How Tempo and Use of Lyrics in Music Affects the Performance of 4-Year-Old Children on Cognitive and Motor Tasks

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Abstract

We were interested in whether the use of tempo and lyrics in music affects the performance of a 4-year-old child's ability to perform cognitive and motor tasks? This idea was derived from a lack of research on variables in music, such as tempo and lyrics, affecting children's performance on various tasks. There was also a lack of research in music affecting motor tasks, which led us to look for a difference in motor and cognitive task completion based on music influence. We conducted two 2 (lyrics/no lyrics) x 2 (tempo [fast or slow music]) x 4 (condition order) mixed design ANOVAs, one for cognitive tasks and one for motor tasks. Each child completed the hundred peg board game as the motor task and a twelve piece wooden jigsaw puzzle for the cognitive task within an allowed time of three minutes for each task. Children were randomly assigned to lyrics or no lyrics as a between-subjects variable, and tempo and condition order were randomly assigned as a within-subjects variable. We found that no lyrics performed significantly better for children in the motor and cognitive tasks. Tempo was also marginally significant for motor tasks and there was an interaction between tempo and condition order for the cognitive task. We believe the children performed better in the no lyrics condition because it reduced demands on working memory and they were better able to perform the tasks. We also believe the tempo influenced motor tasks because they were placing the pegs in the board to the beat of the music. Overall, we believe that if a four-year-old child is to listen to music while working, music with no lyrics and at a faster tempo will allow them to perform better on cognitive and motor tasks.

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In our experiment we tried to show how the use of lyrics or no lyrics and the tempo of the music affect a 4-year-old child's ability to perform cognitive and motor tasks. This was done through a cognitive task of completing a wooden jigsaw puzzle and motor task of placing pegs into a board with a hundred holes, all in the allowed time of three minutes for each individual task. We proposed this idea after noticing that there was a large volume of research in music's effects on cognitive tasks in adolescents, young adults, and adults, but less applied to very young children. There was also a fair amount more research geared toward cognitive ability and less for motor ability through the influence of music and we were interested in looking for a difference between the two tasks.

In addressing our first main research question of how music affects cognitive performance, we started by looking at music affecting adult's cognitive performance. Furnham and Bradley (1997) looked at how introverts and extroverts performed on cognitive tasks while listening to music. Furnham and Bradley (1997) believed that there was an optimal level of arousal for cognitive function and that music could be used to have a positive effect on it by stimulating the brain up to that arousal level. The researchers tested an undergraduate's cognitive ability through using memory recall and reading comprehension tests. Furnham and Bradley (1997) hypothesized that extroverts and introverts would perform differently because they have different optimal arousal levels. The study found that extroverts performed slightly better than introverts, because they needed more music to stimulate their optimal arousal level. In fact, the introverts found the background music distracting because they needed fewer stimuli to achieve optimal arousal level, in turn making the music more of a distraction to them than helpful.

In a similar study by Söderlund, Sikström, and Smart (2007), they found that background noise was beneficial to children on cognitive tasks. Söderlund et al. (2007) argued that white noise was beneficial for ADHD students around ages 9.4-13.7 years old, while harmful to other students without ADHD on certain cognitive tasks. The white noise attenuated performance for the control participants and had a positive impact and improved memory performance for the ADHD participants. The reason for this is that the researchers believed that the results came from the idea of dopamine levels regulating how much white noise was beneficial for optimal cognitive performance. The participants with ADHD had lower levels of dopamine, thus requiring more white noise to achieve optimal levels of arousal then the normal participants without ADHD. Through Söderlund et al. (2007) addressing the phenomenon of stochastic resonance (SR), they showed there was a certain optimal amount of noise that may be helpful for cognitive performance given certain circumstances and whether a participant was ADHD or not.

Furthermore, Schellenberg, Nakata, Hunter, and Tamoto (2007) addressed children's cognitive ability performance based on the influence of music closer to our age range of four-year-olds, by looking at that of five-year-olds. Schellenberg et al. (2007) looked at a Japanese five-year-old's drawing time depending on whether they listened to and sang familiar children's songs or listened to Mozart or Albinoni. The researchers judged how well the children drew by their creativity, energy, and technical proficiency. They found that the children performed better when they listened to familiar songs than Mozart or Albinoni.

