

Article

Emotional Congruence in Childhood: The Influence of Music and Color on Cognitive Processing

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Abstract

Emotions are known to influence cognitive processes, yet the nature of this influence remains debated, particularly during childhood. According to the emotional congruence model, information congruent with an individual's affective state is processed more efficiently than incongruent information. While this effect has been widely studied in adults, evidence in children is still limited. The present research investigates the influence of emotional congruence on selective attention in typically developing children from preschool to fifth grade, using a dual emotional induction paradigm based on music and color. In Study 1, classical music excerpts were used to induce pleasant or unpleasant emotional states and to validate the effectiveness of musical induction across age groups. In Study 2, this musical induction was combined with emotionally valenced color cues (yellow vs. gray) embedded in a visual search task to examine their impact on attentional performance. Results from Study 1 confirmed that music effectively modulated children's emotional valence, although this effect was weaker in younger participants. In Study 2, attentional performance improved significantly when the task was presented on a yellow background, regardless of the valence of the previously induced musical emotion. No robust emotional congruence effect between music and color was observed, although performance was highest in the joyful music–yellow color condition. Overall, these findings suggest that perceptual emotional cues embedded in the task context, particularly positive color cues, exert a stronger and more persistent influence on children's selective attention than transient affective states induced by music. This study contributes to developmental models of emotion–cognition interaction by highlighting asymmetrical valence effects and the predominant role of perceptual emotional signals in childhood attention.

Keywords: selective attention; dual emotional induction; emotional congruence; child development



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1. Introduction

Selective attention is a cognitive process that filters out irrelevant information while preferentially processing information that may be important for achieving an individual's goals (Macdonald et al., 2014). As such, it is directly involved in many complex cognitive processes such as memory and problem-solving (e.g., Rader & Hughes, 2005; Syssau & Monnier, 2012). While this process is partly activated by a conscious system known as attentional control, it also has an unconscious and automatic component (Öhman et al., 2001). Indeed, regardless of an individual's will, the nature of a stimulus competing with others at a given moment determines its ability to capture perceptual resources. This

competition mechanism helps direct attention to improve information selection. Some elements, such as emotions, can redirect attention without the individual's awareness (Smith & Kosslyn, 2009). From a theoretical standpoint, this redirection may be influenced not only by the intrinsic properties of the stimulus but also by its relationship with the observer's internal state (Bower, 1981).

A bias towards emotional stimuli has been demonstrated (Pool et al., 2016). This preferential processing enables rapid activation of processes in the event of threats, favoring a protective response (Vuilleumier & Huang, 2009). In this perspective, emotions play a key adaptive role (Damasio, 2003). However, beyond dangerous situations, many studies highlight a detrimental effect of emotions on attention (Sander et al., 2005; Yiend, 2010). For example, the "emotional Stroop" method reveals more or less longer response times for emotional words depending on the valence and the arousal, suggesting interference with attentional control (Lake et al., 2016; Martynova & Lyusin, 2025). In contrast, models of emotional memory and cognition, such as the associative network model (Bower, 1981), suggest that this interference is not systematic but depends on the match between the stimulus valence and the current mood. Automatic emotion processing may therefore reduce the cognitive resources allocated to tasks, an effect exacerbated when the task is difficult (Ellis & Moore, 1999). Moreover, emotions influence the three stages of spatial attention orientation—disengagement, shifting, and engagement—making it harder to disengage after an initial focus (MacNamara, 2025; Posner et al., 1984; Yiend, 2010). Finally, emotions alter not only attention but also the way information is processed. Negative emotions, such as sadness, enhance attention to details and reduce global processing (Fiedler & Bless, 2001). Conversely, positive emotions can simplify cognitive processing (Chaiken, 1980; Gotoh, 2012), reduce analytical capacities (Oaksford et al., 1996; Storbeck, 2013), and decrease motivation (Bodenhausen et al., 1994; Wegener et al., 1995).

To our knowledge, apart from our own research, no study has directly explored the effect of emotional stimuli on attention in typically developing children. However, the empirical landscape regarding the developmental impact of emotions on cognitive performance presents a notable paradox. On one hand, emotions are often described as detrimental to attention-related processes, particularly when they consume limited cognitive resources during complex tasks (Ellis & Moore, 1999). For instance, children's performance in domains such as spelling has been shown to decline following both positive and negative emotional inductions (Fartoukh et al., 2014), supporting the broader view that emotional processing can interfere with attentional and cognitive control (Gotoh et al., 2008; Storbeck, 2013). On the other hand, a growing body of evidence suggests a facilitating effect of emotions (Rader & Hughes, 2005; Reed et al., 2014; Tong et al., 2025). Pleasant emotional valences, for example, have been found to enhance word recall in children aged 7 to 11 (Brainerd et al., 2010). This theoretical divergence suggests that the impact of emotion is not merely a matter of valence or resource depletion but may be fundamentally modulated by the interaction between a child's internal state and the emotional cues of the task. Bower's (1981) associative network model provides a framework to reconcile these findings, suggesting that emotional congruence—rather than emotion alone—dictates whether an affective stimulus facilitates or hinders cognitive efficiency. These contradictory findings can be critically reconciled by considering that emotional impact is not a fixed property of valence, but a dynamic result of the interaction between the learner's mood and the task environment. We argue that previous studies showing detrimental effects often overlooked the potential for emotional alignment. By applying Bower's (1981) framework to a developmental context, we propose that congruence acts as a cognitive lubricant: it reduces the effort needed to process information, thereby bypassing the typical interference effects seen in incongruent or neutral conditions. While Bower's (1981) model posits that

emotional nodes are integrated into a semantic network, the efficiency of this network likely depends on the maturation of executive functions. In a developmental perspective, we argue that emotional congruence may serve as an ‘affective scaffolding.’ For younger children, whose inhibitory control is still developing, a congruent emotional context may reduce the threshold for information processing, making the selective attention task less cognitively demanding. This reconciliation justifies our hypothesis that performance is not determined by the emotion itself, but by the ‘match’ between the internal state and the external cue.

