinguished from each other.

According to Chambers Dictionary, groove is associated with pleasant and delightful, but also with the realization of an ideal, to be in top form (Kirkpatrick, 1987). For music intended for dancing, groove could hence be understood as a realization of this intention. Inasmuch as groove is perceived as pleasant, regardless of whether one actually does dance or move in any other way, the same should apply to music not meant for dancing or to other rhythmic behaviors, such as ritual and drill (McNeil, 1995). In then becomes a very general aspect, excluded only by the small fraction of the world's musics that are unmeasured and has no regular temporal division that enables anticipation, prediction, and synchronization (Arom, 1991).

Vijay Iyer provides a particularly comprehensive and insightful discussion about the concept of groove, its possible levels of description, and the nature of the sound signal properties that induce it. For example, he describes groove as "an isochronous pulse that is established collectively by an interlocking composite of rhythmic entities" and an "attentiveness to an additional unifying rhythmic level below the level of the tactus" (Iyer, 1998, chap. 2, p. 7; see also Iyer, 2002).

That all people may have the experience of groove in response to music does not necessarily mean that it is similarly induced. A piece of music that makes me experience groove might not do the same for someone else. Indeed, I have heard many musicians vouch that this relation is highly individual. Whether it is entirely individual or very general has important implications for issues of function and origin of groove. In the former case, its function is limited to sensibilities based on personal life history. In the latter case, its function might be quite specific and is more likely to have a biological basis and an evolutionary history. The primary purpose of the present study was to address the individual-general issue, in terms of interindividual consistency of ratings of groove. A secondary purpose was to learn more about the psychological phenomenology of groove. To this end, covariances among groove and a number of words relevant for the experience of rhythm were analyzed, which required word ratings as data. The interesting approach to measure the participants' movements was deferred because of possible interference with the rating task and because larger individual differences were expected in the propensity to move than in the ability to make valid ratings.

The study was designed to provide natural conditions and some degree of ecological validity, in order to meet the demands of a phenomenological approach and those of a first inquiry into these questions. Participants were therefore typical music listeners without formal or professional music training, because these are likely to be more representative of people in general than are musicians. The stimuli consisted of recordings of real music with high artistic and acoustic quality from a wide range of musical styles, geographical areas, and cultural traditions, so as not to unduly limit results to the culture-specific. Music as a social and cultural phenomenon carries values and ideas related to genre and style, as well as to individual works. This influence was minimized by using unfamiliar music examples.

Method

Participants

Ten female and eight male native Swedes acted as listeners. They were regarded as nonmusicians according to the criteria that, apart from obligatory recorder lessons in primary school, none had participated in formal music training or sung or played a musical instrument in a systematic fashion. They were recruited by advertisements on the university campus, ranged from 23 to 54 years in age, and were paid for their participation.

Stimuli

Sixty-four music examples were selected from commercially available CDs and represent a wide range of musics related to various cultural and geographical areas. These can be described as African, African American, Indian, Latin American, Scandinavian, and South European in terms of geographical origin, and as jazz, traditional folk music, Latin, and world music in terms of genre.

All examples were 8 s in duration and were taken from any position within the original sound tracks that constituted a representative and musically meaningful excerpt of that track, typically comprising what could be regarded as one or more complete musical phrases. Their tempi ranged from 55 to 280 BPM. I chose a fixed example duration rather than the number of measures or a complete phrase since such structural quantities might be arbitrary and difficult to assess in some cases. They may also be less relevant for the present study. Although a wide range of tempi and a fixed example duration results in different numbers of beats and hence potentially different amounts of structural information, the number of musical events per unit of time tends to vary less than tempo (Behne, 1976). It is also unknown which sound signal properties affect the experience of groove, so there is no reason to assume that the number of measures is more critical than the number of events or listening time, for example.