However, in addressing our other main research question of motor ability performance based on musical influence, in a study by Joëlle Provasi and Anne Bobin-Bègue (2003), the researchers looked at children two-and-half-years-old to four-years-old ability and their to tap to different spontaneous motor tempos and rhythmical synchronizations. The researchers wanted to see if children could tap to beats of music, anticipate rhythms, and speed up and slow down their tapping by using a screen the child tapped on, recorded their tapping responses, and produced the auditory musical beats. What the researchers found is that by four-years-old, children were very good at anticipating and tapping to sounds, as well as adjusting their motor tapping responses to the time intervals of the beats. The researchers also believed their data showed that as the children became older, they were able to respond to a larger range of beats. That is, they have the motor abilities to tap to a wider range of slower and faster music better than younger children of their age. In relating to the motor task of our experiment, we predicted that the children would perform better on the faster music tempo because they would be placing the pegs in the hundred peg board game to the beat of the music, similar to a child's ability to tap to and anticipate beats.

Looking back to the other cognitive ability studies, we predicted that the faster tempo music will raise arousal levels like the Söderlund et al. (2007) and Furnham and Bradely (1997) studies. However, the one question that remained unaddressed in these studies was how lyrics and tempo affected performance on cognitive and motor tasks? We understand that music at different tempos and noise creates arousal and different levels of arousal, but what happens when lyrics are introduced into the equation? We predicted that this will add one more level of stimulus and become distracting to the children, in turn leading to poorer performance on cognitive as well as motor tasks. Overall, we predicted that no lyrics and fast tempo music will help the child perform best on the motor and cognitive tasks.

Method

Participants

We tested twenty-one 4-year-olds (*M* = 4 years, 4 months) at the The Children's School at Carnegie Mellon University. We tested twelve males and nine females. There were no children excluded from testing. The children were randomly split in half with eleven children in the lyrics condition and the other eleven in the no lyrics condition, which was our between-subjects variable. The children were also randomly assigned to one of four tempo order conditions (fast music tempo first [motor then cognitive task], fast music tempo first [cognitive then motor task], slow music tempo first [motor then cognitive task], and slow music tempo first [cognitive then motor task]) with roughly four to five children per group all receiving the within-subjects variables of tempo (fast/slow) and doing a motor and cognitive task.

Materials

For our materials we used two different games to account for the motor and cognitive task while playing different songs during the games. During the motor task, the participants were faced with a hundred peg board game challenge. The goal was to place as many plastic pegs in the board's holes, the board had a hundred holes, as fast as the child could within the allowed time of three minutes. For the cognitive task the child had a twelve-piece wooden jigsaw puzzle to complete in the allowed time of three minutes. We played either fast music, "Bananaphone" by Creber, Raffi, or a slow song, "Hello Hello" by Dan Zane. The children either received listening to both of these songs with the lyrics in them or the lyrics removed.

Design

We conducted two 2 (lyrics/no lyrics) x 2 (tempo [fast/slow]) mixed design ANOVAs, one for cognitive task and one for motor task. The children were shown first how to place the pegs in the hundred peg board for the motor task or how the puzzle pieces could go together to make a picture for the cognitive task. We then played music at the different tempos of fast or slow after telling the child to start the motor or cognitive task. The child was allowed three minutes to complete each task. All the children were randomly assigned to listen to lyrics or no lyrics music as a between-subject variable and at fast and slow tempo music as a within-subjects variable. The order of performing the motor or cognitive tasks and listening to fast or slow music was also randomly assigned for the children.

Procedure

Practice trial. The children were shown how to place the pieces into the hundred peg board for the motor task. The experimenter demonstrated to the child by placing two or three pieces into the board. The child did not get a chance at practicing or doing this until they began their motor task. For the cognitive task, the experimenter showed how two pieces went together in the twelve piece jigsaw puzzle. They also showed how putting the pieces together started to make a picture and showed the final picture of the puzzle to the child. The child did not start putting the pieces together until it was their turn to start the cognitive task.