Recent research has renewed interest in emotion–attention interactions from a developmental perspective, emphasizing the role of affective cues in attentional orienting and cognitive load regulation (e.g., Pecchinenda & Petrucci, 2021; Zelazo et al., 2024). However, these studies have primarily focused on facial expressions or emotional words, leaving the combined effects of auditory and perceptual emotional induction largely unexplored in children. The present study addresses this gap by examining emotion–attention interactions through a dual induction paradigm combining music and color in early and middle childhood, a population for which empirical evidence remains limited. In using color as an emotional cue, it is crucial to distinguish between its perceptual salience (bottom-up visual capture) and its emotional valence (top-down affective meaning). To ensure that our results reflect emotional congruence rather than mere visual detection advantages, we selected colors (yellow and gray) whose perceptual features, such as luminance and contrast, were standardized. Furthermore, previous research using this identical material in a neutral state found no significant performance differences between these backgrounds (Benintendi et al., 2016), suggesting that any observed effects are driven by the affective value of the color rather than its arousal levels or visual prominence.

The present research follows a two-step design to systematically test the applicability of the emotional congruence framework in a developmental context.

Study 1: Validation of the Affective Stimuli. Before testing the interaction effect, it was essential to ensure that the cross-modal induction (music and color) effectively reached the child’s internal state. Based on the premise that Bower’s network nodes require a clear affective categorization, we hypothesized that children would successfully map the target emotions to the selected auditory and visual cues, confirming the ecological validity of our material for this age group.

Study 2: Testing the Congruence–Attention Interaction. This study aimed to bridge the gap between emotional priming and executive maturation. We formulated two primary hypotheses:

- **Developmental Effect:** Attentional performance (processing speed) would increase with age, reflecting the maturation of the prefrontal cortex and the subsequent strengthening of inhibitory control and processing capacity.
- **Congruence Effect:** Guided by the Emotional Congruence Model (Bower, 1981), we predicted that performance would be optimized when the task’s visual context (color) matched the prior emotional state (music). Specifically, congruence should act as a ‘cognitive facilitator’, reducing the executive load required to filter irrelevant information compared to incongruent conditions. While the Emotional Congruence Model (Bower, 1981) suggests a symmetrical facilitation effect for both positive and negative states through the activation of valence-specific cognitive nodes, developmental literature often reports an asymmetrical ‘positivity bias’ in early childhood (Boseovski, 2010). Younger children may show a greater sensitivity to positive congruence (joy) due to the early maturation of approach-related affect systems. However, we maintain a symmetrical hypothesis as a baseline to test whether the fundamental mechanism

of emotional priming, whereby any mood-congruent cue reduces cognitive load, is already operational across both valences in our age range.

2. Methods

Study 1: Music as an Emotional Inducer

To examine the role of emotional congruence on selective attention, a two-step experimental design was implemented. Study 1 aimed to validate the effectiveness of musical excerpts as emotional inducers in children across different school levels, in order to ensure the reliability of the initial emotional manipulation used in Study 2.

2.1. Participants

A sample of 126 children ($M = 7.62$ years, $SD = 2.71$), ranging from preschool to fifth grade, was recruited from schools affiliated with the Académie de Toulouse (France). To ensure a population of typically developing children, exclusion criteria were applied based on a survey of teachers and parents. Children with hearing or visual impairments, color blindness, or known neurodevelopmental disorders were excluded. While formal ADHD diagnoses were only strictly controlled for in Study 2 (due to the clinical challenges of diagnosing children under six in the Study 1 preschool group, (see [American Psychiatric Association, 2013](#))), the teachers confirmed that none of the participants in Study 1 had identified special educational needs at the time of testing. Furthermore, children with prior familiarity with the musical excerpts were excluded to avoid bias in emotional induction.

2.2. Recruitment Procedures

Participants were recruited from public and private state-contracted schools within the Toulouse Academy (France). Formal administrative authorization was sought and obtained from the regional education authority (Rectorat) as well as from the headteachers of the participating schools. Following this approval, detailed information sheets and consent forms were distributed to families via the students' school diaries. Only children who obtained written informed consent from both parents (or legal guardians) and who provided their own verbal assent on the day of the experiment were included in the study. No financial compensation was provided, and participation was strictly on a voluntary basis.

2.3. Ethical Considerations

We ensured compliance with the "French Code of Conduct for Researchers in Behavioral Sciences" ([Caverni, 1998](#)). Thus, for minor participants, we obtained consent from their legal guardians. The study's objectives were clearly explained, and all participants were informed that their participation was voluntary and that they could withdraw from the study at any time. The results were subsequently shared with the participants. Their anonymity was respected and protected throughout the entire process.

2.4. Materials

2.4.1. Music

Two excerpts of classical music were used: *Le Carnaval des Animaux* by Camille Saint-Saëns and *Prelude No. 4* by Chopin. Played in minor chords with a slow tempo, *Prelude No. 4* is perceived as conveying an unpleasant emotion of sadness ([Gagnon & Peretz, 2003](#)), whereas *Le Carnaval des Animaux*, characterized by a fast tempo and a predominance of major chords, conveys a pleasant emotion ([Gabrielsson & Lindström, 2010](#); [Van der Zwaag et al., 2011](#)). The use of classical music prevents emotional induction through lyrics. Indeed, despite a melody's connotation, language can convey contrasting emotions, and a word may be linked to a personal memory, increasing variability in

emotional responses. Additionally, classical music reduces the likelihood that children are frequently exposed to the melody, such as on the radio. The listening duration for each piece was set at 30 s, as longer exposure does not necessarily ensure a stronger induction but does increase the risk of distraction (Brenner, 2000). These two excerpts have been previously used in studies, although variations in participants' arousal levels have not been assessed (e.g., Largy et al., 2018).

2.4.2. Emotional Self-Assessment Scale

Emotional state was assessed using the Self-Assessment Manikin (SAM; Bradley & Lang, 1994), operationalized through the EEVAI-E child-adapted version (Benintendi et al., 2016). The SAM is a non-verbal pictorial scale measuring emotional valence and arousal (see Figures 1 and 2). While it is widely used with children aged 7 and older, its application with younger populations is supported by its iconic format, which minimizes linguistic and cognitive demands. Extensive research has demonstrated that children as young as 4 years old can reliably use these pictorial scales to report the valence of their emotional states (Chambers & Johnston, 2002). To ensure developmental validity in the present study, all assessments were conducted individually. Each child received standardized oral instructions and a guided practice trial to confirm their understanding of the icons before the actual induction, a procedure recommended for preschool populations to ensure data reliability.



