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Everyday Constraints on Learning: Children's and Adults' Development of the Major/Minor Distinction

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Abstract

Categorization of musical excerpts was accurately predicted by subjects' association of emotional valence with musical properties. The strength of this association prior to training predicted greater category knowledge, predicted types of errors during category learning, and predicted age differences in learning. Training in this association led to as much learning as feedback did.

Key words: cognitive development, learning, categorization, microgenetic study, and music cognition

Introduction

Category learning is often influenced by 'enabling constraints' (Gelman & Williams, 1998). Such constraints direct children's attention to relevant features of the learning task and thereby (1) speed up learning, (2) lead to predictable errors prior to learning, (3) condition transfer of learning, and (4) influence differential receptivity to the types of information that could lead to learning. Although constrained learning has been observed in several 'core' domains that are important to survival, constraints on learning may be more common than implied by the core/non-core dichotomy (e.g., Siegler & Crowley, 1994; Hannon & Trehub, 2005). Category learning in the domain of music cognition was investigated across two experiments. We hypothesized that children and adults are biased to attend to emotional valence when learning to label musical excerpts by mode and that this hypothesized bias would generate accurate predictions about the course of learning.

Emotional Valence and Learning

The major/minor distinction was examined for two reasons: (1) our pilot studies indicated that few musically-untrained participants knew the explicit major/minor distinction, thereby allowing examination of how the explicit distinction is learned and (2) because the major and minor modes are judged to have different emotional qualities (Hevner, 1935/1937), we expected that emotional qualities would have a high psychological relevance in learning the major/minor distinction. The psychological relevance of emotional valence is indicated by the fact that educators

often introduce the major/minor distinction in terms of emotional qualities and by the fact that participants with no musical training spontaneously describe major and minor musical excerpts in emotional terms (major = happy; minor = sad) (Hevner, 1935/1937).

Interestingly, the precise musical definitions of the major and minor modes refer only to the *formal* properties of these musical passages (Cayne, 1991). One reason that music theorists prefer to define modality by these formal qualities rather than by emotional ones is that the emotional qualities that characterize opposite modes also characterize opposite tempi (fast/slow) and pitch (high/low) properties. The effect of tempo on emotional quality is generally stronger and more reliable than the effect of modality (Gagnon & Peretz, 2003). Thus, if people rely on emotional valence in learning the distinction between musical modalities, tempo and pitch could provide conflicting as well as facilitative cues.

Although emotional qualities do not define the major/minor distinction as well as formal properties, attention to emotional qualities may nevertheless *enable* explicit category learning if (1) the learner is already predisposed to think of music in terms of emotional qualities, (2) the learner already roughly aligns mode with emotional valence, and (3) the learner has feedback allowing them to rule out non-modality based sources of emotional valence. Additionally, sensitivity to emotional qualities should *constrain* the learner by (1) limiting the student's ability to learn from definitions that do not refer to emotional valence, (2) leading to errors on problems that pit tempo- or pitch-produced emotional valence against mode-produced emotional valence, and (3) by conditioning the transfer of learning such that transfer is highly likely across problems differing in ways irrelevant to emotional valence, but not very likely across problems that do differ in emotional valence.

Hypothesized Development of the Distinction

A useful way to characterize different aspects of the learning process is suggested by previous work on cognitive change (Siegler, 1996) which distinguishes between the variability, source, path, rate, and breadth of change.

Variability An important source of variability in learning the major/minor distinction may come from individual differences in how much modality is associated with emotional qualities. Differences in the strength of this association have been observed within and across age groups (Hevner, 1935; Gagnon & Peretz, 2003; Dalla Bella, Peretz, Rosseau, & Gosselin, 2001; Kastner and Crowder, 1990; Gerardi & Gerken, 1995; Gregory, Worrall, & Sarge, 1996). We hypothesized that the strength of the association between mode and emotional qualities would facilitate participants' ability to accurately label excerpts prior to explicit training.

Source Because very few people without any musical training can accurately label major and minor excerpts, we assumed that learning the mode distinction required explicit instruction. The active ingredients of such instruction, given subjects' prior bias to attend to emotional qualities in music, would most likely include: (1) information associating mode and emotional valence, and (2) feedback on the correctness of categorizations.

