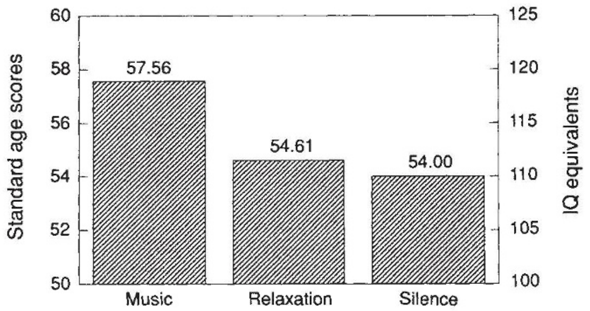
Music and spatial task performance

SIR — There are correlational[1], historical[2] and anecdotal[3] relationships between music cognition and other 'higher brain functions', but no causal relationship has been demonstrated between music cognition and cognitions pertaining to abstract operations such as mathematical or spatial reasoning. We performed an experiment in which students were each given three sets of standard IQ spatial reasoning tasks; each task was preceded by 10 minutes of (1) listening to Mozart's sonata for two pianos in D major, K488; (2) listening to a relaxation tape; or (3) silence. Performance was improved for those tasks immediately following the first condition compared to the second two.

Thirty-six college students participated in all three listening conditions. Immediately following each listening condition, the student's spatial reasoning skills were tested using the Stanford–Binet intelligence scale[4]. The mean standard age scores (SAS) for the three listening conditions are shown in the figure. The music condition yielded a mean SAS of 57.56; the mean SAS for the relaxation condition was 54.61 and the mean score for the silent condition was 54.00. To assess the impact of these scores, we 'translated' them to spatial IQ scores of 119, 111 and 110, respectively. Thus, the IQs of subjects participating in the music condition were 8–9 points above their IQ scores in the other two conditions. A one-factor (listening condition) repeated measures analysis of variance (ANOVA) performed on SAS revealed that subjects performed better on the abstract/spatial reasoning tests after listening to Mozart than after listening to either the relaxation tape or to nothing ($F_{2,35} = 7.08$; $P = 0.002$). The music condition differed significantly from both the relaxation and the silence conditions (Scheffe's $t = 3.41$, $P = 0.002$; $t = 3.67$, $P = 0.0008$, two-tailed, respectively). The relaxation and silence conditions did not differ ($t = 0.795$; $P = 0.432$, two-tailed). Pulse rates were taken before and after each listening condition. A two-factor (listening condition and time of pulse measure) repeated measures ANOVA revealed no interaction or main effects for pulse, thereby excluding arousal as an obvious cause. We found no order effects for either condition presentation or task, nor any experimenter effect.

The enhancing effect of the music condition is temporal, and does not extend beyond the 10–15-minute period during which subjects were engaged in each spatial task. Inclusion of a delay period (as a variable) between the music listening condition and the testing period would allow us quantitatively to determine the presence of a decay constant. It would also be interesting to vary the listening time to optimize the enhancing effect, and to examine whether other measures of general intelligence (verbal reasoning, quantitative reasoning and short-term memory) would be similarly facilitated. Because we used only one musical sample of one composer, various other compositions and musical styles should also be examined. We predict that music lacking complexity or which is repetitive may interfere with, rather than enhance, abstract reasoning. Also, as musicians may process music in a different way from non-musicians, it would be interesting to compare these two groups.



Standard age scores for each of the three listening conditions.

Testing procedure. In the music condition, the subject listened to 10 min of the Mozart piece. The relaxation condition required the subject to listen to 10 min of relaxation instructions designed to lower blood pressure. The silence condition required the subject to sit in silence for 10 min. One of three abstract reasoning tests taken from the Stanford–Binet intelligence scale[4] was given after each of the listening conditions. The abstract/spatial reasoning tasks consisted of a pattern analysis test, a multiple-choice matrices test and a multiple-choice paper-folding and cutting test. For our sample, these three tasks correlated at the 0.01 level of significance. We were thus able to treat them as equal measures of abstract reasoning ability.

Scoring. Raw scores were calculated by subtracting the number of items failed from the highest item number administered. These were then converted to SAS using the Stanford–Binet's SAS conversion table of normalized standard scores with a mean set at 50 and a standard deviation of 8. IQ equivalents were calculated by first multiplying each SAS by 3 (the number of subtests required by the Stanford–Binet for calculating IQs). We then used their area score conversion table, designed to have a mean of 100 and a standard deviation of 16, to obtain SAS IQ equivalents.

Frances H. Rauscher
Gordon L. Shaw*
Katherine N. Ky
Center for the Neurobiology of Learning and Memory, University of California, Irvine, California 92717, USA

* Also at Department of Physics.

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MyoD and c-*fos* expression

SIR — Trouche *et al.*[1] have reported that the down regulation of c-*fos* expression during muscle cell differentiation may result from the binding of the helix-loop-helix (HLH) proteins to a CANNTG motif, or E-box, that occurs within the c-*fos* serum response element (SRE), thereby excluding the binding of the serum response factor (SRF) to this element. We investigated the interaction of HLH proteins with the c-*fos* SRE when molecular clones for E12 were first isolated by screening a phage expression library with the SRE probe[2]. We estimated that the dissociation constant for the myogenin/E12–SRE complex was 10^{-8}–10^{-9} M^{-1} by comparing the relative effectiveness of E-box elements from different genes to compete for binding in the electrophoretic mobility-shift assays. The relatively low affinity of myogenin/E12 for the SRE could result from differences in nucleotide identities at the internal dinucleotide and flanking sequences between the c-*fos* E-box and the consensus HLH binding site[3,4]. By contrast, the dissociation constants for the SRE–SRF or the SRE–SRF/$p62^{TCF}$ complexes have been reported to be 5×10^{-10} and $\leq 10^{-11}$ M^{-1}, respectively[5]. Collectively, these data indicate that it is unlikely that HLH proteins alone can significantly compete with SRF for binding to DNA *in vivo*.

It has been reported in other studies that the c-*fos* SRE is either equally active in muscle and non-muscle cells[6], or that it activates muscle-specific expression[7] when situated upstream from a minimal promoter. Further, a comparison of the