Rating Scales

Fourteen words were subjected to ratings of their appropriateness for describing each music example. Groove was carefully defined prior to the experiment; the literal translation from Swedish was "evokes the sensation of wanting to move some part of the body" and was represented by the shorter word *rörelseskapande* among the words to be rated. *Svängig* (having swing) was also included because it is the closest Swedish synonym for *groove*, as mentioned. The remaining 12 words were selected so as to include motion qualities, rhythmical aspects of music, and qualities typically found in dimension analyses for music in general (e.g., Hevner, 1936). Motion qualities were motivated by the connection between groove and body motion in terms of dance, ritual, and drill. Rhythmical dimensions have been found to include rapidity, uniform–varied, "accent on the first beat" (Gabrielsson, 1973a), and vital–dull (Gabrielsson, 1973b).

This potentially large number of words was balanced by the demand for a manageable task that would not be overly taxing, either in terms of fatigue or in terms of participants' memory of the example just heard. The number of words was minimized according to the criteria that dimensions consistently reported in previous studies should be represented at least with one pole in a bidirectional dimension, which was the case for happy–sad, simple–complex, slow–rapid, and tense–relaxed. Thus, although all rating scales in the present experiment were unidirectional, their dimensional opposites as indicated by previous studies were implicit in the "not at all appropriate" end of the respective scale. A second way to reduce the number of scales was to merge apparently synonymous terms, such as *steady* and *stable*.

The resulting 14 rating scales are listed both with the Swedish words actually used and their English synonyms: Bouncing (*studsande*), Driving *(drivande),* Flowing (*flytande*), Happy (*glad*), Intensive (*intensiv*), Calm (*lugn*), Groove (*rörelseskapande*), Rapid (*snabb*), Rocking (*gungande*), Simple (*enkel*), Solemn (*högtidlig*), Steady (*stadig*), Having swing (*svängig*), and Walking (*gående*). Note again that the idiomatic expression in Swedish for groove is *svängig*, which is quite different from swinging (*svängande*) as a movement quality. The scales appeared as horizontal lines divided by 11 equidistant short vertical lines marked with the numbers 0 through 10, anchored "not at all appropriate" (0) and "very appropriate" (10).

Design

Dependent variables were the 14 rating scales, and the independent variable was music example (64), regarded as a random sample of the entire population of measured music. Each participant individually attended one session, and the music examples were presented in a different random order for each participant. The rating scales also appeared in a different random order on the computer display in each session.

Procedure and Apparatus

The experiment was administered by a custom-made computer program, which played the sound files through the built-in sound card of a PC and collected responses through the computer keyboard. Part of the instruction was (translated from Swedish) "You will hear a large number of music performances. Your task is to rate how well you think that each of 14 words describe how you experience the music." Participants were asked to note on a notepad if they recognized the example or if they had any comments pertaining to difficulties in rating it. They were also encouraged to work in a calm and concentrated fashion and to take a break if feeling tired.

Each trial consisted of a first presentation of the current music example and the appearance of half the rating scales: After these were rated the participant pressed the enter key, which started a second presentation of the music example and made the seven final rating scales appear. The participants had the option to repeat the current example by pressing the space bar on the computer keyboard.

Each session included careful instructions and a few training trials to familiarize the participant with the task and the computer interface. The first block in what was told to be the start of the experiment proper comprised 14 music examples randomly sampled from the entire set of 64. Its purpose was to orient participants about the range of expressive features in the experiment, and these ratings were not included in the analysis. An entire session lasted between 52 and 76 minutes, including a brief interview after the experiment about how the participants experienced the task.

Results and Discussion

According to the interviews, the participants were comfortable with their task. No one indicated that any words were redundant or that they found any words missing. Two participants said they recognized a few examples, but it turned out that they could not correctly

identify them. Four participants said they were uncertain about how to use some of the words, and that they might have changed their rating criteria for these during the experiment. The words so mentioned were Flowing, Simple, Solemn, and Walking. No data were excluded from analysis on the basis of these observations.

There were statistically significant effects ($p < .0001$) of music example ($N = 64$) on all of the 14 rating scales, according to one-way repeated-measures analyses of variance (ANOVA). Such an effect can be the result of one single example being different from all the others. However, plots showed that music examples were approximately normally distributed across each rating scale: The closer to the mean, the more examples. Since the confidence intervals were almost uniform across all music examples, they give an indication about the number of statistically significant levels among the music examples, which is one way to assess the sensitivity of the rating instrument. Given that ratings were based on some stimulus property with a uniform range and distribution across rating scales, small differences in mean ratings between music examples (across participants) and high variability among participants both correspond to low sensitivity: If the average confidence interval were larger than half the range there would be only one level, and no two music examples would be significantly different. In contrast, large differences in mean ratings, which equals a wide range, and low variability among participants correspond to high sensitivity: Ultimately all music examples could be significantly different.