Path If learning is constrained by emotional valence, participants would be expected to make particular errors prior to categorizing by mode. We expected participants' early attempts to label musical excerpts as major and minor would involve mapping these labels onto fast and slow tempi or high and low pitches (respectively).

Rate If attention to emotional valence enables participants to quickly employ the mode, tempo, and pitch approaches, subjects would need feedback on their categorization performance to abandon the tempo and pitch approaches in favor of the mode approach. If so, accurate labeling of excerpts would be accomplished most quickly by those subjects who receive feedback and who are told that major excerpts have a positive emotional quality and that minor excerpts have a negative emotional quality.

Breadth It was assumed that scales and melodies would not differ in their emotional qualities. If this assumption holds, then participants should transfer learning from scale excerpts to melody excerpts.

Experiment 1

The purpose of Experiment 1 was to test hypotheses about adults' ability to learn the major/minor distinction. Adults listened to musical excerpts that varied in tempo, pitch, and mode, and they were instructed to categorize the excerpts on the basis of mode. Two types of instruction were provided to participants in a factorial design: definitions that referenced either the formal structure or emotional quality of scales and corrective feedback.

Method

Participants Sixty-four adults (*mean age* = 20.25) participated in all phases of the experiment because their

pretest scores indicated they did not already possess the major/minor distinction.

Tasks and Materials Participants were given two tasks in the present study: an emotional valence task and a mode categorization task. The *emotional valence task* required that participants rate the emotional valence of 16 scales and melodies as warm and sunny (sun icon), cool and cloudy (cloud icon), or neutral (sun covered by cloud icon) with the help of an 11-point Likert scale. The *mode categorization task* required participants to explicitly label scales and melodies by mode (see Figure 1). Half of the excerpts in this study began on notes below middle C and were termed "low" and half began on notes above middle C and were termed "high." The musical excerpts were composed at two tempi in 4/4 time: fast (110 bpm) and slow (55 bpm). Experimental trial blocks consisted of 4 musical excerpts (i.e., 2 major/2 minor; 2 fast/2 slow; 2 high/2 low). The order of presentation was counterbalanced within each trial block. Excerpt-type (i.e., scale vs. melody) was held constant across a trial block.



Figure 1: Stimuli examples.

Design and Procedure

The present experiment was composed of an emotional valence rating phase, pretest phase, training phase, and posttest/generalization phase. The overall design of the current experiment was a 2 (mode: major/minor) x 2 (tempo: fast/slow) x 2 (pitch: high/low) x 2 (excerpt-type: scale/melody) x 2 (feedback: yes/no) x 2 (definition-type: Formal + Emotional Valence/Formal + Filler) mixed factorial design with feedback and definition-type as between-subjects variables.

Emotional Valence Rating Phase Participants rated the emotional valence of 16 musical excerpts with the help of an 11-point Likert emotional valence rating scale.

Pretest Phase Participants listened to eight major excerpts (4 scales/4 melodies) and eight minor excerpts (4 scales/4 melodies) and were asked to appropriately label the excerpts by mode without feedback from the researcher. If participants correctly categorized more than 75% of excerpts at pretest, they were excluded from the remainder of the experimental phases since it was assumed that they already knew the major/minor distinction.

Training Phase Participants listened to 32 musical scale excerpts and were subsequently asked to categorize these

excerpts on the basis of mode. Training differed by experimental condition. There were four experimental conditions in the training phase of the current study: (1) Feedback/Emotional Valence (F/EV), (2) No Feedback/Emotional Valence (NF/EV), (3) Feedback/Filler (F/Fill), and (4) No Feedback/Filler (NF/Fill).

All participants were given the formal, dictionary definitions for major/minor scales. Each participant was told “Half-steps appear in the major scale between the 3rd and 4th notes and the 7th and 8th notes. The distance between all other consecutive notes is 2 half-steps, and half-steps appear in the minor scale between the 2nd and 3rd notes, the 5th and 6th notes, and the 7th and 8th notes. The distance between all other consecutive notes is 2 half-steps. The exception is that there are 3 half-steps between the 6th and 7th notes.” Half of the participants were also given Emotional Valence definitions (“Major musical scales are happy and cheerful, and minor musical scales are sad and gloomy.”), whereas the other half was given Filler definitions (“Major musical scales are diatonic in structure, and minor musical scales are harmonic, melodic, or natural.”). Additionally, half of the participants were given feedback, whereas the other half was not given feedback.

