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THE MELODY OF SPEECH: WHAT IS THE MELODIC PERCEPTION OF SPEECH REVEALS ABOUT LANGUAGE PERFORMANCE AND MUSICAL ABILITIES

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Annotation: Research has shown that melody not only plays a crucial role in music but also in language acquisition processes. Evidence has been provided that melody helps in retrieving, remembering, and memorizing new language material, while relatively little is known about whether individuals who perceive speech as more melodic than others also benefit in the acquisition of oral languages. In this investigation, we wanted to show which impact the subjective melodic perception of speech has on the pronunciation of unfamiliar foreign languages. We tested 86 participants for how melodic they perceived five unfamiliar languages, for their ability to repeat and pronounce the respective five languages, for their musical abilities, and for their short-term memory (STM). The results revealed that 59 percent of the variance in the language pronunciation tasks could be explained by five predictors: the number of foreign languages spoken, short-term memory capacity, tonal aptitude, melodic singing ability, and how melodic the languages appeared to the participants. Group comparisons showed that individuals who perceived languages as more melodic performed significantly better in all language tasks than those who did not. However, even though we expected musical measures to be related to the melodic perception of foreign languages, we could only detect some correlations to rhythmical and tonal musical aptitude.

Keywords: melodic language perception; melodic perception; melody; phonetic; musical abilities; music perception; singing ability

Introduction: Interdisciplinary research on music and language has become rather diverse over the past two decades. The reason for this development is evident as music and language share a set of characteristics (Jackendoff and Lerdahl 2006). Music and language are based on hierarchical structural aspects, such as the ordering of distinct elements (Jackendoff and Lerdahl 2006; Honing 2011) and consist of tonal and

rhythmical features. The similarities between language and music are rather salient on the acoustic level. This becomes particularly obvious if one looks at speech directed to infants. It is rather slow, shows more pitch variation, and is often perceived to be more melodic in its characteristics than adult speech (Kuhl et al. 1997; McMullen and Saffran 2004). Indeed, song and melody are based on discrete pitches, which are sustained over longer durations compared to speech (Deutsch et al. 2011). Even though language and music show many similarities, they are based on different sound systems. Whereas that for music is based on pitches and timbres, the linguistic sound system consists of pitch contrasts, vowels, and consonants (Patel 2007).

In general, various scientific branches that attempt to analyse rhythmic and tonal aspects of music and their relationship to language prosody have emerged (Krumhansl and Keil 1982; Patel 2007; Patel and Daniele 2003). For instance, the pitch structure of music and language have been extensively studied by Jackendoff and Lerdahl (2006). On a syntactic level, language has also been compared to discrete structural elements of music (Honing 2011; Patel 2003). More recently, diverse scientific branches have started looking at potential positive transfer effects from music to language, and vice versa. For the past two decades the scientific community has shown considerable interest in understanding the underlying mechanisms of musical aptitude and musical training. Whereas the latter is associated with achievement and mastery, musical aptitude is compared to potentials that can be seen as a kind of readiness to learn (Gordon 1989; Law and Zentner 2012). It is generally accepted that musical proficiency is comprised of the interactions between acquired and innate musical capacities (Sloboda 2008). More recently, studies on the relationship between music and language have also discussed potential pre-existing abilities, which may be responsible for the link between both faculties (Swaminathan and Schellenberg 2020; Kragness et al. 2021). This addresses transfer effects between music and language, which are not induced by formal musical training.

According to recently published studies, positive relationships between music and language learning have been found on multiple occasions. For instance, music-based training has been suggested to facilitate duration perception in speech (Chobert et al. 2014) and the ability to segment speech (François et al. 2013). Trained musicians seem to detect incongruities in unfamiliar speech better than non-musicians do (Christiner 2020) and musical aptitude has generally been linked to language functions in children and adults (Christiner and Reiterer 2018, 2019; Christiner et al. 2018; Turker et al. 2017; Turker 2019).