Figure 1. 7-point self-assessment scale ranging from very pleasant to very unpleasant.

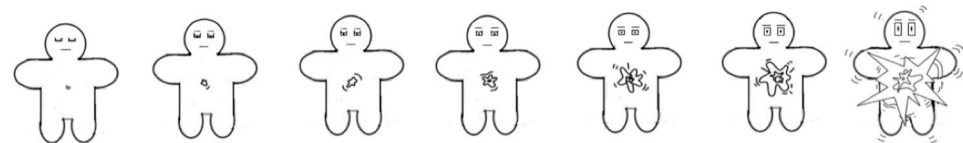


Figure 2. 7-point self-assessment scale ranging from very calm to very excited.

2.5. Procedure

Participants were randomly assigned to evaluate either the auditory stimuli (music) or the visual stimuli (colors) to avoid cross-modal interference. This random assignment was performed at the individual level using a simple drawing procedure.

Individual sessions took place over seven mornings. Each participant first assessed their emotional state using the EEVAI-E scale, indicating their emotional valence ("happy" to "sad") and activation level ("sleepy" to "very excited"). Participants were then divided into two groups. The first group listened to Prelude No. 4 by Chopin to induce an unpleasant emotion, while the second was exposed to Le Carnaval des Animaux by Saint-Saëns to induce a pleasant emotion. They were instructed to listen carefully and focus on their feelings. After listening, participants reassessed their immediate emotional state using the EEVAI-E under the same conditions.

2.6. Statistical Analyses (Study 1)

Emotional state variations were assessed by computing difference scores between Time 1 (before musical induction) and Time 2 (after musical induction) for both self-reported valence and arousal. Negative values indicate a decrease in emotional ratings following induction, whereas positive values indicate an increase. To evaluate the effectiveness of musical emotional induction, paired-sample *t*-tests were conducted to compare participants'

emotional states before and after music listening, separately for joyful and sad musical excerpts. To examine potential developmental differences, additional paired-sample *t*-tests were performed separately for each school level (preschoolers, second graders, fourth graders, and fifth graders) on valence and arousal variation scores. All statistical analyses were conducted using Jamovi 2.6.45, with the significance level set at $p < 0.05$.

Study 2: Dual Emotional Induction and Attentional Tasks

Following the validation of musical emotional induction in Study 1, Study 2 implemented a dual emotional induction paradigm combining music and emotionally valenced color cues embedded in a visual search task to assess their effects on children's selective attention performance. Given the substantial inter-individual variability in emotional perception, this approach was necessary to standardize participants' affective states prior to task execution (Gilet, 2008). The procedure made it possible to form two groups with comparable initial emotional states (joyful vs. sad). Music listening was used as the first emotional induction vector, based on the validation results obtained in Study 1. The decision to maintain the same induction parameters for all age groups, despite the marginal effects observed in preschoolers during Study 1, was a deliberate methodological choice. To ensure a rigorous cross-sectional comparison, it was essential to standardize the stimuli across the entire developmental span (ages 4 to 11). Using different materials for younger children would have introduced a confounding variable, making it impossible to determine whether performance shifts were due to cognitive maturation or stimulus properties. Furthermore, we hypothesized that even if emotional induction is explicitly subtle for younger children, it could still exert a non-conscious, implicit influence on attentional resources, a possibility we aimed to test in the larger sample of Study 2.

2.7. Participants

A sample of 264 children who had not participated in Study 1 ($M = 7.71$, $SD = 2.74$) was recruited. All participants attended schools affiliated with the Académie de Toulouse (France). To ensure the internal coherence of the two-study design, exclusion criteria regarding neurodevelopmental disorders were maintained across both phases. However, specific formal exclusion for attention deficit hyperactivity disorder (ADHD) was primarily emphasized in Study 2, as a reliable diagnosis is clinically challenging to establish in children under six years of age—the primary population of Study 1—due to the high variability in behavioral maturation during preschool years (American Psychiatric Association, 2013). By age 6–7, the starting age for Study 2, the diagnosis becomes more stable as symptoms interfere with formal schooling (Barkley, 2014). Consequently, excluding children with diagnosed ADHD in Study 2 was a necessary step to ensure that the results of the selective attention task reflected typical developmental patterns, while the Study 1 population represented the standard preschool demographic used for stimulus validation.

2.8. Ethical Considerations

The ethical conditions were identical to those in Study 1.

2.9. Recruitment Procedures

The recruitment procedures were identical to those in Study 1.

2.10. Materials

2.10.1. Music

To induce an initial emotional state, the two musical excerpts tested in Study 1 were used: *Le Carnaval des Animaux* by Camille Saint-Saëns and *Prelude No. 4* by Chopin. The

listening duration for each piece was set at 30 s, as longer exposure does not necessarily ensure stronger induction but increases the risk of distraction (Brenner, 2000).

2.10.2. Cancellation Task

The visual cancellation task was modeled after the standardized Cancellation subtest of the WISC-V (Wechsler Intelligence Scale for Children—Fifth Edition), selected for its high clinical validity in measuring processing speed and selective attention. The visual cancellation task was used to assess visual selective attention and processing speed. As modeled after the WISC-V, this task requires both the rapid scanning of stimuli and the selective identification of targets among distractors, reflecting the efficiency of attentional search under time constraints. The choice to maintain a level of complexity consistent with standardized developmental tools was a proactive decision to ensure the task's accessibility for the youngest participants, thereby minimizing attrition and ensuring that performance reflected attentional processes rather than purely cognitive or motor difficulty. To examine the role of emotional context, color was directly integrated into the task to maintain the induction effect during performance (Ekman, 1984). One hundred thirty items, including 25 targets, were presented in white on A3 landscape-format sheets. Based on Study 1 findings, which confirmed that yellow and gray are, respectively, associated with joy and sadness in children, the background of each sheet was either bright gray (R149 G149 B149) or bright yellow (R254 G249 B16). These colors were standardized using Munsell's notation system (Munsell, 1929), accounting for hue, brightness, and saturation to ensure perceptual consistency. To address the potential confound between emotional congruence and visual salience, we relied on previous experimental validation of our stimuli. In a prior study using the same visual cancellation material (Benintendi et al., 2016), we specifically tested for a 'salience effect' by comparing performance on gray and yellow backgrounds without emotional induction. The results showed no significant difference in detection speed or accuracy between the two colors, confirming that these backgrounds are equivalent in terms of visual salience for white targets. Consequently, any performance variations observed in the current study can be confidently attributed to emotional congruence rather than low-level perceptual features.