Posttest/Generalization Phase Participants listened to 16 musical excerpts and were asked to label them by mode without feedback from the researcher. Those excerpts heard at posttest were equivalent to the excerpts heard at pretest to determine if training facilitated learning.

Results and Discussion

Variability We hypothesized that “experts,” participants who correctly categorized more than 75% of musical excerpts on pretest, would also most strongly associate emotional qualities with mode. We measured the strength of this association for each subject by taking the absolute value of the difference in emotional valence rating for the major and minor excerpts divided by the total span of the Likert scale (*EV Span for modality*). The EV Span for modality had a possible range of 0% to 100%. Expert adults had higher EV Spans than did non-expert adults (experts, $M = 42\%$, non-experts, $M = 20\%$), $F(1, 82) = 25.0, p < .001$. Adults who learned the major/minor distinction (i.e., correct categorization of at least 75% of scales after training) had higher EV Spans for modality than did those adults who did not learn the distinction (i.e., correct categorization of less than 75% of scales after training) (learners, $M = 28\%$, non-learners, $M = 18\%$), $F(1, 63) = 4.57, p < .05$.

Source We next examined whether adults’ categorizations of modality were affected by the particular experiences they received during the feedback phase. We performed a training group (F/EV, NF/EV, F/Fill, NF/Fill) X test phase (pretest and posttest) ANOVA on percent correct categorizations. The percentage of correct categorizations increased from pretest to posttest, $F(1, 127) = 13.68, p < .01$. Paired t-tests revealed pretest to posttest differences in the F/EV training group (53% to 72%) and in the F/Fill

training group (50% to 60%). There was a trend towards a main effect of feedback, (Feed, $M = .26$, No Feed, $M = .09$), $F(1, 63) = 3.83, p < .10$. There was also a main effect of definitions (Formal + EV, $M = .27$, Formal + Filler, $M = .08$), $F(1, 63) = 5.28, p < .05$.

Path Categorization accuracy was influenced by the perceived emotional qualities of the musical excerpts: fast excerpts were often labeled “major,” whereas slow excerpts were often labeled “minor.” Interestingly, this trend was *magnified* during the training and posttest phases, presumably because participants who were provided with definitions referencing emotional valence ignored feedback except where it fit their pre-conceived association between emotional valence and modality (Figure 2).

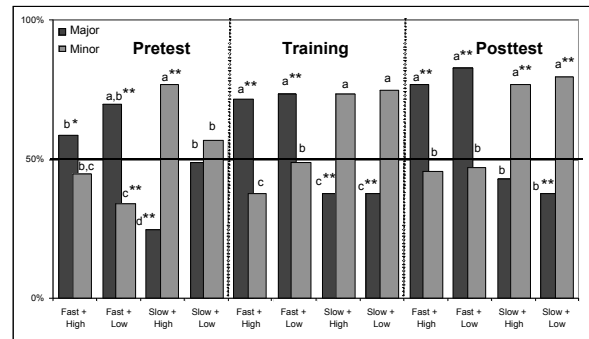


Figure 2. Adults’ correct categorizations by tempo, pitch, & mode; * $p < .05$, ** $p < .01$ (Chance = 50%); a > b > c > d.

To examine the various categorization approaches (“mode”: correct; “tempo”: major = fast/minor = slow; “pitch”: major = high/minor = low; “other”: all major, all minor, opposite) that participants used more directly, a backward-trials graphing procedure was used to illustrate the path of change during the training phase (Siegler, 1996). The 0 trial block refers to participants’ first correct categorization by mode; thus, by definition, performance on this trial block was 100% correct. The -1 trial block refers to performance on the trial block immediately before the 0 trial block; trial block +1 refers to performance on the trial block immediately after the 0 trial block.

As predicted, the most common error prior to first use of the mode approach was categorization based on tempo. On Trial Block -1, 48% of adults categorized on the basis of tempo at above chance levels (Chance: mode = 31%, tempo = 13%, pitch = 13%, other = 44%) (Figure 3).

