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The role of executive functioning in children's attentional pain control: An experimental analysis

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ABSTRACT

Directing attention away from pain is often used in children's pain treatment programs to control pain. However, empirical evidence concerning its effectiveness is inconclusive. We therefore sought to understand other influencing factors, including executive function and its role in the pain experience. This study investigates the role of executive functioning in the effectiveness of distraction. School children (n = 164) completed executive functioning tasks (inhibition, switching, and working memory) and performed a cold-pressor task. One half of the children simultaneously performed a distracting tone-detection task; the other half did not. Results showed that participants in the distraction group were engaged in the distraction task and were reported to pay significantly less attention to pain than controls. Executive functioning influenced distraction task engagement. More specifically, participants with good inhibition and working memory abilities performed the distraction task better; participants with good switching abilities reported having paid more attention to the distraction task. Furthermore, distraction was found to be ineffective in reducing pain intensity and affect. Executive functioning did not influence the effectiveness of distraction. However, a relationship was found between executive functioning and pain affect, indicating that participants with good inhibition and working memory abilities experienced the cold-pressor task as less stressful and unpleasant. Our findings suggest that distraction as a process for managing pain is complex. While it appears that executive function may play a role in adult distraction, in this study it did not direct attention away from pain. It may instead be involved in the overall pain experience.

1. Introduction

Distraction is an intuitive way of coping with pain and is often used in children's pain management [45,55]. The existing reviews on the effectiveness of distraction in children generally report small to moderate positive effects in pain reduction [12,19,39,53,55,60]. However, results are heterogeneous and were collected using different pain measurement tools, research settings, and individuals delivering the distraction [12,53,60]. This may point to the role of moderating variables [22,39] in these effects. This study investigates the role of executive functioning as a moderator of distraction effectiveness in reducing pain.

Executive functioning refers to several cognitive functions (eg, goal-shielding, attentional control, problem-solving, self-regulation) [33,34,37]. Research has identified 3 important executive functions: inhibition (ie, the ability to inhibit dominant automatic or prepotent responses), task switching (ie, the ability to shift between multiple task operations or mental sets), and working memory (ie, updating and monitoring information on an ongoing basis) [25,34,44,50]. These functions share a small common variance but are generally considered unitary constructs [3,15,34,50,56,57].

Executive functioning involvement has been hypothesized as critical in distraction effectiveness [43,69]. It has been argued that distraction task engagement, and consequently, the effectiveness of distraction, increases in individuals with better task switching, inhibition, and working memory skills. It is likely that these individuals have greater ability to (1) switch to the distraction task whenever pain interferes [20,21]; (2) inhibit the

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predominant response of attending to the pain and resist disruption by pain [27,51]; and (3) maintain focus on distraction tasks and prioritize information in working memory relevant to ongoing tasks [16–18,26]. Research investigating this hypothesis has mainly focused on the role of working memory [43], indicating that working memory minimises the interference of goal-irrelevant distracters, and plays a role in visual, auditory, and tactile attention [16,17,42]. Also, less pain is reported when distraction tasks requiring higher working memory engagement are used [8]. Research investigating the role of inhibition and task switching in attentional pain control is scarce. One preliminary study in university students has found a relationship between executive functioning and distraction task engagement, with particular support for the role of inhibition, but no relationship with distraction effectiveness was found [69]. As this was the only study using the current paradigm, we sought to explore this question in children. Research on the relationship between executive functioning and distraction effectiveness in children is, to our knowledge, nonexistent. However, because of the large diversity in executive functioning at different ages [11,34], research in a pediatric population has the potential to facilitate the detection of effects of executive functioning on distraction task engagement and distraction effectiveness, and may therefore make an important contribution.

In this study, schoolchildren first performed general executive functioning tasks and subsequently performed a cold-pressor task (CPT). Participants were randomly assigned to distraction or control groups. We hypothesized that executive functioning would moderate the relationship between group and distraction effectiveness, indicating that children with better executive functioning abilities would benefit more from distraction. Additionally, we explored the relationship between executive functioning and distraction task engagement.