2.10.3. Emotional Self-Assessment Scale

The EEVAI-E scale was used to assess changes in participants' emotional states following the task (see Figures 1 and 2).

2.11. Procedure

Participants were assigned to one of the four experimental conditions (2 Emotions [Joy vs. Sadness] $\times$ 2 Background Colors [Yellow vs. Gray]) through a stratified random assignment procedure. To ensure group equivalence, randomization was conducted at the individual level within each school, balancing for both gender and age (grade level). This ensured that developmental differences and classroom-related factors were equally distributed across the four conditions, with approximately the same number of participants in each group.

Individual sessions were conducted by two experimenters over ten mornings to control for the effects of daily attentional rhythm (Janvier & Testu, 2005).

After listening, they immediately assessed their emotional state using the EEVAI-E scale. Each listening group was then divided into two subgroups. Half of the participants who listened to the joyful music performed the cancellation task on a yellow background (congruent condition), while the other half performed it on a gray background (non-congruent condition). The transition between the end of the musical excerpt and the start of the cancellation task was kept minimal to maximize the induction effect. Following

the 30 s listening period, children took approximately 15 to 20 s to complete the EEVAI-E self-assessment scale. Immediately thereafter (within 5 s), the experimenter provided the signal to start the cancellation task. Thus, the total interval between induction and task execution was less than 25 s, ensuring that the affective state remained active throughout the 45 s task duration.

The same procedure was followed for participants who listened to the sad music. The task required participants to cross out as many target images as possible within 45 s. To minimize experimenter bias, a standardized protocol was strictly followed for all participants. The instructions for the cancellation task were delivered using a pre-written script to ensure consistency across conditions: "On the sheet, there are several cats. Find and cross out, as quickly as possible, the ones that are exactly like the model at the top. When I say 'go,' you will turn the sheet over, and when I say 'stop,' you will put your pencil down. Do you understand?". Regarding experimenter blinding, while the nature of the stimuli (colored sheets) precluded a complete double-blind design during administration, several measures were taken to eliminate potential expectancy effects. First, the two experimenters were unaware of the specific hypotheses regarding the interaction between color and music during the data collection phase. Second, the use of a pre-written, standardized script for instructions and a neutral, non-contingent posture during the task execution ensured that experimenter-participant interactions were identical across all four conditions. Finally, the scoring of the cancellation sheets was performed post hoc by a researcher blinded to the participant's prior musical induction condition.

2.12. Statistical Analyses (Study 2)

A post hoc power analysis was conducted to evaluate the robustness of our findings. With a sample of 264 children, the study achieved a statistical power ($1-\beta$) exceeding 0.99 for the main effect of school level and the main effect of background color. Furthermore, the analysis of emotional congruence (condition effect) also showed high statistical power. This confirms that the sample size was more than sufficient to detect the central effects of our model. To control for the inflation of familywise error rate due to multiple comparisons, Bonferroni corrections were applied to all post hoc tests. For the main effects and interactions in the ANOVAs, partial eta-squared (η^2p) is reported as a measure of effect size to provide a more robust interpretation of the findings beyond values alone.

3. Results

3.1. Results of Study 1

3.1.1. Analysis of the Effects of Emotional Induction Through Music

Paired-sample *t*-tests were conducted to determine whether there was a significant difference between participants' initial emotional state and their state after music exposure. Significant results were found for valence variation, $t(62) = -8.72$, $p < 0.001$, and arousal, $t(62) = -5.8$, $p < 0.001$, following Le Carnaval des Animaux (joy induction). For Prelude No. 4 (sadness induction), significant differences were also observed for valence and arousal ($t(62) = 19.67$, $p < 0.001$; $t(62) = 2.6$, $p = 0.01$, respectively).

3.1.2. Analysis of the Effects of School Level on State Variation After Joy Induction

Paired-sample *t*-tests conducted separately for each school level showed revealed a significant effect of listening to Le Carnaval des Animaux on valence for second graders ($n = 16$), $t(15) = -5.84$, $p < 0.001$, fourth graders ($n = 15$), $t(14) = -4.938$, $p < 0.001$, and fifth graders, $t(15) = -5.69$, $p < 0.001$. This effect was marginally significant for preschoolers ($n = 16$), $t(15) = -1.96$, $p = 0.069$, ns. A significant effect on arousal was also found for second graders ($n = 16$), $t(15) = -3.15$, $p < 0.01$, fourth graders ($n = 15$), $t(14) = -2.485$,

$p = 0.023$, and fifth graders ($n = 16$), $t(15) = -4.95$, $p < 0.001$. No other effect was significant, F_s , ns. Table 1 presents mean variations (T1–T2) and standard deviations for valence and arousal, where negative values reflect a decrease after induction and positive values reflect an increase (see Table 1).

Table 1. Variation in Self-Assessment of Valence and Arousal by School Level and Music Type.

School Level	Joy Induction				Sadness Induction			
	Valency		Arousal		Valency		Arousal	
	M(SD) T1	M(SD) T2	M(SD) T1	M(SD) T2	M(SD) T1	M(SD) T2	M(SD) T1	M(SD) T2
Preschoolers	5.69 (1.45)	6.13 (1.1)	4.94 (2.21)	5.56 (2.07)	6.53 (0.84)	4.21 (1.93)	4.21 (2.25)	4.05 (2.42)
Second graders	5.44 (1.1)	6.69 (0.60)	4.63 (1.67)	6 (0.89)	5.5 (0.97)	2.31 (0.7)	3 (1.59)	2.75 (1.53)
Fourth graders	5.38 (0.96)	4.12 (0.82)	4.56 (1.32)	3.56 (1.71)	5.38 (0.96)	3 (0.82)	4 (1.32)	3.56 (1.71)
Fifth graders	5.19 (0.91)	6.38 (0.62)	3.94 (1.34)	5.5 (0.97)	5.5 (0.73)	2.44 (0.96)	4 (1.37)	3.19 (1.38)

3.1.3. Analysis of the Effects of School Level on State Variation After Sadness Induction

We examined the effect of school level on changes in valence and arousal following exposure to the musical excerpt inducing sadness. The analysis revealed a significant effect of Prelude No. 4 by Chopin on valence variation for preschoolers ($n = 16$), $t(15) = 5.04$, $p < 0.001$, second graders ($n = 16$), $t(15) = 12.18$, $p < 0.001$, fourth graders ($n = 16$), $t(15) = 11.78$, $p < 0.001$, and fifth graders ($n = 16$), $t(15) = -5.69$, $p < 0.001$. Regarding arousal variation, the effect was significant only for fifth graders, $t(15) = -4.95$, $p < 0.001$. No other effect was significant, F_s , ns. (see Table 1).

