Interactive Versus Passive Distraction for Acute Pain Management in Young Children: The Role of Selective Attention and Development

Karen A. Wohlheiter, PhD, and Lynnda M. Dahlquist, PhD
Department of Psychology, University of Maryland

All correspondence concerning this article should be addressed to Karen Wohlheiter, PhD, The Children's Hospital of Philadelphia, 3535 Market St., 13th Floor, Suite 1382, Philadelphia, PA 19104, USA. E-mail: wohlheiterk@email.chop.edu

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Objective To examine whether age and developmental differences in selective attention influence young children's differential responses to interactive and passive distraction. **Methods** 65 3- to 6-year-old children underwent three cold-pressor trials while receiving no intervention, playing a video game (interactive distraction), or watching a video game (passive distraction). In addition, children completed a test of selective attention, and parents completed ratings of attention. **Results** Consistent with neurocognitive models of pain, children benefited more from interactive distraction than from passive distraction. Although older children demonstrated superior pain tolerance overall, age and selective attention skills did not moderate children's responses to the distraction intervention. **Conclusions** These findings suggest that younger preschoolers can benefit from interactive distraction to manage acute pain, provided that the distraction activity is developmentally appropriate. Research is needed to determine whether developmental issues are more important moderators of children's responses to distraction when faced with more challenging task demands.

Key words children; cold pressor; distraction; pain; video games.

Introduction

Although distraction is widely recognized as an effective acute pain management strategy for children (Uman, Chambers, McGrath, & Kisley, 2008), recent research suggests that certain types of distraction tasks may be more effective than others. For example, some studies have demonstrated that interactive distraction, which requires the child to cognitively engage with the distracting stimulus, is more effective than passive distraction, which only requires the child to visually or auditorily observe the distracting stimulus (e.g., Dahlquist, McKenna, Dillinger, Weiss, & Ackerman, 2007; Mason, Johnson, & Wooley, 1999). However, empirical findings are mixed, with some studies finding no differences between interactive and passive distraction (e.g., Weiss, Dahlquist, & Wohlheiter, 2011), and others reporting certain applications of passive distraction to be more effective than some forms of interactive distraction (MacLaren & Cohen, 2005). Methodological limitations, such as the use of interactive and passive tasks that differ on many dimensions other than interactivity (e.g., cartoons vs. electronic games), hinder the interpretation of these discrepant findings (Dahlquist et al., 2007; Weiss et al., 2011).

The hypothesized superiority of interactive distraction is consistent with current neurocognitive and cognitive–affective models of attention and pain that propose that pain is evolutionarily predisposed to interrupt and capture attention and to become a compelling motivation for action and escape behaviors (Eccleston & Crombez, 1999, p. 361). To combat this ''bottom up'' selection of attention by pain, the individual must deliberately use central cognitive resources to redirect attention away from pain (Eccleston, 1995; Legrain et al., 2009). This ''top down,'' intentional, goal-directed, and effortful process is thought to be activated in working memory (Legrain et al., 2009).

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Distraction tasks that involve the intentional and effortful direction of attentional control (i.e., require ongoing central attentional processing), therefore, should be more effective in combating pain than tasks that demand less central cognitive processing (i.e., passive tasks that involve little executive functioning, or repetitive routinized tasks that become automatic, rather than controlled, over time) (Eccleston, 1995; Law et al., 2011). Thus, in theory, interactive distraction should be more effective than passive distraction.

Dahlquist et al. (2007) tested this premise in a tightly controlled comparison of interactive video game distraction (delivered via virtual reality technology) and passive distraction (i.e., watching the same video game footage used in the interactive distraction condition, delivered by the same virtual reality technology) with children aged between 5 and 13 years undergoing cold-pressor pain. They found that both distraction conditions improved the children's pain threshold and pain tolerance scores, and that the interactive distraction condition was significantly more effective than the passive distraction condition.

However, there is some evidence that age may moderate the differential efficacy of interactive versus passive distraction. In the Weiss et al. (2011) study of sixty-one 3- to 5-year-old preschool children, both interactive and passive distraction resulted in improvements in cold-pressor pain tolerance; however, their interactive video game distraction condition did not result in improvement in cold-pressor pain tolerance that was superior to the effect of passively watching the output generated by the same video game.