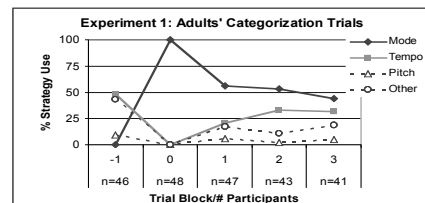


Figure 3. Adults’ errors prior to/following “mode” approach.

Rate To examine whether different types of training produced different rates of learning, we performed a training condition (F/EV, NF/EV, F/Fill, NF/Fill) X test phase (pretest, training trial blocks 1-8, posttest) ANOVA on percent correct categorizations. Although there was a main effect of condition and test phase, training group and test phase did not interact, indicating that rates of learning were comparable across training groups.

Breadth Although participants were trained only on scales, they generalized learning to novel melodies presented after the training phase. Participants were just as successful at categorizing scales as melodies across experimental phases, possibly due to the fact that the EV Spans for modality did not differ based on excerpt-type.

Experiment 2

The purpose of Experiment 2 was to test hypotheses about adults', ten-year-old children's, and five-year-old children's ability to learn the major/minor distinction. It was hypothesized that if children failed to associate the emotional valence of major/minor excerpts with mode, learning of the major/minor distinction would not be facilitated. Participants listened to musical excerpts that varied in pitch and mode, they were instructed to categorize the excerpts on the basis of mode, and tempo was varied across participants rather than within participants.

Method

Participants Sixty-four adults (*mean age* = 19.32), 64 10-year-olds (*mean age* = 10.25), and 48 5-year-olds (*mean age* = 5.7) participated in all phases of the experiment because their pretest scores indicated they did not already possess the major/minor distinction.

Tasks and Materials All tasks and materials used in the current experiment were the same as those used in Experiment 1 except where differences are indicated. Tempo was made a between-subjects variable. Experimental trial blocks consisted of 4 musical excerpts (i.e., 2 major/2 minor; 2 high/2 low).

Design and Procedure

The design and procedure used in the current experiment was the same as used in Experiment 1 except where differences are indicated. The overall design for the current experiment was a 2 (mode: major/minor) x 2 (tempo: fast/slow) x 2 (pitch: high/low) x 2 (excerpt-type: scale/melody) x 2 (feedback: yes/no) x 2 (definition-type: Emotional Valence/Filler) mixed factorial design with tempo, feedback, and definition-type as between-subjects variables.

Training Phase Participants were not provided with the formal, dictionary definitions for major/minor scales. Our pilot studies indicated that formal definitions did not facilitate categorization of musical excerpts by mode, and it was hypothesized that the formal definitions would confuse/distract the children participants.

Results and Discussion

Variability Prior to training adult "experts" most strongly associated emotional qualities with modality (experts, $M = 42\%$, non-experts, $M = 30\%$), $F(1, 92) = 7.61, p < .01$. There were too few ten-year-old and five-year-old experts to have the statistical power to generate meaningful tests of our hypothesis. Adults who learned the major/minor distinction showed a tendency to have higher EV Spans for modality than did those adults who did not learn the distinction (learners, $M = 34\%$, non-learners, $M = 24\%$), $F(1, 63) = 3.30, p < .10$. Ten-year-olds who learned the major/minor distinction had higher EV Spans for modality than did those ten-year-olds who did not learn the distinction, (learners, $M = 38\%$, non-learners, $M = 23\%$), $F(1, 63) = 7.70, p < .01$. There was a main effect of age on EV Span for modality, $F(2, 218) = 7.32, p < .001$. Post-hoc tests indicated that 5-year-olds associated emotional valence with modality less than adults, $t(144) = 3.88, p < .001$ and 10-year-olds, $t(124) = 2.24, p < .05$.