Working memory (WM) capacity has been described as a system that enables the storing, manipulating, and maintaining of temporary information (Baddeley 2003). Complex WM capacity has an influence on multiple cognitive domains such as intellectual (Conway et al. 2002, 2003; Engle et al. 1999) and mathematical ability (Schmader and Johns 2003). Therefore, WM capacity has received considerable attention in music and language research and is associated with individual differences in the mastery of first and foreign languages (Baddeley et al. 1998; Dörnyei and Ryan 2015; Majerus et al. 2006; Wen and Skehan 2011). In language research, the subsystem of the WM, the phonological short-term memory (STM), is the most important capacity for observing individual differences in language abilities (Wen and Skehan 2011). STM capacity is related to the ability to remember larger phonological structures and is the most important cognitive capacity that predicts refined language abilities of multilinguals and polyglots (Baddeley et al. 1998). Therefore, if language abilities are assessed, STM capacity should be investigated as well. Whereas, in language research, STM has intensively been studied, in music research, it is different. There is a controversy over whether a "tonal loop" in music as an equivalent of the phonological loop for language capacity exists or not. Although early research suggested a separate storage for tonal and speech material (Salame and Baddeley 1989), more recently it has been shown that the processing of musical and verbal sounds show overlaps (Williamson et al. 2010). Brain research reported that verbal and tonal storage rely on largely overlapping neuronal networks (Koelsch et al. 2009). This may be one reason why STM capacity is associated with enhanced language and with improved musical capacities.

In the past two decades, extensive research on the relationship between music and language has been published in the fields of education and aptitude. These publications mainly aimed at illustrating the positive effects of music on language ability and language learning progress. Several studies have reported a link between musical ability and foreign speech production, such as the ability to pronounce foreign languages (Milovanov et al. 2009; Milovanov and Tervaniemi 2011; Pastuszek-Lipinska 2008). In aptitude research, both tonal and rhythmic musical abilities predicted phonetic skills in the learning of unfamiliar languages. Whereas a tonal subtest, as measured by the AMMA test (Gordon 1989), was more predictive for adults in the ability to pronounce multiple languages (Christiner 2020), the opposite was found for children, where rhythmic predictors were found to explain enhanced language skills (Swaminathan et al. 2017). Language typology also seems to influence the relationship between language and music. Tone language imitation ability was predicted by tonal

aptitude, whereas non-tone language imitation was predicted by rhythmic aptitude (Christiner et al. 2018). Singing, for instance, was found to facilitate the learning of new vocabulary (Ludke et al. 2014) and was often employed as a learning tool in the foreign language classroom for beginners. For example, foreign words were presented and learnt together with a melody (Anton 1990). Singing new words in foreign languages is also assumed to facilitate retaining new utterances more easily (Ludke et al. 2014). The key role for this has often been ascribed to melody (Purnell-Webb and Speelman 2008). Indeed, infants also acquire new utterances much faster when they are sung (Thiessen and Saffran 2009). Melody is also said to serve as a mnemonic with which utterances are stored in the long-term memory (Gordon et al. 2010) and "[…] seems to act as a path or a cue to evoke […]" information (Fonseca-Mora 2000, p. 150). On these grounds, melody not only plays a key role in music but also in language acquisition processes.

Assessing Musical Abilities

For measuring musical abilities, various approved musicality tests are available. Most of them are perception tasks, which at least consist of rhythmic and tonal subtests. The Advanced Measures of Music Audiation (AMMA) test developed by Gordon (1989) has been used in multiple investigations and reliably measures the ability to discriminate tonal and rhythmic changes in paired musical statements. In addition, interdisciplinary research that used the AMMA test and compared tonal and rhythmic abilities to phonetic language abilities is available (Christiner and Reiterer 2013, 2015, 2019; Turker et al. 2017 increasingly more studies show contradictory results when the relationship between music perception (pitch discrimination) and production is investigated (Berkowska and Dalla Bella 2009). While some studies have reported a relationship between the production and perception of music (Demorest et al. 2015; Demorest and Pfordresher 2015), others have not (Loui et al. 2009; Pfordresher and Mantell 2014; Tremblay-Champoux et al. 2010). Therefore, if musical abilities are assessed, the inclusion of music performance and music perception measures will more reliably illustrate the musical capacities of individuals. Measuring musical performances is achieved best by introducing singing tasks. This has the advantage that non-musicians who do not play a musical instrument can participate in the research as well (Dalla Bella et al. 2007). In general, singing tasks are subdivided into two main categories: imitation (repeating new, unfamiliar melodies or songs) and tasks where participants have to sing familiar songs. While imitation tasks are often used for advanced singers, familiar song singing tasks are often targeted at non-musicians (Dalla Bella et al. 2007, 2009). The assessment of singing performance can be carried out by