3.2. Results of Study 2

3.2.1. Analysis of the Effects of Emotional Inductions on Selective Attention

A 4 (school levels: preschoolers vs. second graders vs. fourth graders vs. fifth graders) $\times$ 2 (colors: yellow vs. gray) $\times$ 2 (music: joyful vs. sad) ANOVA was conducted ($n = 264$). The dependent variables were the percentage of targets crossed out, and the percentage of errors made. The analysis revealed a large developmental effect of school level on the number of targets crossed out, $F(3, 248) = 140.867$, $p < 0.001$, $\eta^2 p = 0.630$. Fifth graders crossed out more targets ($M = 69.64$, $SD = 19.243$) than fourth graders ($M = 61.21$, $SD = 21.068$), who in turn performed better than second graders ($M = 46.85$, $SD = 14.763$), who performed better than preschoolers ($M = 18.33$, $SD = 9.746$), $p_s < 0.01$. However, no significant effect of school level was found on the percentage of errors made, $F(3, 248) = 2.091$, ns. The error rate remained globally low ($M = 2.32$, $SD = 13.791$). A significant effect of background color on the number of targets crossed out was observed, $F(1, 248) = 19.852$, $p < 0.001$, $\eta^2 p = 0.074$, representing a moderate practical impact. However, no such effect was found for the number of errors made, $F < 1$, ns. Participants who performed the task on a yellow background, associated with a positive emotional valence, crossed out more targets ($M = 49.23$, $SD = 26.133$) than those who performed it on a gray background, conveying sadness ($M = 47.51$, $SD = 25.483$). A significant interaction between school level and color was also found for the number of targets crossed out, $F(3, 248) = 3.107$, $p = 0.027$, $\eta^2 p = 0.036$. However, this interaction was not significant for the percentage of errors, $F < 1$, ns. Although no simple effect of music was significant, $F(1, 248) = 1.852$, ns., a non-significant trend toward an interaction between music and color was observed for the percentage of

targets identified. Given that this effect did not reach the conventional alpha level of 0.05, it must be interpreted with extreme caution and is treated here as a preliminary observation rather than a confirmed interaction. No effect was found for the percentage of errors, $F(1, 248) = 1.044$, ns. No other significant effects were observed (F s, ns.).

3.2.2. Analysis of the Effects of Emotional Congruence on Selective Attention

A 4 (school levels: preschoolers vs. second graders vs. fourth graders vs. fifth graders) $\times$ 4 (conditions: joyful music–yellow color vs. joyful music–gray color vs. sad music–gray color vs. sad music–yellow color) ANOVA was performed. This analysis found no significant differences in the number of errors made during the attentional task (F s, ns.). Regarding the number of targets crossed out, significant effects of school level, $F(3, 248) = 140.867$, $p < 0.001$, $\eta^2 p = 0.630$, and condition, $F(3, 248) = 8.091$, $p < 0.001$, $\eta^2 p = 0.089$, were observed. The mean performance and standard deviations for each emotional condition are summarized in Table 2. However, the interaction between experimental conditions and school level was not significant, $F < 1$, ns. This absence of interaction shows that the impact of the different emotional conditions followed a similar pattern across the four developmental stages tested.

Table 2. Attentional Performance (Percentage of Targets Identified) by Experimental Condition.

Emotional Condition	Music Valence	Background Color	Mean (%)	SD
Congruent Positive	Joyful	Yellow	55.16	27.34
Incongruent	Joyful	Gray	43.21	23.56
Congruent Negative	Sad	Gray	45.15	22.80
Incongruent	Sad	Yellow	49.91	27.92

Post hoc comparisons (Fisher's LSD) indicated that performance in the [Joyful Music/Yellow Color] congruent condition ($M = 55.16$, $SD = 27.34$) was significantly higher than in the [Joyful Music/Gray Color] ($M = 43.21$, $SD = 23.56$, $p < 0.001$) and [Sad Music/Gray Color] ($M = 45.15$, $SD = 22.80$, $p < 0.001$) conditions. Performance in the [Sad Music/Yellow Color] condition ($M = 49.91$, $SD = 27.92$) also significantly exceeded the [Joyful Music/Gray Color] condition ($p = 0.016$). Results are summarized in Figure 3.

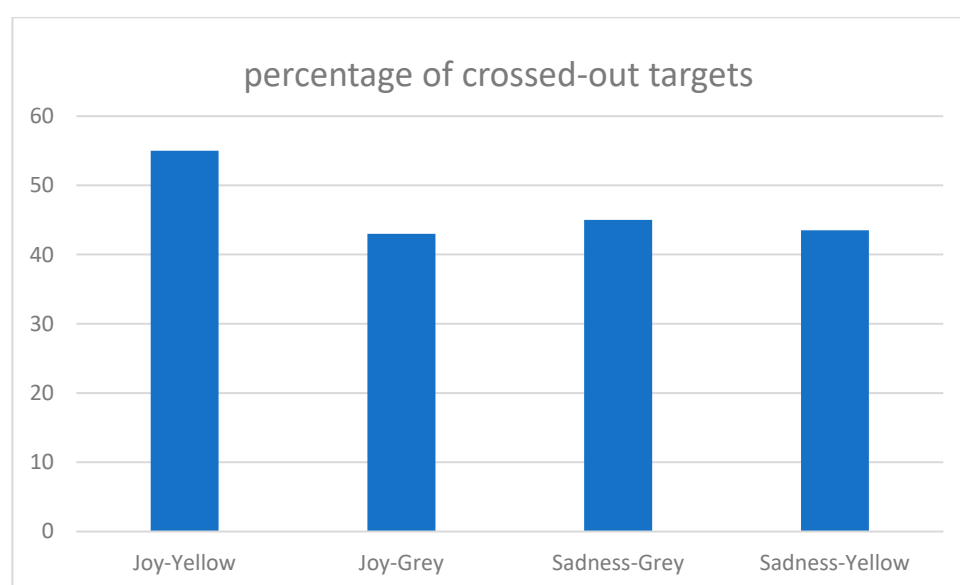


Figure 3. Percentage of crossed-out targets based on emotional induction conditions.