Motor task. For the motor task the child was faced with a board with a hundred holes in it that small plastic pegs could be placed into it. After being told how the game worked, they were allowed three minutes to place in as many pieces as possible. We made sure to have pegs of all the same color (we used green) so that the child would focus solely on the motor aspect of the task and not get distracted mixing colors and trying to make pictures. Depending on the condition, the child listened to music with lyrics or no lyrics and at a fast or slow tempo. At the end of the three minutes, we recorded the number of pegs placed in the board. We converted that to a rate of number of pegs per minute placed as a form of measurement and to analyze later.

Cognitive task. For the cognitive task the child tried to complete a twelve piece wooden jigsaw puzzle. They were allowed three minutes to complete as much of the puzzle as possible. The puzzle consisted of making a picture of some familiar animals to four-year-olds, such as a dog, cat, fish, bird, and turtle. Depending on the condition, the child listened to music with lyrics or no lyrics and at a fast or slow tempo. When the three minutes were up, we counted the number of pieces the child had correctly put together. We converted that to a rate of number of puzzle pieces per minute placed together correctly as a form of measurement and to analyze later.

Results

Our research question was to determine whether lyrics/no lyrics and music tempo (fast/slow) affect the time it takes 4-year-olds to complete cognitive and motor tasks? We originally set out to conduct two 2 (lyrics/no lyrics) x 2 (tempo [fast/slow]) mixed design ANOVAs, one for the cognitive task and one for the motor task. Our independent variables were lyrics/no lyrics and tempo. Our between-subjects variable was lyrics/no lyrics with two levels (lyrics or no lyrics) and our within-subjects variable was tempo of the music with two levels (fast or slow music). For our dependent variable of interest, we looked at the rate of completion for the cognitive and motor task. After assessing peripheral variables of gender (two levels and between-subjects [male or female]) and order of the task or condition (four levels and between-subjects [fast music tempo first {motor then cognitive task}, fast music tempo first {cognitive then motor task}, slow music tempo first {motor then cognitive task}, and slow music tempo first {cognitive then motor task}), we found it necessary to include condition since it produced significant results. For our final statistical analyses we conducted two 2 (lyrics/no lyrics) x 2 (tempo [fast/slow]) x 4 (condition) mixed design ANOVAs, one for the cognitive task and one for the motor task.

For the cognitive task, we found main effects for lyrics/no lyrics, F (1,13) = 3.40 and p = 0.09. This between-subjects variable was marginally significant at a significance level of α = 0.05 and marginally significant α = 0.05 to 0.10. Overall no lyrics performed better than lyrics (M = 0.52, SD = 0.51). This gives us statistical evidence to suggest that listening to music without lyrics helps children perform better on cognitive tasks than listening to music with lyrics (See figure 1). Tempo F (1, 13) = 0.02, p = 0.91 a within-subjects-variable and condition F (3, 13) = 0.89, p = 0.47 a between-subjects variable were non-significant main effects.

For the cognitive task we did find an interaction between condition and lyrics/no lyrics F (3, 13) = 4.16, p = 0.03 for the between-subjects variable. However, there were too few subjects in each group to do follow-up analyses of the nature of the interaction. There was an interaction for tempo and condition F (3, 13) = 4.35, p = 0.03 for the within-subjects variables (See figure 2). This meant that the effect of tempo depended on the order of the task. To find the nature of the significant interaction we conducted paired t-tests between tempo and condition. When fast tempo is compared to all four conditions, t(20) = 2.34, p = 0.03, we find a significant effect, but not slow music compared to all four conditions, t(20) = 1.45, p = 0.16. If the paired t-tests are broken up to compare both tempos to each of the four conditions, we find a marginally significant result for fast music tempo first (motor then cognitive task) t(4) = 2.15, p = 0.10, but not the other three conditions, fast music tempo first (cognitive then motor task) t(4) = 1.86, p = 0.14, slow music tempo first (motor then cognitive task) t(4) = -0.095, p = 0.92, and slow music tempo first (cognitive then motor task) t(5) = -0.28, p = 0.79. This gives us statistical evidence to suggest that when completing a cognitive task, fast music is marginally significant in helping improve performance for the children. We also have statistical evidence to suggest that doing a fast music motor task and then a cognitive task with fast music will yield better results on the cognitive task. For a list of all the cognitive task means and standard deviations see table 1.