means of computerized methods, which focus on pitch accuracy (Salvador 2010). Another option is to use rating scales where the performances are evaluated based on specific criteria by experts (Hornbach and Taggart 2005; Rutkowski and Snell Miller 2002). Rating scales can be used in a rather flexible way and adapted to evaluate specific rating criteria (Larrouy-Maestri et al. 2013), and longer sequences can easily be assessed (Christiner 2020). The latter approach has been chosen in this study.

1.2. Assessing Pronunciation Skills and the Melodic Perception of Speech

Measuring individual differences in the ability to pronounce new words can be achieved best by using unfamiliar short sequences of language stimuli that individuals are instructed to repeat. Subsequently, their performances will be assessed by experts or native speakers. These measurements are of high ecological validity because they simulate a foreign language situation in which new words or phrases are learned. In addition, the same language stimuli can easily be rated for how melodic they appear to listeners.

Using unfamiliar utterances as test stimuli, however, has more advantages. One is that individual differences in the performances also vary depending on foreign language capacity. Therefore, using language stimuli that are unfamiliar to individuals ensures that educational influences on performances are reduced—a common approach, which has successfully been used in previous investigations (Christiner and Reiterer 2013; Christiner and Reiterer 2015; Christiner and Reiterer 2018). Another benefit is that sociolinguistic influences are minimized and reduced. This means that neither the impact of the message of the content, nor the recognition of particular speech styles and social identities, can trigger certain likes, dislikes, or social categorizations and infer that speakers possess particular personality attributes (Giles and Billings 2004). Since recently the nature of short sequences of unfamiliar languages as test stimuli have been investigated in more detail, this represents another advantage. For instance, factor analysis revealed that typologically different short sequences of language stimuli load onto the same factor, which suggests that short sequences of unfamiliar speech measure general pronunciation ability, even if they are typologically different (Christiner 2020). This finding has two crucial implications. One is that imitation tasks of different languages represent a general aptitude and pronunciation measurement. The second is that many languages can be used to create a single measurement, which represents a more reliable concept to measure pronunciation skills.

Regarding approaches towards measuring the melodic perception of speech from a musicological point of view, there are further good reasons to use unfamiliar utterances. One is that, in initial foreign language learning situations, language input is

rather meaningless and may force naïve listeners to treat language stimuli similar to musical statements (Milovanov et al. 2009). This suggests that more music-resembling language features (e.g., speech melody) are in the foreground of the speech material to which individuals are exposed to. Indeed, natural pitch modulations in spoken language have a lot in common with tone transitions in musical melodies (Oechslin et al. 2010), and brain research provided evidence that prosodic information is predominantly processed in the right area of the auditory cortex (Meyer et al. 2002) when linguistic information is rather poor in content (Perkins et al. 1996). In consideration of the criteria and measurements, which were discussed in the former two sections, the research design was created. This means that neither the impact of the message of the content, nor the recognition of particular speech styles and social identities, can trigger certain likes, dislikes, or social categorizations and infer that speakers possess particular personality attributes (Giles and Billings 2004). Since recently the nature of short sequences of unfamiliar languages as test stimuli have been investigated in more detail, this represents another advantage. For instance, factor analysis revealed that typologically different short sequences of language stimuli load onto the same factor, which suggests that short sequences of unfamiliar speech measure general pronunciation ability, even if they are typologically different (Christiner 2020). This finding has two crucial implications. One is that imitation tasks of different languages represent a general aptitude and pronunciation measurement. The second is that many languages can be used to create a single measurement, which represents a more reliable concept to measure pronunciation skills.