One possible explanation for the failure to detect a superior effect for interactive distraction in the Weiss et al. (2011) study is that preschool children lack the cognitive skills needed to actively engage with an interactive distraction task when also faced with a competing pain stimulus. Preschool children have more immature executive functioning and central attentional skills than do elementary school-aged children. Preschoolers demonstrate rapid changes in these skills between the ages of 2 and 7 years as the prefrontal cortex matures (Kane & Engle, 2000; Rosen & Engle, 1998; Sinclair & Taylor, 2008). Specifically, selective attention—a prerequisite for the development of sustained attention—begins to develop in early childhood (Hale, 1979). Children develop increased ability to attend to structured tasks such as games between the ages of 3 and 5 years (Ruff, Capozzoli, & Weissburg, 1998). In addition, children's inhibition and set-shifting skills improve during this period such that 5- and 6-year-old children have better selective attention skills than younger preschool-aged children (Espy, 1997).

These developmental differences in selective attention skills may influence how children respond to interactive video game distraction. Video games require children to selectively attend to the game and to follow a specific set of structured rules. Such interactive distraction tasks may not be appropriate for young preschool children or children with comparably immature selective attention skills. In contrast, older preschoolers should be better able to maintain focus on structured interactive tasks, such as video games, when confronted with competing painful stimuli because of their better developed selective attention and inhibition and set-shifting skills. Thus, children aged >4 years may be better able to benefit from interactive distraction tasks than those aged <4 years.

It is also possible that younger children require more extensive training and experience with an interactive distraction task for it to be effective. Weiss et al. (2011) noted that few of their participants had ever played video games. Thus, although the children demonstrated basic mastery of the video game (i.e., ability to maneuver through the game and execute game-relevant activities), they might not have been familiar or competent enough with the video game to sustain attention to the interactive task in the face of pain. The current study addressed this concern by providing children more extensive training in the video game before using it as the interactive distraction task.

Aims and Hypothesis

The primary aims of the study were to understand how age and selective attention skills affect the utility of interactive versus passive distraction for preschool- and early school-aged children experiencing cold-pressor pain. The length of time children tolerated cold-pressor discomfort was compared during baseline (no distraction), interactive distraction (playing a developmentally appropriate video game), and passive distraction (watching prerecorded video game footage from the same video game). We expected that all children would benefit from both distraction interventions relative to baseline (no distraction). In addition, we hypothesized that age and selective attention skills would moderate the effects of the two distraction interventions, with older children and children with better selective attention, inhibition, and set-shifting skills (i.e., attention-related executive functions) showing the greatest differential benefit from interactive distraction relative to passive distraction.

Method

Study Design

A within-subjects design was used. All participants underwent three cold-pressor trials—a baseline trial followed by

two distraction trials (an interactive distraction trial and a passive distraction trial presented in counterbalanced order). A subset of participants ($n = 28$) underwent a second baseline trial. This design element allowed for a comparison of the pain tolerance scores of children who underwent two baseline trials (baseline-only group) with the pain tolerances scores of the children who received one baseline trial followed by interactive distraction (interactive distraction group) and the pain tolerance scores of the children who received one baseline trial followed by passive distraction (passive distraction group). Both distraction groups were expected to show greater improvements in pain tolerance than the children who experienced two baseline trials. Children were stratified by age and sex and randomized to one of the following orders of experimental condition presentation using the urn randomization method (Wei & Lachin, 1998): (1) single-trial baseline, interactive distraction, then passive distraction; (2) single-trial baseline, passive distraction, then interactive distraction; (3) two-trial baseline, interactive distraction, then passive distraction; or (4) two-trial baseline, passive distraction, then interactive distraction (see Figure 1).

Participants

Participants were recruited at back-to-school events or by informational letters distributed to parents in suburban middle-class neighborhoods. All participants were screened before enrollment. Children with mental retardation or hearing or vision impairment and those who should not be exposed to cold-temperatures (e.g., children with sickle cell anemia, cardiac problems, Raynaud's disorder, frostbite history) were not eligible for the study. No children were excluded because of these reasons.