For the motor task, we had main effects for tempo F (1, 13) = 5.35, p = 0.04, lyrics/ no lyrics F (1, 13) = 4.17, p = 0.06, and condition F (3, 13) = 3.78, p = 0.04. At a significance level of α = 0.05 and marginally significant α = 0.05 to 0.10, we had significant main effects for tempo and condition and a marginally significant main effect for lyrics/no lyrics. To find the direction of the main effects we conducted a post-hoc Tukey test. We found that lyrics does better than no lyrics (M = 0.52, SD = 0.51) and fast tempo does better than slow tempo (M = 12.88, SD = 2.70) (See figure 3). We also found that fast music tempo first (motor then cognitive) did better than fast music tempo first (cognitive then motor) p = 0.03, M = 3.87, SD = 1.18 and slow music tempo first (cognitive then motor) did better than fast music tempo first (cognitive then motor) p = 0.04, M = 3.49, SD = 1.13. There were also no significant interactions for the motor task group. For a list of all the motor task means and standard deviations see table 2.

Discussion

The goal of our study was to see if lyrics/no lyrics and music tempo (fast/slow) affect the time it takes 4-year-olds to complete cognitive and motor tasks? In looking at the results overall we see that performance on a motor task is marginally improved listening to music without lyrics versus lyrics. This makes sense in the minds of children that in having fewer demands on the working memory by not listening to the lyrics, they are better able to do the motor task. We also found significant improvements on a motor task if they listened to fast music. This makes sense in that the faster the music is, the faster one wants to keep up with the beat and place the pieces in the board to the tempo of the music. If we want a four-year-old child to do the best on a motor task, they need to listen to music with no lyrics to lower demand on working memory and use fast music, so they place the pieces close to the beat of the music. However, further research should be done to see if there is a threshold where the music becomes too fast and distracting and no longer becomes beneficial.

In looking at the results of the cognitive task, we see that once again not having lyrics marginally improves performance. This makes sense in a cognitive task in that working memory is reduced by not having to pay attention to the lyrics and focuses more on the demands of the cognitive task. It was also interesting to note that performance on the cognitive task varied by the order of doing a motor or cognitive task first and the speed of the music before and after. We found that if someone starts off doing the cognitive then motor task at a slow tempo and switches to fast tempo later, they perform better. This can make sense in that as one speeds up the music as they work, they start to work faster and get better. But as a limitation of our study, we do not know if there was a learning curve in the cognitive task. The child completed the same puzzle twice and may have remembered where some of the pieces go. This study could be redone with two similar but different puzzles to see if one obtains the same results. Also further research should be done to see if there is a certain speed increase in tempo of music and threshold to how fast the music can go before it becomes distracting. It was interesting to note that the children performed better starting off with a fast tempo music motor task and then doing a fast tempo cognitive task. Maybe the fast tempo music and motor task get the child’s brain stimulated and working so they are ready to perform better on a cognitive task by the time they are faced with it. The motor task before the cognitive task could act as a warm-up to get the brain processes working, but further research would need to be done to see if this is true.

Relating back to our initial research, Furnham and Bradley (1997) showed that there was an optimal level of arousal from music that helped improve cognitive performance. Söderlund et al. (2007) showed this as well by showing arousal levels vary in normal children and children with ADHD for cognitive tasks by different levels of white noise exposures in the background. We saw in our study that switching music tempos affected cognitive ability, showing that there is some arousal level affected by music tempo in the background. While we saw faster music was better than slower music for cognitive tasks, we did not look for an optimal music tempo. Further research could be done assessing the beats per minute and the performance of a child on a cognitive task, and then maybe we could find the optimal beats per minute to do cognitive tasks. All we know based on Provasi and Bobin-Bègue (2003) study was that children adjust their task, such as tapping, to the beats of music in motor tasks. This was evident in our motor task by placing pegs faster. It seemed as if this was true for the cognitive task, but further research should be done to confirm this link of a motor task observation to cognitive tasks. It would also be important to test this study with different kinds of music. We tested pop children's music and it would be interesting to see what happens when different genres are used such as classical, blues, or rock. Lastly, it would be interesting to see if switching languages of the music has the same impact on cognitive performance. Further research could show whether listening to music in another language might act like listening to music with no lyrics in our study and improving cognitive performance or acts as a distracter and increases demands on working memory, reducing performance.