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Since we aimed at providing information about whether individuals who perceive languages to be more melodical than others also perform better in the pronunciation of unfamiliar languages (Q1), we used measurements based on a previous test design. We selected four samples in five different languages. Subjects were tested for how well they could retrieve the samples as well as how melodic the samples appeared to them. As it is plausible that the language material provides information about general phonetic and pronunciation ability (Christiner 2020), we analyzed the five languages separately and as a single measurement. Since we also wanted to investigate whether there is a relationship between musical measures and how melodic languages are subjectively perceived (Q2), we decided to include different tests of musical abilities: the AMMA test as a music perception task and singing as a music performance task. In addition, we hired professionals, amateurs, and non-musicians for this investigation to create further musical categories of different training status. We assumed that if melody has an impact on language capacities, individuals who perceive languages to be more melodic will also perform better in the language performance tasks and probably also in the music measurements. Finally, we also wanted to know whether the characteristic of how melodic languages appear to individuals is also a predictor for explaining the variance in the language performance beside previously found indicators, such as STM capacity, singing ability, the number of foreign languages, and musical aptitude (Q3).

Materials and Methods

Participants

For this investigation we recruited 86 participants. All of them voluntarily participated in the study, and informed consent was obtained from all subjects involved in the study. None of them reported to have any hearing or other impairments. In this study, 36 participants were male, and 50 participants were female.

Educational Status

The participants' educational status was entered according to the educational status that had been completed at the testing time. The results revealed that 42 participants completed secondary academic school (general qualification for university entrance), 15 had a bachelor's degree, 26 had a master's or a doctoral degree, and 3 did not indicate their educational status.

Musical Measurements

Musical Background

The participants reported their musical activity, the musical instruments played, and had to label themselves to be either non-musicians, amateurs, or professional

musicians. It was explained that being a non-musician meant that they are not capable of playing a musical instrument. In addition, they were also asked whether they no longer train or play musical instruments despite having trained for years. The latter were not included in this study. Being an amateur meant that they should be capable of playing one or more musical instruments, as well as that they play musical instruments occasionally, but not professionally. Being a professional musician included that the participants played regularly publicly as members of an orchestra at least for two years, or studied music for three semesters, or were music teachers. The results showed that, based on the definitions, 30 were classified as professional musicians, 21 as amateurs, and 35 as non-musicians. We also collected information about the number of instruments the amateurs and musicians played. The responses showed that 22 played one, 18 played two, 2 played three, 4 played four, 5 played five, and 1 played seven instruments. Musical Aptitude: Advanced Measures of Music Audiation

The AMMA test measures the participants' potential to discriminate paired musical statements that are either different or the same. Participants have to choose between three different conditions such as whether the paired musical statements are the same or include rhythmical or tonal change. The paired musical statements are embedded in one test design where either tonal, rhythmic, or no changes can occur. This test is usually targeted at university music and non-music majors and high school students and is an aptitude test. The test consists of 33 items. The first three are familiarization tasks and were excluded from the final analysis

Singing Ability

Singing ability was tested and measured in two different ways. One task was to sing the familiar song "Happy Birthday," since this is usually targeted at both professionals and non-professionals (Dalla Bella et al. 2007; Dalla Bella and Berkowskaa 2009; Christiner 2020; Christiner and Reiterer 2013, 2019; Christiner et al. 2018).