Sixty-one preschool children (30 of whom were boys) participated in the study. Children's ages ranged from 37 to 83 months ($M = 58.87$, $SD = 14.09$). Fifty-three participants (87%) were Caucasian, 5 (8%) were African American, 1 (1%) was biracial, and 2 (3%) were Asian. The sample was primarily middle class, with Hollingshead (1975) socioeconomic status raw scores ranging from 32 to 66 ($M = 53.9$, $SD = 8.27$).

Measures

Demographic Questionnaire

Parents completed a demographic questionnaire about their child's race, health, educational placement, and parents' education and occupation.

Selective Attention

The Visual Attention subtest of the Developmental Neuropsychological Assessment (NEPSY; Korkman, Kirk, & Kemp, 1998) was used to assess selective visual attention. The NEPSY is a widely used neuropsychological assessment tool for children aged 3–12 years. NEPSY scores have been found to correlate with parental report of executive functioning on the Behavior Rating Inventory of Executive Function (BRIEF) (Korkman et al., 1998). The Visual Attention subtest requires the child to selectively attend to target stimuli while ignoring nontarget items.

		Cold Pressor Trial			
Experimental Condition Order	*n*	1	2	3	4
Baseline, Interactive Distraction, Passive Distraction	15	Baseline	Interactive Distraction	Passive Distraction	
Baseline, Passive Distraction, Interactive Distraction	18	Baseline	Passive Distraction	Interactive Distraction	
Baseline, Baseline, Interactive Distraction, Passive Distraction	16	Baseline	Baseline	Interactive Distraction	Passive Distraction
Baseline, Baseline Passive Distraction, Interactive Distraction	12			Passive Distraction	Interactive Distraction
Total	61				

Figure 1. Experimental design. Shaded trials were used in the within-subjects analyses of children's pain tolerance across experimental conditions (i.e., baseline, interactive distraction, and passive distraction). Trials within the dotted lines were used in the group by trial analysis examining whether pain tolerance improved during interactive and passive distraction over and above any improvements owing to simply undergoing two baseline cold-pressor trials.

This subtest comprises two tasks; however, for the purposes of this study, only the ''cats'' task was used because it was appropriate for the full age range of the study. In the cats subtest, children are presented a two-page set of 96 line drawings, some of which are pictures of cats and some of which are distracters. The child is instructed to make an ''X'' through all the cats as quickly as he/she can. Scores were calculated based on the efficiency index (Total Points Earned = [Correct Responses − Commission Error]/ Performance Time).

Inhibition and Set-Shifting Skills

Parents reported their child's ability to inhibit their behavior and shift their attention on the Inhibit and Shift subscales of either the BRIEF for 6-year-old children or the BRIEF-Preschool version (for children aged <6 years) (Gioia, Isquith, Guy, & Kenworthy, 2000). These measures are commonly used to obtain parental ratings of executive functioning in children. The Inhibit scale on the BRIEF measures impulsivity and inhibitory control. Lower scores indicate better inhibitory control. The Shift scale on the BRIEF measures the ability to tolerate change, switch attention, and make transitions. Lower scores indicate better attentional shift skills. The BRIEF and the BRIEF-Preschool take approximately 15–20 min for parents to complete. Possible raw scores ranged from 10.00 to 30.00 for the Inhibit subscale and from 8.00 to 24.00 for the Shift subscale.

Both the BRIEF-Preschool and original BRIEF have been found to be valid and reliable measures of executive functioning in children. Internal consistency of the BRIEF-Preschool ranges from Cronbach's α values of .85 to .97 (Gioia, et al., 2000). Internal consistency of the school-aged version of the BRIEF ranges from Cronbach's α values of .80 to .98. Both versions have also demonstrated strong temporal stability. When the BRIEF and BRIEF-Preschool were given 4.5 weeks apart to parents of school-aged and preschool children, respectively, test–retest reliability coefficients ranged from .78 to .90 for the BRIEF-Preschool. In school-aged children, the test–retest reliability was .82 (Gioia, et al., 2000).

