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The effect of beam slope on the perception of melodic contour

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ABSTRACT

Musical score reading is a complex task, which involves attending and interpreting multiple visual constituents that are graphically congested. The present investigation examined the 'beam', which although consistently found in music notation, is typically considered as providing no more information than marking metric boundaries (i.e., chunking). However, we provide evidence here that beams enhance visual perception of contour. In Study 1, a Stroop-like paradigm was used in which participants were required to judge the direction of notes or the beam in a compound figure; the two dimensions were either congruent or incongruent. A congruency effect was observed in both tasks, confirming that both notes and beam are processed automatically during score reading. In Study 2, an additional auditory stimulus was presented. The results not only replicated the findings of Study 1, but showed that beams affect both visual and auditory perception. Finally, group differences surfaced: musicians were more affected by the direction of notes than non-musicians when attending to beams, but the effect of beams on judging note direction was comparable in both groups. The implications for understanding musical score reading – specifically issues related to melodic contour – are discussed.

1. Introduction

How difficult is it to read music notation? Music has been compared to a language – albeit non-verbal in nature – with standardized grammatical structures and syntax that allow all those who are literate to understand its meanings. Like most languages, music also has animated features to personalize self-expression. Music notation is a unique reading system employing spatial position of tones embedded into graphical representations. Almost forty years ago, Sloboda (1981/2005) concluded that music notation is the symbolic temporal structure of music. The current study considers the rapid perceptual coding processes of score readers. While the psychological effectiveness of music notation is the extent to which readers are able to retrieve information about music from the score, the compactness of the system often poses problems when more than one aspect of the same event has to be noticed causing an increase in the visual density of the information. It is often suggested (e.g., Agrillo & Piffer, 2012; Benassi-Werke, Queiroz, Araujo, Bueno, & Oliveira, 2012; Cohen, Evans, Horowitz, & Wolfe, 2011) that more efficient sight-readers are those who are particularly attuned to superordinate structures with consequential economy of coding, and that such processes occur by organizing material into higher-order interrelationships which represent certain regulations and limitations leading to cognitive expectancies. However, research demonstrating such assumptions is sporadic (with the majority of studies having been implemented by Sloboda between 1970 and 1990), and for the most part investigations comparing between musicians and non-musicians have not established high levels of ecological validity (simply because empirical tasks usually require knowledge of music and performance experience). Sloboda (1984/2005) stated that finding a way to measure music reading with absolute novices is problematic as the absence of knowledge about the names, functions, and symbols of music puts non-musicians at a disadvantage causing biases and subsequent falsification of findings. With this in mind, the current study examined the effects of an auxiliary graphic constituent found in music notation (i.e., beam) on the perception of melodic contour from a series of notes (i.e., the graphic representation of sound) and tones (i.e., the actual auditory sounds themselves). Most specifically, by manipulating *beam-slope* we examined whether the direction of the beam is processed automatically as part of score reading, and whether such processing differs between expert musicians and non-musicians. The use of beams allows for highly reliable comparisons between musicians versus non-musicians, particularly because while musicians are superior in judging pitch height (and the representation of such in musical notation), beams which connect between notes are no more than a commonplace line marking of direction and slope to which both musicians and non-musicians have an equivalent everyday knowledge and experience for decoding plane (such as ascending, descending, and maintaining a horizontal level).

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1.1. From neumes to Western musical notation

Predating the use of verbal language, behavioral repertoires involving toned utterances and expression through sound were learned by rote memorization as an oral tradition (Grout & Palisca, 1996). Early forms of notation were developed to prompt users of pitched intonation, and then later for melodic inflections. For example, signs were employed to accent the text; these developed into a set of topographical instructions known as punctuation. Such symbols, referred to as *neumes*, were used in Greek and Roman literature as well as in the Biblical *cantillation* of the ancient Hebrews. They not only served as an aid of interpretation (i.e., division of text into sentences, clauses, etc.) with which to increase reading clarity, but also instructed the reader as to when, where, and how to apply vocal inflections in order to heighten the emotional meanings of the scripture. In addition, signs were employed by cantors and monks as *cheironomic symbols* to phrase melodic shapes in a timely fashion; they made physical gestures employing hand movement patterns that developed into choir directing (i.e., conducting). Neumes were also inserted above written texts to indicate melodic movement; the relative direction and intervallic relation between notes eventually developed into music notation. About the 9th Century the practices of notating music began. Initially, space was not used to indicate duration, but rather shapes were employed; round, square, and diamond shaped note heads indicated duration of varying lengths. Over time several rhythmic conventions became the accepted practice as standard durations (multiples of each other) that setup rhythmic groupings separated by metric bar lines known as *meter*. Notation became more of a general custom about the late 12th Century with an increasing focus on polyphonic music, which rose to even greater heights in the 14th Century when the performance of notated synchronized parts became fashionable. Then, alongside the rise of instrumental music in the 16th Century, notation became more accurate with detailed specifications by composers written inside the score as guidelines to perform their works. Although some music notation systems such as Ancient Greek and Chinese remained *phonetic* (i.e., sounds represented by numbers, letters, or signs), Western music notation is *diastematic* or *intervallic* (i.e., sounds represented graphically). Readers are referred elsewhere for a musicological outline covering the development of Western music notation (see: Gorog, 2015; Strayer, 2013).