3.2.3. Analysis of the Effect of Emotional Induction on the Child's Experienced Emotion

Given the initial results, it appears that color had a more significant impact on selective attention task performance than music. Therefore, we sought to determine whether emotional induction via music and color led to a change in emotional state. A mixed ANOVA with repeated measures was conducted on 4 (school levels: preschoolers vs. second graders vs. fourth graders vs. fifth graders) $\times$ 2 (music: joyful vs. sad) $\times$ 2 (colors: joyful vs. sad) for valence and arousal, assessed using the EEVAI test. This analysis revealed a significant change in participants' positioning on the valence scale, $F(1, 248) = 280.552$, $p < 0.001$, $\eta^2p = 0.531$, correlated with color and school level: $F(1, 248) = 8.109$, $p = 0.005$, $\eta^2p = 0.032$, and $F(1, 248) = 4.630$, $p = 0.004$, $\eta^2p = 0.053$, respectively. No significant interaction involving music was observed, suggesting that color-based induction had a more persistent effect on emotional self-reports than musical induction. Thus, positioning on the emotional valence scale decreased more after exposure to the gray color (Time 1: $M = 5.73$, $SD = 1.166$; Time 2: $M = 5.46$, $SD = 1.438$) than after exposure to the yellow color (Time 1: $M = 5.92$, $SD = 1.109$; Time 2: $M = 5.76$, $SD = 1.285$). Additionally, Fisher's post hoc test showed that second graders scored higher on the valence scale (Time 1: $M = 6.07$, $SD = 0.888$; Time 2: $M = 5.83$, $SD = 0.968$), $p = 0.027$, compared to fourth graders (Time 1: $M = 6.02$, $SD = 1.120$; Time 2: $M = 5.88$, $SD = 1.453$), and fifth-graders (Time 1: $M = 5.57$, $SD = 0.880$; Time 2: $M = 5.39$, $SD = 1.137$), $p = 0.020$. Regarding changes on the arousal scale, the analysis did not reveal any significant effect, $F < 1$, ns.

4. Discussion

4.1. Summary of Findings

In Study 1, we expected a variation in emotional state based on music exposure, regardless of school level. Thus, we formulated two hypotheses: a decrease in emotional valence and arousal after listening to Prelude No. 4 by Chopin (sadness) and an increase after listening to Le Carnaval des Animaux by Saint-Saëns (joy). The results show that after listening to Prelude No. 4, children rated their emotional state as sadder, whereas after Le Carnaval des Animaux, they placed themselves higher on the valence scale. However, this effect was only marginally significant among the youngest participants. A possible explanation is that 43.75% of preschoolers had already rated themselves as very happy before listening. A complementary analysis excluding these children revealed a significant effect of joyful music on emotional valence, $t(8) = -2.874$, $p < 0.03$. This suggests that the scale used did not allow an increase to be measured for participants already positioned at the extreme. A different scale before and after induction could address this limitation, although the observed effect might persist with another tool.

Another hypothesis concerns the maturation of emotional competencies. Although emotion identification begins in the first months of life (Vauclair, 2004), it is not fully acquired until around age 7 (Golse, 2010; Simoës-Perlant & Lemerrier, 2018). Between ages 3 and 6, children gradually develop their abilities for emotional expression and regulation (Olds & Papalia, 2005), which influences how they respond to emotional stimuli (Mikolajczak et al., 2009; Saarni, 2000). Thus, it is possible that preschoolers' experience emotions too intensely for our material to detect variations. This could also explain why arousal was less sensitive to emotional induction: the variation was significant only for second graders and fifth graders in the joyful condition and only for fifth graders in the sad condition. The use of classical music might be a factor, as some studies suggest it increases alpha waves, promoting relaxation (Flores-Gutiérrez et al., 2007; Pérez Lloret et al., 2014). Additionally, the relatively short exposure time may have limited its effect on this dimension.

Consistent with the adult literature regarding the affective potency of music (Hunter et al., 2010; Koelsch, 2014; Vuoskoski & Eerola, 2011), our findings demonstrate that children as early as preschool age are highly sensitive to the emotional properties of both auditory and visual cues. Crucially, Study 1 provides empirical evidence that, within this developmental context, gray is not perceived as an emotionally neutral stimulus but is consistently associated with negative valence (sadness). This finding is fundamental as it justifies the status of the gray background in Study 2 as a sadness-congruent anchor rather than a mere neutral baseline. Consequently, these results establish a robust empirical foundation for examining how the interaction between music-induced internal states and color-based external cues influences cognitive performance. By validating this cross-modal induction procedure, we can systematically test the emotional congruence hypothesis within a selective attention paradigm, as explored in Study 2.

Study 2 aimed to evaluate the impact of emotions on selective attention in children of different school levels. As expected, an age-related effect was observed: the number of targets crossed out increased with development, confirming the findings of Trick and Enns (1998). At age 5, children have limited visual search strategies, which gradually improve until about age 7 (Rueda et al., 2005). However, contrary to our hypothesis based on the associative network model, no main effect of congruence between music and color was observed on selective attention. Children performed better when the cancellation task was presented on a yellow background, regardless of the valence of the previously heard music. This suggests that color alone influenced attention. The literature has already highlighted the effect of colors on cognitive processes (Sinclair et al., 1998; Soldat et al., 1997), particularly when color is present during the task. Indeed, this effect may partly result from the fact that, unlike color, the music was not present during the task itself. Emotional states induced by music are typically short-lived (Habibi & Damasio, 2014), which may explain why the effect of music did not persist throughout the attentional task. Furthermore, presenting the emotional induction concurrently with the task is likely to engage brain areas such as the anterior cingulate cortex, which is involved in attention and responds to the visual presentation of emotional information (Carretié et al., 2004). Therefore, it would be interesting to replicate the study by integrating the music into the task itself, in order to potentially strengthen or interact with the effect of color on attentional performance. Several methodological choices support the validity of these findings. First, the visual cancellation task was specifically modeled after the WISC-V subtest ensuring its developmental appropriateness for measuring both visual selective attention and processing speed. While the temporal gap between musical induction and task performance could be viewed as a limitation, the task's 45 s duration is well within the window of stability for mood induction effects (Westermann et al., 1996). This uniform duration was maintained across all groups to allow for direct developmental comparisons, and the low error rates in the youngest participants confirm its appropriateness. Furthermore, the decision to stop the music before the task was a proactive strategy for cognitive load management (Sweller, 1988), preventing auditory–visual interference that could have biased the results in younger children. To ensure that the observed color effects were emotional rather than perceptual, background colors were standardized using the Munsell system to control for luminance and contrast. Crucially, previous research using this exact material (Benintendi et al., 2016) demonstrated no significant difference in performance between yellow and gray backgrounds in neutral states, confirming that our results are not driven by visual salience. Finally, while error rates were low across all groups, this does not indicate a ceiling effect; rather, it confirms that the instructions were well-understood, allowing the number of targets processed to serve as a sensitive measure of attentional efficiency. Regarding the potential influence of stimulus familiarity, it is important to note that the material used in