Equipment

A portable cold-pressor apparatus was used to examine pain tolerance. The apparatus was similar to ones used in previous studies (e.g., Piira, Hayes, Goodenough, & von Baeyer, 2006; Weiss et al., 2011). An Igloo (Houston, TX) plastic ice cooler (Model Ice Cube 4) was used. An AquaClear (Italy) pump (Model K-19002) was placed on the cooler wall farthest from the participant's hand to circulate the water and prevent warming surrounding the hand. The water temperature for each cold-water task was approximately $10^{\circ}C \pm 1^{\circ}C$. Children were not permitted to keep their hands in the cold pressor longer than the uniformed ceiling of 4 min. An Emerson (St. Louis, MO) stopwatch (Model SPORT) was used to measure pain tolerance. Pain tolerance was measured to the one tenth of a second. A thermometer was placed inside the cold pressor to monitor the water temperature. A digital biofeedback monitor, purchased from Biomedical.com (Model CLF SC911), was used to measure hand temperature at baseline and between each cold-pressor trial.

The study equipment was set up in the same configuration at each study location. Adesso privacy screens (Model HX1111, Walnut, CA) were used to keep the visual environment standardized across the study settings. Three 172.7-cm-high screens were set up: one behind the 81.3-cm-high television cart, one on the left side of the participant, and one on the right side of the participant. A DVD player and a 19-inch flat-screen television were used to play the video game footage during the passive distraction task.

To provide distraction, we used the V-Smile (Arlington Heights, IL) TV Learning System (Model 80-61220). V-Smile games are designed for children aged 3–7 years. According to their parents, none of the children had played this game before. For this study, ''Journey to Paradise Falls,'' a game on the Up!© V-Smile Smartridge©, was used. In this game, children needed to navigate a house attached to balloons to collect shapes of varying colors. When they collected the shapes and balloons, a pleasant musical tone sounded. The child was also instructed to avoid hitting helicopters, airplanes, and ducks. This game was used because it could be played easily with one hand, could be played for 4 min, and was similar in format to the game used in Weiss et al.'s (2011) study of preschoolers and video game distraction. This allowed for a comparison of the results using a different game while maintaining similar procedures and video game tasks.

The video game was started at the same place with the same difficulty level for each participant. However, unlike the game used in Weiss et al.'s study, this game automatically adjusted to the level of ability of the child. For example, one task required the child to find a matching stimulus (e.g. yellow star) from an array of colored shapes, one of which was also a yellow star. If the child was not successful after several trials, the game automatically provided fewer choices or eventually all yellow stars as potential matches, so that the child was guaranteed success. Alternatively, if the child had several successful matches, the colors and shapes would appear in more

variable patterns. In addition, the visual background constantly changed (i.e., the city skyline, the presence of airplanes, ducks, or balloons) regardless of the child's skill level. This made the audio–video output entertaining even when children were less successful and when they were watching, rather than playing, the game.

Experimenters

All study procedures were conducted by the first author and by advanced undergraduate psychology students. Parents were not present during the cold-pressor trials. For 15% of participants, two experimenters were present to allow for reliability checks. Interrater reliability for pain tolerance was excellent (r (61) = .998, $p < .01$).

Procedure

Parental Informed Consent and Child Assent

Study procedures were approved by the University Institutional Review Board. Informed consent was obtained from participant's parents before any study procedures were conducted. Because of the young age of the study participants, extensive assent procedures were conducted to ensure comprehension and avoid coercion. First, the experimenter determined the child's understanding of the concept of refusal. Then, the child's willingness to participate was assessed. In addition, before each cold-pressor trial, the experimenter assessed the child's understanding of the fact that he/she could terminate the cold-pressor trial at any time. The scripts described the next section are adapted from Weiss et al. (2011).

> *Before we start playing games, I have a question for you. Do you like to eat bugs? If I asked you to eat bugs, what would you say to me? (They should say ''no''). Okay, well, just like you said ''no'' to eating bugs, it is o.k. for you to say ''no'' to playing my games today. I will not be mad at you if you decide not to play any games, and nobody else like your mom or your dad will be mad at you if you decide not to play any games. Will I be mad at you if you don't play games today? Will your mom or dad be mad at you if you do not want to play games?'' (Child needed to say no to both questions in order to continue).*

All children were able to understand the questions and answered ''no'' at the appropriate times. Of the 65 children for whom parental consent was obtained, two expressed reservations about the cold-water task, and therefore did not participate.

Baseline

Before starting the cold-pressor trial, finger temperature was measured. The child's finger temperature was also checked after each cold-pressor trial to ensure that the temperature remained stable throughout the procedures.