The second singing task was more complex. It consisted of two imitation tasks where parts of an unfamiliar song had to be learnt in a rather short period of time. Therefore, we used an adapted version of a singing task, which we had successfully used in previous research (Christiner 2020; Christiner and Reiterer 2013). The adaptation meant omitting the longest sequence. Based on previous findings we knew that participants managed to sing the short sequences of the two parts of the song no matter whether they were musicians or not (Christiner 2020). The aim of this task was to actively engage

the participants in a singing learning condition to measure their singing ability. This learning condition was split into two parts, which became increasingly difficult. The participants had to sing the original part of the song after they had listened to the original sound file three times (lyrics were provided). Singing with lyrics demonstrates the full vocal repertoire and makes it possible to address more rating criteria (Larrouy-Maestri et al. 2013). The lyrics and the notes of the short sequence of the song are provided in the supplement (Figure S1). The original part of the song was accompanied by musical instruments.

the participants had to sing the song for the recording without background music and only from memory as well as possible. The participants were further instructed to repeat the song in a key which they found comfortable, as key did not play a role in the final ratings.

The singing performances of the participants were rated and evaluated by singing experts (two male and two female raters) who received some compensation for their work. The procedure had successfully been used and tested in previous studies (Christiner and Reiterer 2013). The rating criteria for both songs were melodic and rhythmic ability.

Therefore, the raters were instructed to evaluate how well the participants were able to repeat the new melodies of the two imitation tasks and how well they sang the melody of the song “Happy Birthday.” For the rhythmic ratings, they were asked to evaluate how well the participants were able to maintain the original rhythms of the two imitation tasks and how accurate the rhythmic structure of “Happy Birthday” appeared to the experts. Therefore, the raters received a login and performed the ratings online. They had to evaluate all performances of all participants. Since it was not possible to do the ratings within a single sitting, the ratings consisted of two main sections and three subsections. The main sections were divided into the rhythmic and melodic ratings, and the subsections were comprised of the two imitation tasks and “Happy Birthday.” We did not mix rhythmic and melodic ratings since we wanted the raters to focus on only one element during the rating process before they went on to the next rating criterion. The first six performances in all rating sections were familiarisation tasks. Therefore, we took samples of participants who had scored high, average, and low in previous investigations. The performances of the participants in this investigation were presented in randomized order. The rating scales ranged from 0, “min,” to 10, “max.” Based on the ratings, two scores, one for melodic performance (melodic singing ability) and one for rhythmic performance (rhythmic singing ability), were determined. Both scores were compound measures of the ratings for the two

singing tasks, respectively. This approach was based on the findings of former research where we had assessed the nature of the same singing ratings we used in this investigation. There, factor analysis showed that familiar and unfamiliar song singing tasks belong to one factor. This was also shown to be consistent after a follow-up reliability analysis (Christiner 2020). Therefore, we also applied an interrater reliability by means of using Cronbach's alpha coefficients to assess the internal consistency of the performances of our raters. This was determined for melodic singing ability and rhythmic singing ability. For interrater reliability, Cronbach's alpha coefficients were determined as well for melodic singing ability as for rhythmic singing ability. For melody, the Cronbach's alpha coefficient was 0.95, and for rhythm it was 0.93. Thus, interrater reliability was very high in both cases.

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Conclusions

The results of this investigation show that how accurately new languages are pronounced depends on several cognitive skills. We found that the more languages individuals spoke, the more accurately they pronounced the unfamiliar languages. The same was true for STM capacity, which was also enhanced in individuals who possess elaborate pronunciation skills. In addition, our findings indicate that musical ability predicts individual differences in taking up new languages. Tonal aptitude and the ability to sing melodies predicted well individual differences in pronunciation skills. The findings of this study also add a new dimension to research on individual differences by showing that individuals who perceive languages as more melodic than others also retrieve and pronounce utterances more accurately. We speculated that musical abilities could be responsible for the extent of melodic language perception but found only little evidence. Except for a few correlations between musical aptitude and the melodic perception of languages, none of our other musical measures offered any link to how melodic the languages sounded to our participants. Future directions may include an acoustic analysis of why particular natural languages are perceived to be more melodic and tuneful than others. Since speech can also be turned into song by repetition of utterances, factors outside the acoustic domain and its relationship to the melodic perception should be investigated as well. In this respect, sociocultural and sociolinguistic approaches should also be included to reveal what shapes an individual's capacity to perceive languages in melodic terms.

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