this study was specifically designed for this research. Although the task format is inspired by the work of [Corkum et al. \(2005\)](#), the visual boards and the specific target (a simplified line drawing of a cat) were entirely original. Therefore, no participant could have had prior exposure to this specific version of the task. Furthermore, the use of a simplified line drawing rather than a detailed photograph minimizes the influence of individual differences in stimulus familiarity, ensuring that the task focuses on the efficiency of visual search and attentional scanning.

Despite the absence of a global congruence effect, a significant difference was observed between the [joyful music—yellow color] and [sad music—yellow color] conditions, with better performance in the first. This suggests that color effects might be reinforced by musical congruence, aligning with research on composite induction methods ([Jallais & Gilet, 2010](#); [Mayer et al., 1995](#)). However, the absence of a difference between [sad music—yellow color] and [sad music—gray color] indicates a predominant effect of color on the task. This result could be explained by a positivity bias in children ([Monnier & Syssau, 2017](#)), as positive stimuli are prioritized ([Brainerd et al., 2010](#)). Additionally, negative emotions such as sadness are more difficult to identify and induce in young children ([Lima & Castro, 2011](#)).

Our results also show an age-related effect on color influence. No significant effect was observed in preschoolers, but a difference appeared in second graders (+13.39% more targets crossed out with the yellow background), fourth graders (+13.85%), and fifth graders (+8.73%). This progression could be explained by task complexity, which requires limited attentional resources ([Ellis & Moore, 1999](#)), as well as by the development of emotional competencies and inhibitory strategies ([Rueda et al., 2005](#)). The acquisition of efficient target detection strategies allows for better allocation of cognitive resources ([Macdonald et al., 2014](#)), thereby facilitating the processing of task-irrelevant yet emotionally valenced information, such as background color, and enhancing its influence on attentional performance. In addition, theories related to the development of emotional competencies in childhood provide further insight into these findings (e.g., [Ernst et al., 2006](#)). For an emotional stimulus to be appropriately processed, children must be able to identify its nature, valence, and intensity ([Bellinghausen, 2012](#)). This identification process, even when it occurs implicitly, enables the experience of an emotion that is congruent with the triggering event. Although the ability to discriminate basic emotions appears to be present from the first months of life ([Vauclair, 2004](#)), numerous studies suggest that (a) the identification of emotional valence for primary emotions is typically acquired around the age of 7 (e.g., [Golse, 2010](#)), and that (b) emotional recognition abilities, particularly through facial expressions, continue to refine throughout development, both in terms of accuracy and processing speed ([Herba et al., 2006](#)). Thus, at the age of 5, emotional competencies are still undergoing substantial development. This is also the case for visual detection and inhibitory skills, as previously reported ([Rueda et al., 2005](#); [Trick & Enns, 1998](#)).

Interestingly, the present findings suggest that increasing age is first associated with an amplification, and subsequently with a reduction, of the effect of color on selective attention performance. This pattern may be explained by the concurrent development of emotional competencies, such as emotion regulation ([Cole et al., 2004](#); [Spinrad et al., 2006](#)), and target detection strategies ([Rueda et al., 2005](#)). As target detection strategies become more efficient, the task becomes less demanding, allowing children to allocate part of their attentional resources to peripheral information ([Macdonald et al., 2014](#)). This deeper processing of color may in turn facilitate the activation of specific emotions ([Pelet, 2010](#)). However, the subsequent acquisition of emotional regulation skills may enable children to rapidly downregulate the emotional impact conveyed by the task context ([Mikolajczak et al., 2009](#)), thereby reducing the difference in attentional performance between the yellow and gray background conditions.

4.2. Theoretical and Practical Implications

The findings of the present study offer significant contributions to our understanding of the emotion–attention interface in developing populations. From a theoretical perspective, our results extend Bower’s (1981) associative network model to a developmental context, demonstrating that children as young as preschool age are sensitive to emotional congruence. By showing that performance is optimized when the task’s visual environment matches the child’s internal state, we provide a critical reconciliation for the previously contradictory findings in child literature. This suggests that the “detrimental” versus “facilitating” effects of emotion are not fixed but are instead modulated by the structural alignment between affective cues and cognitive goals. Furthermore, the observed dominance of positive congruence aligns with the positivity bias framework (Boseovski, 2010), suggesting that joyful states may be particularly effective in mobilizing early executive resources.

Regarding the practical significance of our findings, while the effect of age (school level) naturally dominates the variance ($\eta^2p = 0.630$), the moderate effect of emotional congruence ($\eta^2p = 0.089$) carries important implications for learning environments. A moderate effect size in an attentional task indicates that the emotional context of a task is not merely a marginal distraction but a systematic modulator of performance. Specifically, the difference in targets crossed out between the positive congruent condition ($M = 55.16$) and the incongruent joyful-gray condition ($M = 43.21$) represents a substantial gain in attentional efficiency. In a classroom setting, such a boost suggests that aligning a child’s mood with the emotional cues of the instructional material could significantly reduce the executive load, allowing for more fluid information processing. Conversely, the lack of significant effect on error rates—despite the changes in processing speed—suggests that emotional congruence acts as a cognitive lubricant for speed and engagement rather than a factor in accuracy.