The experimenter read the following script to describe the cold-pressor trial.

> *We are going to play a water game. For this game, we want to see how long you can keep your hand in this cold water. Your hand may feel cold or hurt. I want you to try to keep your hand in the water for as long as you can, but take your hand out of the water when it gets too cold or hurts too much. When you are finished with this game, you will get a sticker. I have a bunch of stickers you can choose from—which kind do you want? O.k. each time you play the cold-water game, you can get one sticker!*

The experimenter also demonstrated how to place and keep his/her hand in the water. The experimenter pretended to put her hand in the water up to her wrist, waited, and after a period stated, ''It's getting cold.'' After waiting several more seconds, she stated, ''It's too cold,'' and removed her hand from the water. This demonstration was conducted to encourage children to keep their hands in the water until it became too uncomfortable instead of removing it immediately after it began to feel cold.

The experimenter then asked several questions to assess their comprehension of the instructions. First, the experimenter asked, ''I am going to put your hand in the water and what are you going to try to do?'' Children responded, ''keep my hand in the water,'' or ''leave it in the water.'' The experimenter then asked, ''When are you going to take your hand out of the water?'' The children responded ''When it gets too cold,'' or ''When it hurts too much?'' The majority of the preschool children in the study did not have any difficulty understanding the script or instructions. In a few cases, the script and probe questions needed to be repeated. Only one child was unable to demonstrate understanding of the study procedures and was eliminated from the study.

No distraction was provided during baseline. The length of time participants kept their hands in the water was recorded. One child was excluded from the analyses because the child's baseline pain tolerance reached the 4-min ceiling (resulting in a final sample of 61 children).

Immediately after the participant removed his or her hand from the cold water, the finger temperature was measured, and the child was asked to place his or her hand in a warm water bath maintained at 35°C. The

child's hand was rewarmed within 2°F of the baseline finger temperature before proceeding to the next cold-pressor trial.

Interactive Distraction

Participants were told that they would be playing a video game at the same time as they play the cold-water game. Participants were allowed to practice playing the game for 90 s. After the practice period, the game was reset to the beginning. The same start point and starting game difficulty level were used for all participants.

The experimenter reminded the children that they were going to put their hand in the cold water while they played the video game and that they should take their hand out of the water when it got too cold or hurt too much. After 10 s of game play, the experimenter placed the child's nondominant hand in the cold water and began timing. Experimenters were instructed to observe whether children were actively steering the joystick and playing the video game. None of the participants stopped playing the video game during interactive distraction. Timing stopped immediately after the child removed his/her hand from the water. Pain tolerance was recorded; finger temperature was measured; and the child's hand was rewarmed to within 2°F of their original finger temperature.

Passive Distraction

During passive distraction, children watched prerecorded video game output of the same video game segment used in the interactive distraction condition on the TV monitor. After 10 s of watching the TV, the experimenter placed the child's hand in the water and began timing. Experimenters were instructed to note whether any child appeared to stop watching the TV; none of the children appeared disinterested or stopped watching the TV. Timing stopped immediately after the child removed his/her hand from the water, and pain tolerance was recorded. Finger temperature was measured, and the child's hand was rewarmed to within 2°F of their original finger temperature.

Poststudy Procedures

After completing the study, children picked a small prize valued <$3.00. Parents were compensated $20.00 for completing study measures and transportation costs.

Analysis Plan

All continuous variables were assessed for skewness and kurtosis. Because pain tolerance scores were positively skewed, logarithmic transformed pain tolerance scores were used for all parametric inferential analyses.

Figure 1 presents the order in which participants underwent the experimental conditions. A 2×2 (order by condition) analysis of variance (ANOVA) was used to test whether order of experimental condition presentation (e.g., passive distraction first vs. second) affected pain tolerance scores obtained during baseline versus passive distraction (for children who received two baseline trials, only the last baseline was used in this analysis). A similar 2×2 ANOVA was conducted for interactive distraction.

Because order was not significant for either the interactive distraction or passive distraction conditions, the data were collapsed across order. This allowed for the primary test of the effectiveness of interactive and passive distraction relative to baseline to be conducted as completely within-subjects ANOVA comparing pain tolerance during baseline, interactive distraction, and passive distraction (for children who received two baseline trials, only the last baseline was used in this analysis) (given as shaded areas in Figure 1).