In conclusion, it is important to know how well our results generalize to other populations and the external validity of our experiment. Overall our participants come from a very specific group of children from The Children's School. Our results generalize well to four-year-olds at The Children's School and children of similar backgrounds, but how much further can we generalize our results? We believe the motor task results could be fairly generalized to all four-year-olds who would recognize the kind of music we played. This would mostly be children that understand English fairly well as one of their main languages. This belief is based on that mostly all children develop roughly the same in motor abilities regardless of their socioeconomic status. Every child has equal access to various objects to work on motor skills, so all four-year-olds should be roughly on the same playing field. As for the cognitive task, we believe this can be generalized to a smaller population. The reason for this thinking is that education and socioeconomic status affects how well and far a child's brain develops and advances by this stage in life. Our cognitive task results should generalize to four-year-olds of roughly the same education level and socioeconomic status of the children at The Children's School. We would also hope that our results can generalize to other age groups, but that leap may be too far to make. Although some of our initial research comes from adult populations, our music and tasks were very age specific, probably indicating that our results only relate to four-year-olds. Other studies at different ages and music used could be done to verify that these findings relate to different age groups.

The last question with external validity and our study is how specific our design relates to our findings? This would be if various experimental designs of our experiment were conducted, would we get similar or different results? As stated earlier, the type of task used may affect results, such as type of and number of pieces used in the puzzle for the cognitive tasks. We believe the motor task is fairly standard and variations of it used might produce similar results. The reason for the puzzle being specific to our results is its difficulty and learning curve, since every puzzle is different in difficulty and nature. Many experiments with various puzzles could be conducted to see if similar results are found to our experiment. In the end, we believe our experiment had a mixture of results that generalized to larger populations and results that were more specific to our experiment design.

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Table 1

Means and standard deviations of results from the cognitive task.

	Cognitive Task		
Condition	Lyrics/No Lyrics	*M*	*SD*
Fast Music Cognitive Task			
Fast Music Tempo First (Motor Then	No Lyrics	5.31	1.11
Cognitive Task)	Lyrics	2.00	0.67
Fast Music Tempo First (Cognitive	No Lyrics	5.47	1.34
Then Motor Task)	Lyrics	2.42	2.19
Slow Music Tempo First (Motor	No Lyrics	4.36	3.84
Then Cognitive Task)	Lyrics	2.89	2.20
Slow Music Tempo First (Cognitive	No Lyrics	2.76	1.68
Then Motor Task)	Lyrics	5.77	1.41
Slow Music Cognitive Task			
Fast Music Tempo First (Motor Then	No Lyrics	9.52	4.98
Cognitive Task)	Lyrics	2.11	0.51
Fast Music Tempo First (Cognitive	No Lyrics	5.91	1.07
Then Motor Task)	Lyrics	3.53	3.62
Slow Music Tempo First (Motor	No Lyrics	2.63	1.80
Then Cognitive Task)	Lyrics	1.17	0.71
Slow Music Tempo First (Cognitive	No Lyrics	1.78	1.07
Then Motor Task)	Lyrics	4.73	1.87

Table 2

Means and standard deviations of results from the motor task.