Source Similar to Experiment 1, we examined whether categorizations of modality were affected by the particular experiences subjects received during the feedback phase. For adults, the percentage of correct categorizations increased from pretest to posttest, $F(1, 127) = 20.52, p < .001$. Paired t-tests revealed pretest to posttest improvements in the F/EV training group (54% to 87%), in the NF/EV group (51% to 74%), and in the F/Fill training group (59% to 72%), p 's $< .01$. For 10-year-olds, there was a tendency for improvement in the F/EV group (56% to 69%), $p < .10$. There was a main effect of feedback for adults, (Feed, $M = .51$, No Feed, $M = .02$), $F(1, 63) = 12.76, p < .001$ and nearly a main effect for 10-year-olds (Feed, $M = .12$, No Feed, $M = -.21$), $F(1, 63) = 3.6, p < .10$. There was a main effect of definitions for adults (EV, $M = .56$, Fill, $M = -.03$), $F(1, 63) = 9.54, p < .001$, and 10-year-olds (EV, $M = .17$, Fill, $M = -.26$), $F(1, 63) = 5.78, p < .01$. There was nearly a significant interaction between feedback and definition type for adults (F/EV, $M = .67$, NF/EV, $M = .45$, F/Fill, $M = .35$, NF/Fill, $M = -.41$), $F(1, 63) = 3.96, p < .10$.

Path Errors for all age groups on pretest were not well predicted by emotional valence. However, adults' categorizations reached higher levels of accuracy during the training and posttest phases than in Experiment 1 (Figure 4).

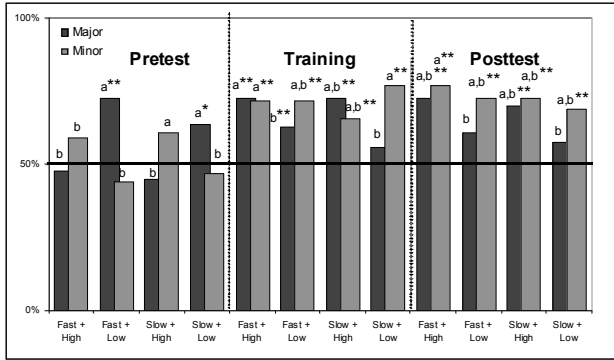


Figure 4. Adults' correct categorizations by tempo, pitch, & mode; * $p < .05$, ** $p < .01$ (Chance = 50%); $a > b$.

As predicted, the most common error prior to first use of the mode approach was categorization based on pitch (see Figures 5, 6, and 7). On Trial Block -1, 57% of adults, 47% of 10-year-olds, and 48% of 5-year-olds categorized on the basis of pitch at above chance levels (Chance: mode = 31%, pitch = 13%, other = 56%). Age differences were greatest not in initial approaches but in continued use of the correct approach that had been rewarded with positive feedback.

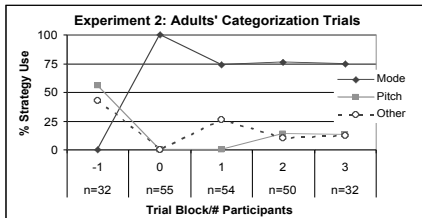


Figure 5. Adults' errors prior to/following "mode" approach.

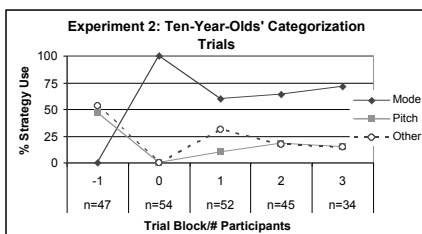


Figure 6. Ten-year-olds' errors prior to/following "mode" approach.

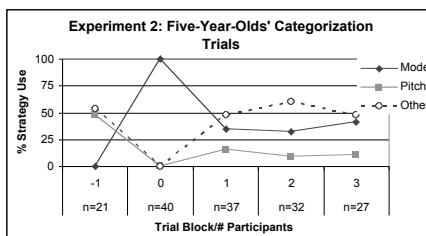


Figure 7. Five-year-olds' errors prior to/following "mode" approach.

Rate Similar to Experiment 1, we examined whether different types of training produced different rates of learning. There was a main effect of condition and test phase for both adults and 10-year-olds. There was a significant condition x test phase interaction for adults, $F(15, 383) = 3.62, p < .001$.