To test whether improvements in pain tolerance scores from baseline to distraction were greater than achieved merely as a function of repeated exposure to the cold-pressor testing, the sample was divided into three groups: the children who underwent two baseline trials ($n = 28$), the children who received one baseline trial followed by interactive distraction ($n = 15$), and the children who received one baseline trial followed by passive distraction ($n = 18$). A 3×2 (group × trial) ANOVA was conducted on pain tolerance scores across the first two cold-pressor trials (illustrated in portion of Figure 1 outlined by dotted lines).

Tests of moderation were examined in a series of 3×2 ANOVAs in which experimental condition (baseline, interactive distraction, passive distraction) was the within-subjects variable and the moderator of interest (i.e., age or attentional skill) was the between-subjects variable (for children who received two baseline trials, only the last baseline was used in this analysis). The degree to which age and attentional skills correlated with improvements in pain tolerance change from baseline to distraction also was calculated.

Results

Preliminary Analyses

As shown in Table I, the distribution of pain tolerance scores was significantly positively skewed and kurtotic. A $\log_{10}$ transformation of the data resulted in a more normal distribution, which was within the acceptable limits suggested by Tabachnick and Fidell (2001).

Two 2×2 (order × condition) repeated-measures ANOVA were conducted to evaluate whether order affected the degree of change in pain tolerance scores from baseline

Table I. *Descriptive Statistics for Raw and Log_{10}-Transformed Pain Tolerance Scores ($n = 61$)*

	Raw scores (in seconds)			Transformed scores (Log_{10})		
Experimental condition	*M* (*SD*)	Range	Skew	*M* (*SD*)	Range	Skew
Baseline	19.8 (15.7)	2.5–102.7	2.7*	1.2 (0.34)	0.39–2.01	−0.55
Interactive distraction	46.9 (49.4)	3.6–236.4	2.6*	1.5 (0.37)	0.60–2.40	0.15
Passive distraction	36.4 (41.6)	2.0–238.0	2.8*	1.4 (0.36)	0.30–2.40	0.09

Note. *$p < .05$.

to distraction. Neither the main effect of order nor the order by trial interaction was significant for the passive distraction condition or for the interactive distraction condition (all p values $> .25$). Therefore, the data were collapsed across order of presentation.

Primary Analyses

A within-subjects ANOVA comparing each participant's last baseline pain tolerance score with his/her pain tolerance scores during interactive distraction and passive distraction resulted in a significant main effect for experimental condition (F (2, 58) = 7.61, $p < .001$, $\eta_p^2 = .21$). Post hoc paired *t*-tests indicated that, when compared with the last baseline trial, pain tolerance scores were significantly higher during interactive distraction (t (60) = 8.25, $p < .001$) and passive distraction (t (60) = 6.47, $p < .001$). As predicted, pain tolerance during interactive distraction was significantly greater than pain tolerance during passive distraction (t (60) = 3.17, $p < .001$; Figure 2).

To examine whether improvements in pain tolerance from baseline to both distraction conditions were greater than changes resulting simply from repeated exposure to cold-pressor testing, a 3 × 2 (group × trial) ANOVA was conducted comparing the pain tolerance scores of children who underwent two baseline trials (baseline-only group) with the pain tolerances scores of the children who received one baseline trial followed by interactive distraction (interactive distraction group) and the pain tolerance scores of the children who received one baseline trial followed by passive distraction (passive distraction group). As expected, there was a significant group by trial interaction (F (2, 58) = 9.78, $p < .001$, $\eta_p^2 = .25$). A series of paired *t*-test post hoc analyses demonstrated that there was a significant increase in pain tolerance from trial 1 to trial 2 for those who received the passive distraction intervention during trial 2 (t (17) = 2.43, $p < .026$), and for those who received the interactive distraction intervention during trial 2 (t (14) = 3.59, $p < .003$). However, scores did not improve from trial 1 to trial 2 (t (27) = 1.44, $p = .162$) in the baseline-only group; repeated exposure to the cold pressor did not result in improvement in pain tolerance.