The present study employed a random sample of music examples, and the range and distribution of properties that formed the basis for the ratings are therefore unknown. However, given the relatively large number of samples, the range of properties can be assumed to be fairly representative, and the distribution can be assumed to be approximately normal. Because values are clustered around the mean, the number of significant pairwise differences among music examples is a dubious indicator of rating consistency. Furthermore, ratings by human operators tend to be adjusted to the stimulus variability, such that the stimulus property is proportionally mapped onto the rating scale (Madison & Merker, 2003; Watt & Ash, 1998). Such mapping was facilitated in the present study by the presentation of 14 representative music examples prior to the experiment proper. Indeed, the grand mean across rating scales was 5.30, which is close to the center of the scale (5). In an experiment with more than one rating scale, one can assume that the mapping is made with respect to the perceived mean range of variation, which might account for differences in mean, minimum, and maximum ratings among rating scales. In others words, ratings tend to express the ability to discriminate and represent different levels of subjective experience, rather than differences in absolute levels of the eliciting stimulus properties. While this is a serious problem when the aim is to provide such mapping, that is, for questions of a psychophysical nature, it is an advantage for the present purpose of assessing phenomenology and interindividual consistency in the face of eliciting stimulus properties of which we are ignorant and therefore cannot control: It is likely that the automatic adjustment to scale makes the rating statistics more comparable in terms of subjective experience, in spite of possible (but unknown) differences in the magnitude and range of stimulus properties.

Thus, confidence intervals will express rating consistency in an absolute sense, even if there are no differences in mean ratings: Floor and ceiling effects would lead to small confidence intervals, for example. The number of possible significantly different levels within the range of ratings actually given will express both consistency and the levels of subjective experience, which is a more useful statistic. These levels were computed as follows. The largest difference equals the range (R), within which two levels must be separated by at least two confidence intervals (CI), and three levels by at least four confidence intervals, and so forth, which means that levels $= R / 2CI + 1$. For groove, the mean 0.95% confidence interval across all music examples was 0.91, and the range of ratings for music examples across participants was 5.06(8.11 – 3.05). Thus, the number of levels was 3.77. Table 1 shows mean, minimum, and maximum rating for all 64 music examples across participants. It also shows the mean 0.95 confidence interval across music examples and the resulting number of levels.

Table 1 shows that the range of mean confidence intervals was rather small: from 0.64 (Rapid) to 0.92 (Bouncing). The range of ranges was considerably larger: 3.33 (Walking and Solemn) to 8.16 (Calm), closely followed by 7.44 for Rapid, which is probably the most objective variable. We can conclude that the experience of Walking, for example, was perceived as having a smaller range than the experience of Groove or Rapid. We cannot, however, conclude that the actual range of whatever physical property of the sound signal that induces these experiences differs among the scales. The music examples in the present sample all have a clear beat, which means that they all should induce groove to some extent. It is therefore of more practical interest that 18 participants are sufficiently consistent

TABLE 1. Descriptive statistics for the rating data across participants

	Mean	Minimum	Maximum	Range	0.95 CI	# Levels
Driving	6.09	3.11	7.83	4.72	0.78	4.02
Simple	4.97	2.38	7.50	5.12	0.88	3.90
Flowing	6.07	3.33	7.44	4.11	0.78	3.62
Happy	5.61	3.38	7.55	4.17	0.67	4.07
Rocking	5.67	4.00	7.55	3.55	0.89	2.98
Walking	5.19	3.33	6.66	3.33	0.83	2.99
Solemn	3.89	2.05	5.38	3.33	0.90	2.84
Intensive	5.30	2.00	8.27	6.27	0.81	4.89
Calm	4.70	1.00	9.16	8.16	0.82	5.99
Groove	5.57	3.05	8.11	5.06	0.91	3.77
Steady	5.54	3.50	7.66	4.16	0.78	3.65
Rapid	4.99	1.22	8.66	7.44	0.64	6.74
Bouncing	4.68	1.72	7.05	5.33	0.92	3.87
Having swing	5.96	3.83	7.60	3.77	0.75	3.48

in their ratings that almost four significantly different levels of groove can be discerned. Comparing among rating scales, we find that the number of levels for groove is intermediate, close to the grand mean number of levels (4.06). The number of levels was smallest for Solemn (2.84) and largest for Rapid (6.75)—the latter a consequence of the smallest confidence interval and the next widest range.