Breadth Although participants were trained only on scales, they generalized learning to novel melodies presented after the training phase. Participants in all three age groups were just as successful at categorizing scales as melodies across experimental phases, possibly due to the fact that the EV Spans for modality did not differ based on excerpt-type.

General Discussion

Similar to learning in 'core' domains, learning of the major/minor distinction was constrained by domain-relevant properties, specifically by the emotional qualities that characterize major versus minor musical excerpts.

Evidence for Enabling Constraints

Variability The general hypothesis that attention to the emotional valence of musical excerpts facilitates learning of the major/minor distinction led to predictions about the relation between prior knowledge and learning. We had specifically hypothesized that an important source of individual differences in knowledge of the major/minor distinction would be the extent to which subjects associated mode with emotional valence. Support for this hypothesis was found in both experiments with expert adults, where participants who could accurately label the modality of musical excerpts prior to training were most likely to rate major and minor passages as differing greatly in emotional qualities. Learners across the experiments also tended to or did have significantly higher EV Spans for modality than did non-learners indicating that those participants who most strongly associated modality with emotional qualities also tended to correctly categorize more excerpts by the mode approach after receiving feedback.

Source If attention to the emotional valence of musical excerpts facilitates learning of the major/minor distinction, two important sources of learning should be: (1) information associating modality and emotional valence and (2) corrective feedback. Adult and ten-year-old participants who received both feedback and emotional valence definitions during the training phase generally showed the most improvement from pretest to posttest. Feedback and definitions seemed to contribute to correct categorizations in an additive manner.

Path The hypothesis that attention to the emotional valence of musical excerpts facilitates learning of the major/minor distinction also generated accurate predictions about the types of errors that would precede learning. Specifically, it was predicted that initial attempts to label modality would involve mapping the terms 'major' and 'minor' onto

musical features that share the emotional valence of major and minor excerpts. During pretest and training (but prior to the first use of the mode approach) in Experiment 1, adults labeled fast excerpts as major and slow excerpts as minor. In Experiment 2, where tempo was varied between rather than within subjects, adults reported relatively small differences in emotional valence across excerpts differing in tempo, but reported the greatest differences in emotional valence for high versus low excerpts and major versus minor excerpts. Similarly, before first use of the mode approach, the most common approach used by 5-year-olds through adults was to label high excerpts as major and low excerpts as minor.

Rate The hypothesis that attention to emotional valence enables participants to quickly employ the mode, tempo, and pitch approaches also generated predictions about the conditions under which learning would be fastest. It was predicted that subjects would need feedback on their categorization performance to abandon the tempo and pitch approaches in favor of the mode approach. In Experiment 1, the difference between adults' pretest and posttest performance was greatest for the training condition where change was expected to be greatest (F/EV); however, the trial-to-trial differences during the training phase did not reliably differ across training conditions. In Experiment 2, adult performance was accurately predicted by our hypotheses: adults in the F/EV training group showed the greatest trial-to-trial gains.

Breadth Scales and melodies were experimentally equated such that differences in emotional valence were neither predicted nor found. It was anticipated that learning that occurred from training on scales would generalize to novel melodies. Results were strongly consistent with this hypothesis: across both experiments, participants were just as successful at categorizing melodies as they were at categorizing scales.

Origin of Constraints on Musical Category Learning

Presumably, few people would argue that music is an evolutionarily privileged domain: the domain of music offers little if any survival benefits to its listeners (Pinker, 1997). The constraints on music learning may be similar to constraints found in other non-privileged domains (e.g., tic-tac-toe and arithmetic strategies, Siegler & Crowley (1994)). In this view, the link associating the emotion of happiness with major musical excerpts and the emotion of sadness with minor musical excerpts is not innate and has not been subjected to natural selection. Two of the findings from our present experiments support this conclusion: (1) some (though not many) adults failed to report different emotional valences for major and minor excerpts and (2) the difference in the emotional ratings of major and minor excerpts increased greatly with age and experience. In addition, there are many possible sources for this association that may be found in the broader culture (e.g., movies in which the leitmotifs of villains are in the minor mode and those of

heroes are in the major mode). Thus, while the association between emotional valence and modality was found important for learning to label major and minor excerpts accurately and found to influence the course of learning, there are also reasonable grounds to suspect that the association is acquired from cultural learning.

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