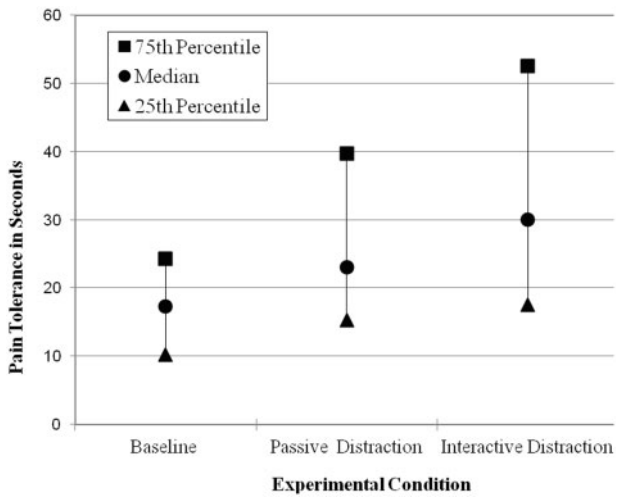

Figure 2. Medians and interquartile ranges for untransformed pain tolerance scores across baseline, passive distraction, and interactive distraction.

Moderation Analyses

Age

Age in months was not significantly correlated with baseline pain tolerance scores (r (61) = −.031, $p = .813$). Age was not significantly related to the magnitude of change in pain tolerance from baseline to interactive distraction (r (61) = −.061, $p = .642$) or to passive distraction (r (61) = −.105, $p = .420$).

To examine whether age was related to a differential response to the two distraction conditions relative to baseline, participants were divided into two age-groups: a younger (3 and 4 years old; $n = 31$) and an older (5 and 6 years old; $n = 30$) group. Each participant's last baseline pain tolerance score was compared with his/her pain tolerance scores during the interactive and the passive distraction trials in a 3 × 2 (condition × age-group) ANOVA. The results indicated a significant effect for condition (F (2, 118) = 44.02, $p < .001$, $\eta_p^2 = .43$) and for age (F(1, 59) = 33.11, $p < .001$, $\eta_p^2 = .36$), with older children demonstrating greater pain tolerance. The age by condition interaction was not significant (F (2, 118) = 0.059, $p = .94$, $\eta_p^2 = .001$).

Attention Skills

On the BRIEF Inhibit scale, scores ranged from 10 to 31, with a mean of 19.30 ($SD = 5.5$); scores on the BRIEF Shift scale ranged from 8 to 47, with a mean of 12.77 ($SD = 5.25$). NEPSY selective attention scores ranged from −0.19 to 1.05, with a mean of.29 ($SD = .18$). Participants who were older had better (i.e., lower) scores on the BRIEF Inhibit scale (r (59) = −.375, $p < .001$) and better (i.e., higher) scores on the NEPSY selective attention task (r (61) = .750, $p < .001$). There was not a significant correlation between age and scores on the BRIEF Shift scale (r (59) = .012, $p = .93$).

Scores on the BRIEF Inhibition subtest were marginally related to the magnitude of change in pain tolerance from baseline to interactive distraction (r (59) = .235, $p = .07$), but were not related to improvements during passive distraction ($p = .82$). Scores on the BRIEF Shift subscale were not related to change in pain tolerance between baseline and passive distraction or to changes during interactive distraction (all p values > .20). Finally, performance on the NEPSY selective attention task was not significantly correlated with change in pain tolerance from baseline to interactive distraction (r (61) = .131, $p = .313$) or to passive distraction (r (61) = .061, $p = .643$).

Relations between participants' selective attention, inhibit, and set-shifting skills and their differential responses to the distraction interventions were examined by dividing the sample into two groups—those who scored above the sample mean on the respective measure of attention versus those who scored below the mean—and comparing their pain tolerance scores across trials in a series of 2 (group: high vs. low) × 3 (experimental condition) ANOVAs. Children with better attentional skills were expected to obtain relatively greater benefits from interactive distraction than from passive distraction.

A mean split was used to divide the sample in terms of below-average (i.e., below 19.80; $n = 31$) or above-average (i.e., 19.80 and higher; $n = 31$) performance on the BRIEF Inhibit subscale. A 2 × 3 (Inhibit group × condition) ANOVA indicated that there was neither a significant main effect for inhibit group (F (1, 58) = 1.426, $p = .237$, $\eta_p^2 = .02$) nor a significant interaction of inhibit group by condition (F (2, 116) = 1.87, $p = .159$, $\eta_p^2 = 0.03$).