The *Orthochronic System* (OS) has been the major Western notational system for over 450 years. A central feature of OS is its abstractness, and while it does not denote a specific instrument, it does identify pitch and rhythmic relationships between notes and groups of notes. Sloboda (1981/2005) claimed this character may explain why the system has endured. OS has relevance to all musicians regardless of instrument, the historic period of music, or the music style of the repertoire performed. Nonetheless, such generality is exactly why it is necessary for each instrumentalist to have additional symbols indicating numbers for fingerings, or how to execute performance (i.e., finger stops, peddling, bowing, sticking, blowing, breathing, etc.). Moreover, a set of non-instrument-specific universal-symbols are employed for performance commands such as the nature of the attack, loudness, and phrasing. Certainly, when too many details clutter a score, readers are easily burdened. Hence, one of the strengths of OS concerns spatial constraints for simplicity of transparency. Most noticeably is the overarching employment of five horizontal lines on which note heads are placed to represent pitch height. Namely, the codification of pitch frequency is based on the spatial position of the tone on the musical stave, while a graphic set of note-head permutations designate the temporal flow of time placed within a structure that is metrically divided by bar lines.

OS is indeed a matchless system that not only integrates pitch dimensions such as frequency, duration, and volume, but also involves spatial-temporal organization as represented by single graphic symbols. Akiva-Kabiri and Henik (2012, 2014) acknowledged that the spatial positions of tones embedded in graphical representations provide a huge amount of information that is processed automatically. The first to delineate distinctions between language notation (i.e., text) versus music notation (i.e., score) was Sloboda (1981/2005) who outlined four characteristic differences: (1) whereas a text portrays a single sequence of events, a score must be able to specify different events occurring at the same time (i.e., parallel streams of information); (2) whereas text-readers are mainly concerned with understanding and remembering what they read, score-readers are essentially concerned with performing, and therefore score layout is much more important than textual arrangement or font design; (3) whereas text-readers are able to pace their own reading to accommodate the layout, score-readers cannot lose their place or experience ambiguity not even for a minute if they are to maintain the temporal flow of the performance, and hence spacing layout is far more significant for a score; and (4) whereas the position of one letter in relation to its neighboring letter is trivial in a word text, a score presents readers with complex spatial constraints at the microscopic level causing the reader to consider the positioning of each note in respect to its neighboring note.

1.2. Music reading: a task in pattern recognition

Music reading is essentially a task of recognizing familiar musical configurations as printed on the page (Waters & Underwood, 1999; Wolf, 1976). The notes readers see are essentially building blocks of larger units. Even before musicians have played a single note, they become aware of many familiar patterns, simply by searching for visual cues in the score. Musicians are so familiar with these configurations that they do not seek them consciously, but rather are processed automatically. In fact, musicians generally see a few cues and fill them with what seems appropriate to complete the pattern.

As a system, OS has to be as compact as possible, and the denseness of material poses a problem when more than one aspect of the same event has to be noticed. Therefore, a host of accepted structural conventions are employed by theoreticians, composers, performers, and publishers; these increase retrievals of information among the visual density of the score especially when distinctive visual features of the same symbol representation might indicate different aspects of the notated tones. In this connection, Sloboda (1981/2005) commented that "musicians accustomed to reading orthochronic notation at sight become very sensitive to slight changes in notational practices… Informationally and structurally [slight changes might have] absolutely no consequences at all, but [are] psychologically disruptive… the subjective impression is of something quite wrong about them" (pg. 67). Sloboda (1976a, 1976b) asserted that the perceptual difficulties of music notation regularly surface from complications in the vertical localization of individual notes whereby they may be inferred from the surrounding context. Accordingly, there is no absolute distinction between 'correct' and 'incorrect' subcomponents of music, but rather there is a continuum ranging from 'highly likely' to 'highly unlikely'; these parameters vary among players according to their degree of familiarity with the style. Although it is usually acknowledged that skilled sight-readers process notes automatically, through extensive observation Wolf (1976) concluded that in reality much guesswork is actually involved in score-reading. The first to elucidate on Wolf's finding was Sloboda (1978a/2005) who borrowed the concept of *proof-readers' error* from the literature on text reading; namely, the tendency for incorrectly spelled words to be overlooked especially when the misspelling is trivial. Sloboda claimed that music reading does not depend upon decoding of stimulus information to build up a mental representation, but rather readers use prior knowledge and expectancy to supplement and/or replace stimulus information. Hence, as musicians become more familiar and competent score-readers, they use previous knowledge to skim over the text and predict correctly what should be played. It would seem, then, that proficient score-reading is partially based on an ability to decide probable continuations within an idiom, indicating that musicians require both implicit and explicit knowledge of music theory