	Motor Task		
Condition	Lyrics/No Lyrics	*M*	*SD*
Fast Music Motor Task			
Fast Music Tempo First (Motor Then	No Lyrics	15.33	2.36
Cognitive Task)	Lyrics	13.33	1.20
Fast Music Tempo First (Cognitive	No Lyrics	15.00	1.41
Then Motor Task)	Lyrics	9.00	2.03
Slow Music Tempo First (Motor	No Lyrics	12.22	2.04
Then Cognitive Task)	Lyrics	14.00	2.83
Slow Music Tempo First (Cognitive	No Lyrics	14.78	0.96
Then Motor Task)	Lyrics	14.44	0.51
Slow Music Motor Task			
Fast Music Tempo First (Motor Then	No Lyrics	16.00	2.83
Cognitive Task)	Lyrics	13.78	2.12
Fast Music Tempo First (Cognitive	No Lyrics	11.83	0.24
Then Motor Task)	Lyrics	8.22	3.72
Slow Music Tempo First (Motor	No Lyrics	12.11	1.39
Then Cognitive Task)	Lyrics	11.17	4.48
Slow Music Tempo First (Cognitive	No Lyrics	13.56	2.14
Then Motor Task)	Lyrics	13.33	0.58

Figure 1. Mean rate of puzzle pieces per minute in the conditions lyrics/no lyrics and fast/slow tempo music for the cognitive task.

Cognitive Task Performance

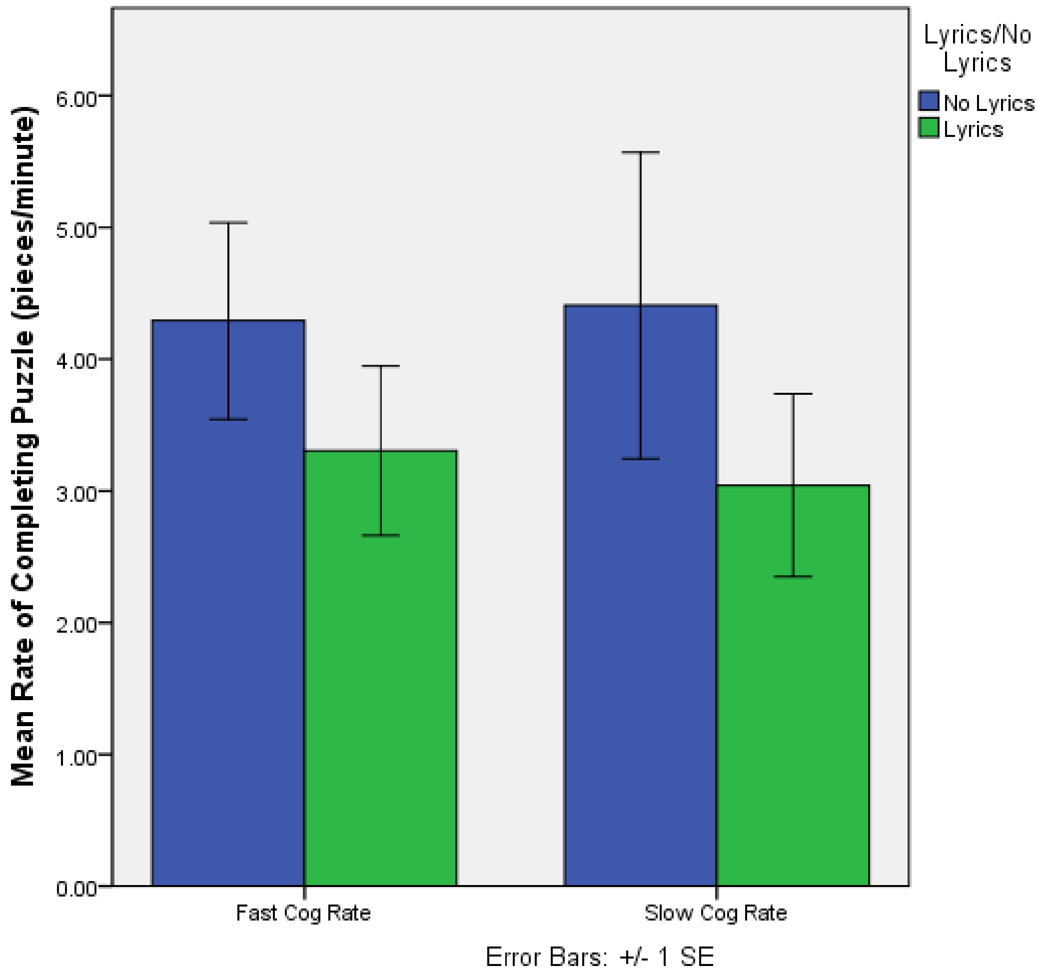

Figure 2. Mean rate of puzzle pieces per minute in the interaction of task order and music tempo for the cognitive task.