In conclusion, groove seems to be no more difficult to discriminate and rate than other dimensions found for music experience in music research (Farnsworth, 1969; Gabrielsson, 1973a; Gray & Wheeler, 1967; Hevner, 1936; Kleinen, 1968; Nielzén & Cesarec, 1981, 1982; Wedin, 1969, 1972). It appears even somewhat easier than to rate Having swing (3.48 levels), although there were music examples with a very pronounced swing rhythm and a typical swing style as well as examples decidedly without any of these attributes.

We turn now to the relations between groove and the other rating scales, which in turn correspond to experiential dimensions commonly found for music. Exploratory statistical techniques such as factor analysis can only find relations among variables and dimensions that are present in the data and that exhibit sufficient variability. The present sample of music was unrestricted in all aspects that might conceivably be reflected in the ratings (see in/exclusion criteria in Method, Stimuli), except that all examples should have a clear beat. The range of groove from mellow, slow ballads with a beat to rubatized solo music such as Debussy's Syrinx was thus not included. As mentioned, rating scales were selected so as to represent all dimensions that are consistently reported in previous research, that is, Happy (representing happy–sad), Simple (simple–complex), Intensive and Calm (tense–relaxed), and Solemn. Motion qualities were represented by Bouncing, Driving, Flowing, Rapid, Rocking, Steady, and Walking.

A factor analysis usually gives more easily interpretable results when interindividual variability is excluded. The following factor analyses (principal component extraction, varimax normalized factor rotation) were therefore based on means across participants, supported by the robust results reported above. A two-factor solution could be interpreted as tension–relaxation and groove (with 67.7% total explained variance), a three-factor solution added flow with the eigenvalue 1.72 and 74.7% total explained variance. A four-factor solution increased the explained variance to 79.8%, with the addition of a factor with high positive loadings for Happy, Rocking, and Having swing. Although the eigenvalue for the fourth factor initially was only 0.72 (5.14%), its explained variance increased to 14.8% by the factor rotation. The explained variance that can be attributed to groove was 25.5% for the two-factor solution, 25.5% for three factors, and 21.8% for the four-factor solution, which also featured a dimension for Having swing. The factor loading matrix for this solution is shown in Table 2.

Table 2 can be interpreted as follows. Factor I seems to reflect rhythmical simplicity and the movement quality of walking. One could speculate that this corresponds with uniform accentuation of regularly occurring events with intervals close to those characteristic for human gait. It might represent the commonly found simple–complex dimension, which covaries with the rhythmic simplicity associated with Walking, Calm, and Steady, and has negative loadings for the rhythmic complexity associated with Driving, Intensive, Bouncing, Rapid, and Having swing. Thus regular–irregular might be more fitting than simple–complex, for example.

TABLE 2. Factor loadings for a four-factor solution, varimax rotated

	I	II	III	IV
Driving	−.43	**.78**	.25	−.12
Simple	**.85**	−.18	−.12	.08
Flowing	.21	−.06	−.10	**.86**
Happy	−.17	.34	**.75**	−.23
Rocking	.50	.04	**.78**	−.01
Walking	**.78**	−.08	.09	.30
Solemn	.32	−.25	.10	.62
Intensive	−.65	.62	.01	−.24
Calm	.70	−.48	−.19	.34
Groove	.03	**.86**	.30	−.07
Steady	**.82**	−.20	.05	.33
Rapid	−.68	.61	.21	−.13
Bouncing	−.52	.61	.18	−.30
Having swing	−.30	.29	**.77**	.22
% expl. var.	30.9	21.8	14.7	12.3

Note. Factor loadings higher than 0.7 appear in bold.