2. Methods

2.1. Participants

A total of 239 schoolchildren (ages 9–19 years) from 9 elementary and high schools in Ghent (Belgium) were invited to participate in a cold-pressor experiment. Children were randomly recruited (by means of a computerized program) from a sample of 1015 schoolchildren, who participated in a large questionnaire study on paediatric pain, and consented to be re-contacted for experimental research [70]. Forty-eight declined to participate, mainly due to lack of interest or time. Eleven met one of the exclusion criteria, namely previous experience with the cold-pressor task (n = 2); heart conditions, cuts and sores on the hand to be immersed, chronic pain (n = 3); epilepsy, developmental disorders (autism and attention deficit hyperactivity disorder) (n = 2); colour blindness (n = 3); dyslexia, or poor comprehension of the Dutch language (n = 1). One hundred eighty children remained (98% Caucasian), but due to scheduling problems and time constraints, only 174 actually participated (response rate 97%). Data from 12 children were excluded from further statistical analysis: five participants did not endure the cold-pressor task for 1 minute (control group: n = 4, 2 girls, M_{age} = 11.00 years, SD = 0.82 years; distraction group: n = 1 girl, 12 years), one participant made too many errors on the distraction task (3 SDs above the group error mean), 2 participants (both in the distraction group) reported not experiencing pain during the CPT, one participant reported having severe chronic pain at the time of testing despite previous screening, and 3 participants' trials were subject to technical problems. The remaining sample consisted of 162 children (control group: n = 84, 40 girls, M_{age} = 13.80 years, SD = 2.68; distraction group: n = 78, 42 girls, M_{age} = 13.95 years, SD = 2.55).

All children were Belgian and reported good health and psychological functioning. A minority of the sample reported minor medical problems (20%), in most cases allergies and asthma. Seventy-four percent of the children's parents were married or cohabiting. Sixty-nine percent of the mothers and 63% of the fathers were educated beyond the age of 18 years. Children and parents participated voluntarily and received reimbursement to cover transportation costs (25–35 euro). Both provided a written informed consent (and assent, where applicable) and were fully debriefed after the experiment. The experiment was approved by the ethical committee of the Faculty of Psychology and Educational Sciences of Ghent University.

2.2. Materials and measures

2.2.1. Sample characteristics

Sociodemographic characteristics of the child and parents (eg, child's sex, age, psychological and physical health [open questions], education level, parents' current profession, family situation) were obtained by means of an ad hoc questionnaire, which was completed by the parents.

2.2.2. Pain experience

Children's pain experience prior to the experiment was assessed with 6 items based on the Varni–Thompson Pediatric Pain Questionnaire [66]. Children were asked to indicate whether they had experienced pain during the past 2 weeks (yes/no). Overall pain intensity (4-point scale: 0 = "a little bit" to 3 = "very much") and frequency (4-point scale: 0 = "once" to 3 = "all the time") were also assessed. Using an adapted visual/numeric analogue scale, children indicated the worst pain they experienced during the last 2 weeks (0 = "no pain" to 100 = "very much pain"). Further, participants were asked to indicate all pain locations on a manikin figure. Finally, participants were asked to indicate on the visual/numeric analogue scale (0 = "no pain" to 100 = "very much pain") the pain they experienced at the moment of testing.

2.2.3. Cold-pressor task (CPT)

Children participated in a pain-inducing cold-pressor task (CPT) [73]. The cold-pressor apparatus was a metallic water container (type Techne B-26 with TE-10D, size 53 × 32 × 17 cm; Bibby Scientific, Staffordshire, UK). Inside the apparatus, a circulating water pump (type Techne Dip Cooler RU-200) was used to prevent heat formation around the immersed hand [73]. We used a fixed-immersion paradigm (ie, immersion during a fixed time interval) in which children immersed their hand for 1 minute, rather than a tolerance paradigm (ie, immersion until the pain can no longer be tolerated). Tolerance paradigms are less useful in experiments with youth participant groups that encompass a broad age range, as younger children tend to tolerate the CPT for a shorter period of time than do older children [35], and the pain experience may be confounded by variance in immersion duration [21]. By using a fixed immersion interval, each participant experienced the same physical stimulation conditions. The water temperature was kept constant at 12 °C. Previous research has revealed that this temperature and 1 minute immersion duration creates a painful stimulus of moderate pain intensity and is suitable for investigating distraction effects [68,69]. A highly intense pain stimulus was considered undesirable in this experiment as distraction is argued to fail for high intense pain [22].

To standardize the hand temperature, children were asked to immerse their hand in a container filled with water of room temperature (21 °C) (type Julabo TW20, size 56 × 35 × 32 cm; Julabo USA, Allentown, PA, USA) prior to cold-water immersion.