4.3. Limitations and Future Directions

Methodological limitations should be acknowledged. First, the temporal gap between musical induction and task execution may have reduced the persistence of the induced emotional state, particularly in younger children. Second, although pictorial scales were used, developmental differences in emotional understanding may have influenced self-reports. A limitation of the present study is that individual data regarding socioeconomic status (SES), language background, and IQ were not explicitly collected. However, participants were recruited from a diverse range of public and private state-contracted schools, ensuring a broad representation of the general population. All children followed the standard French national curriculum, suggesting typical cognitive development and native or near-native proficiency in the French language.

A potential limitation is that classroom clustering effects were not statistically controlled through multilevel modeling. However, the risk of a cluster bias is minimized by our experimental design. Participants within each classroom were randomly assigned to the different experimental conditions, ensuring that environmental or teacher-related factors were balanced across groups. Furthermore, the children were recruited from schools with similar socio-economic backgrounds, reducing the potential for significant inter-school variance in the cognitive processes measured.

Furthermore, as our study focused on basic sensory and affective processes through music and color, these fundamental emotional mechanisms are generally considered robust to minor socioeconomic variations (Benintendi et al., 2016; Zelazo et al., 2024), unlike complex linguistic or mathematical tasks. This suggests that the observed results, or the

lack of a strong congruence effect, primarily reflect the developmental maturation of the emotion–attention interface rather than environmental or socio-educational factors.

Additionally, although sample sizes varied slightly across school levels, this disparity does not compromise the validity of the developmental comparisons. Statistical analyses were conducted using methods robust to unbalanced designs, and tests of variance confirmed the stability of the data across age groups.

Another point raised concerns the reliance on self-report measures to validate emotional induction. While physiological or behavioral measures (e.g., heart rate or facial coding) could provide objective data, self-reports remain the most direct way to assess the subjective experience of emotional valence in children. In a school setting, non-invasive tools like the SAM/EEVAI-E are preferred to minimize participant stress, which could otherwise interfere with the attentional task. Furthermore, self-report scales have been extensively validated in developmental research as reliable indicators of induced affective states (Bradley & Lang, 1994; Benintendi et al., 2016). Regarding the temporal gap between musical induction and task performance, the visual cancellation task followed the music immediately and lasted only 45 s. This short duration minimizes the risk of emotional fading, as mood induction effects are known to remain stable for several minutes (Westermann et al., 1996). While this temporal gap could be viewed as a limitation, it was a deliberate choice to prioritize cognitive load management (Sweller, 1988). By limiting the task to 45 s and using the colored background as a continuous emotional anchor, we ensured that the induction remained active without the interference of a dual-task paradigm (auditory and visual). This trade-off was essential to maintain the purity of the attentional measure in young children, as maintaining background music during the task could have divided attentional resources and biased the results.

Regarding the nature of the cognitive measure, it is important to qualify the interpretation of the cancellation task. While this paradigm is a gold-standard measure of selective attention, the very low error rates observed across all age groups (approaching ceiling-level accuracy) suggest that the task primarily challenged the speed and efficiency of visual scanning rather than the complex inhibition of distractors. Consequently, the observed effects (or lack thereof) may reflect the impact of emotional congruence on the ‘mobilization’ of processing speed rather than on the qualitative accuracy of attentional filtering. Future research should incorporate more cognitively demanding tasks with higher distractor interference, such as a Flanker or Go/No-Go paradigm, to determine if emotional congruence exerts a stronger influence when selective attention requires higher levels of inhibitory control.

Furthermore, no formal manipulation check was conducted immediately before the attentional task in Study 2. This decision was based on the need to avoid metacognitive interference and was justified by the cumulative evidence from our research program. The effectiveness of the musical induction was independently validated in Study 1, while the emotional impact of the colored backgrounds (yellow and gray) had been previously established in our earlier work (Benintendi et al., 2016). Given this robust foundational evidence, we prioritized a seamless transition to the 45 s attentional task to maintain the ‘emotional flow’ and prevent cognitive overload. Regarding the task design, the same duration (45 s) was applied across all age groups. While this might raise concerns about developmental appropriateness, it was necessary to maintain a standardized measure of processing speed. The very low error rates across all groups suggest that the task was accessible even for the youngest participants, though future research could benefit from adaptive time limits to avoid potential ceiling effects in older children. Furthermore, while familiarity with the task’s stimuli (cats) or prior exposure to similar cancellation tests was

not formally assessed, the random assignment of participants across conditions likely balanced any idiosyncratic interest in the material.

A potential limitation is the absence of a neutral color condition (e.g., white or cream). However, the inclusion of such a group was deemed unnecessary based on previous baseline findings (Benintendi et al., 2016), which demonstrated that yellow and gray backgrounds do not yield different performance levels in a neutral emotional state. In the present study, the gray condition served as a control for the yellow condition, and vice versa, within a congruence paradigm. This allowed us to specifically isolate the interaction between musical induction and color valence, rather than measuring the absolute facilitative effect of color compared to a neutral baseline.

Finally, while the strong attentional salience of color might be questioned, our previous work (Benintendi et al., 2016) suggests that the effects observed are primarily driven by emotional valence rather than low-level perceptual features. Future studies using eye-tracking could further disentangle these mechanisms by analyzing precise gaze patterns on colored backgrounds.

5. Conclusions

Emotions play an adaptive role in cognitive functioning but may also act as a source of distraction, which helps explain the heterogeneous findings reported in the literature (Eysenck & Byrne, 1992; Blanchette, 2006). By examining emotional congruence effects on selective attention in childhood, the present study contributes to a better understanding of how emotional information interacts with attentional processes during development. Beyond the specific findings, the present results suggest that perceptual emotional cues embedded in the task context may exert a stronger and more persistent influence on children's attentional performance than transient affective states induced prior to task execution. In particular, the predominance of color effects highlights the importance of considering the temporal availability and perceptual salience of emotional inducers when investigating emotion–attention interactions in children. These findings emphasize the need for careful methodological control of emotional induction procedures throughout experimental tasks, as emotional states are highly sensitive to contextual and internal fluctuations (Kuppens et al., 2010). Accounting for interindividual variability and task-related characteristics appears essential to better capture the complexity of emotional influences on attention during development. Future research should further investigate how different types of emotional inducers interact over time and explore the role of additional factors, such as task demands and regulatory abilities, in shaping emotion–attention dynamics in childhood.

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