Factor II has its highest loading for Groove and goes together with Driving, Intensive, and to some extent with Rapid and Bouncing. Both Driving and Intensive seem to reflect movement induction. This is not obviously the case for Rapid, however, but in a natural sample it is conceivable that music intended to be less Driving and Intensive is also slower. It is thus likely that Rapid is involved in spurious correlations as a result of dependencies inherent in the sample.

Factor III has high loadings for Happy, Rocking, and Having swing. It probably assumes the commonly found dimension happy–sad, which tends to covary with Rapid and Having swing because the swing music examples tend to be fast, and a high tempo is associated with happiness (Juslin & Laukka, 2003).

Factor IV is mainly associated with Flowing, but to some extent also with Solemn, Calm, and Steady. In previous research Flowing is rarely included, whereas Solemn is a commonly found factor. It is therefore difficult to interpret this factor. It might be the case that Flowing is a unique dimension for music experience, although this has not yet been established. Alternatively, the nature of the present music sample or the rating scales' focus on rhythm might have emphasized this dimension in the minds of the listeners. Future research should include flowing in order to explore its nature and apparent correlation with Solemn.

As for the dimensions commonly found in other studies, the four present factors have accounted for simple–complex, happy–sad, and solemn, but not for slow–rapid and tense–relaxed. Rapid and Intensive behave almost identically. Their factor loadings are similar in Factors I and II: negatively associated with Simple, Walking, and Steady, and positively associated with Groove and Driving. Again, the nature of the present music sample or the rating scales might readily have altered the relative importance of the experiential dimensions as compared to previous studies, which mainly used classical art music as stimuli.

The important conclusions of the factor analysis are for the present purpose as follows.

First, groove emerges as a prominent dimension if we ask for it—previous studies did not. It amounts here to the second largest factor, accounting for 21.8% of the total variance, although all music had a clear beat and was to some extent movement-inducing. Note that the minimum mean rating of groove was 3.05, while the smallest minimum mean rating among all scales was 1.0 (for Calm). If unmeasured music or music with a less pronounced beat had been included, groove would surely have accounted for an even larger proportion of the total variance.

Second, groove was to some extent independent of Having swing. This is not surprising: Having swing is in Swedish the established term in closest correspondence with the present definition of groove, but it is also strongly associated with swing music, and the present sample comprised a relatively large number of swing examples. I suggest that separate factors for Groove and Having swing emerged because Groove was a purer concept as a result of having been carefully defined, while Having swing represented both Groove and swing music in the minds of the listeners. A similar study should be performed with non-Swedish participants to clarify this issue. However, it is notable that this result does not contradict the notion that groove is a cross-cultural phenomenon and perhaps a human universal.

Third, if swing corresponds to swung notes, there are apparently other means to induce movement; indeed, the music examples rated highest for groove were neither jazz nor did they exhibit a swing rhythm.

Fourth, tempo as reflected in ratings of Rapid exhibits no simple relation to groove. The critical properties that elicit groove seem therefore fairly independent of beat tempo. The correlation between Groove and Rapid was only 0.28 ($p < .05$), and the correlation between Groove and tempo was .23 (n.s.).

Fifth, what can the factor analysis indicate about stimulus properties that elicit groove? Not much. There are no clear relations between Groove and any of the rhythmic or movement qualities. The only hint is an intermediate loading in Factor II for Bouncing. However, it is not at all clear what bouncing might correspond to in acoustical or musical terms.

Future research may profitably investigate the experience of groove with respect to systematic control over

genre or musical style and with respect to tempo (Madison, 2003). Those results might give hints about the difficult issue of which acoustical, musical, or structural properties of sound patterns that are associated with groove, given that the present study has shown a systematic relation between the experience of groove and such properties present in a random sample of music. However, the unsystematic variation of such properties across the present sample makes it very difficult to obtain hints about relations between groove and particular sound properties from the present study. If such properties could be quantitatively specified and measured, a correlation analysis might yield some ideas and possibly hypotheses, but this is outside the scope of the present study.

Another interesting question for future research is whether different cultures and musical styles employ the same devices to induce movement. More specifically, the commonality of these means will, at the appropriate level of description, provide essential insight into the brain's processing of complex sound patterns and into the possible function of groove.

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