Task Order: Cognitive Task

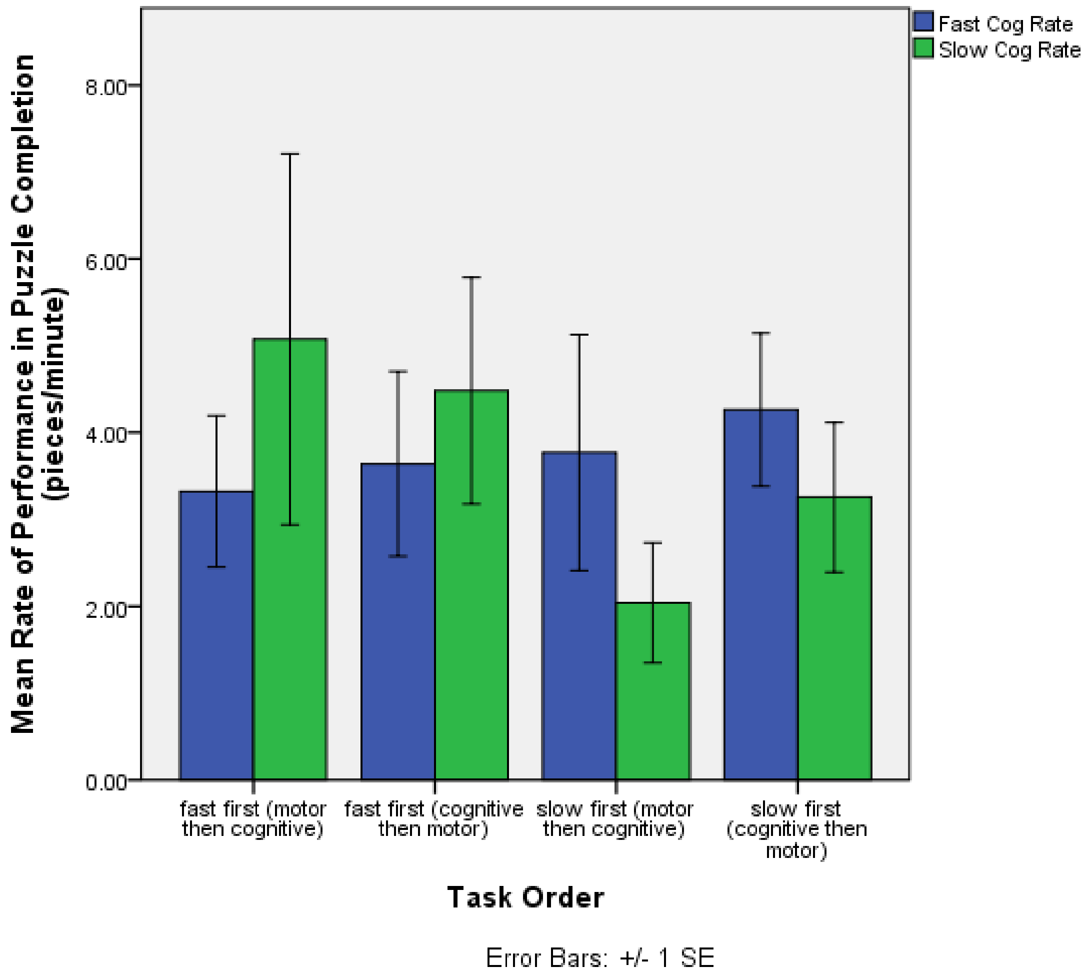

Figure 3. Mean rate of pegs per minute in the conditions lyrics/no lyrics and fast/slow tempo music for the motor task.

Motor Task Performance