Children were placed in the below-average group for Attentional Shift performance on the BRIEF if their subscale score was below the sample mean of 12.77 ($n = 24$); the remainder were considered above average. A 2 × 3 (Attentional Shift group × condition) ANOVA indicated that there was neither a significant main effect for attentional shift group (F (1, 58) = .004, $p = .950$, $\eta_p^2 = .00$) nor a condition by attentional shift group interaction (F (2, 116) = .488, $p = .615$, $\eta_p^2 = .008$).

Participants were assigned to the below-average selective attention group if they scored below 0.289 mean on the NEPSY selective attention task ($n = 31$), and to the average-and-above selective attention group if they scored higher than 0.289 ($n = 30$). The 3 × 2 (condition × selective attention group) ANOVA revealed a significant main effect for condition and a significant main effect for selective attention (F (1, 59) = 19.135, $p < .001$, $\eta_p^2 = .25$). Children with higher NEPSY selective attention scores had higher pain tolerance. The condition by selective attention interaction was not significant (F (2, 118) = 0.69, $p = .933$, $\eta_p^2 = .001$).

Discussion

The current study used an experimental design to understand how young children respond to interactive and passive distraction for acute pain. The study also explored how differences in children's age and selective attention skills—including inhibition and set-shifting skills—influence their responses to interactive and passive distraction. The results support the utility of distraction as a pain management technique for preschool and young school-aged children, and the superior benefit of interactive distraction. Both younger and older preschool/early elementary school-aged children demonstrated greater pain tolerance during the interactive distraction condition, compared with the passive distraction condition. Although older children demonstrated superior pain tolerance overall, age and selective attention skills did not moderate children's responses to the video game distraction intervention. Taken together, these results inform and extend the literature in two main ways: (a) by demonstrating that younger preschoolers can benefit from interactive distraction to manage pain, provided that the task is developmentally appropriate, and (b) by supporting the use of cold-pressor studies in young children.

The current findings are consistent with neurocognitive models of pain that suggest that tasks that involve central executive functioning and/or more deliberate, rather than automatic, regulation of attention should be more effective in combating pain than passive tasks that require less central cognitive resources (e.g., Eccleston, 1995; Legrain et al., 2009). In the current study, the interactive task required greater central attentional resources than the passive task. In particular, children needed to manipulate the joystick to try to collect balloons and avoid hitting items. Additionally, the information on the

screen was constantly changing; children needed to constantly attend to the various demands of the game. Thus, ongoing intentional and effortful use of attentional control was involved. Finally, the interactive task also required problem-solving skills, which also engaged executive functioning.

The interactive task used in the current study appeared to be more effective than the one used by Weiss et al. (2011) with preschoolers. The mean baseline pain tolerances for both studies were similar. However, participants in the study by Weiss et al. experienced an average change of 13.57 s between the interactive distraction and baseline trial, whereas in the current study, there was an average change of 24.29 s between the interactive distraction and baseline.

There are several possible reasons why the interactive task worked better in the current study. First, the video game in the current study adjusted to the level of ability of the child, making it almost impossible for children not to succeed. This adjustment may have led to a less frustrating game-playing experience. Less frustration may have resulted in the expenditure of fewer executive functioning resources toward self-control and emotion regulation, allowing for more attention on the actual game.

In addition, the interactive task provided contingent auditory and visual feedback when the child was performing well on the game. For example, when a child collected a shape or balloon, they would gain more balloons (i.e., points) and a pleasant musical tone would play. This positive feedback may have led to increased motivation to play the game and to greater persistence in the interactive distraction task, resulting in a higher pain tolerance. Because children in the Weiss et al. (2011) study had a greater chance of being unsuccessful, less competent children in their study probably received less positive feedback.

However, it is also possible that the superiority of the interactive distraction condition was solely due to the 90-s practice period children received before the actual interactive distraction trial, which, in effect, gave them greater overall exposure to the distraction stimulus than the children in the passive distraction condition, who did not have any pretrial exposure to the game. Although possible, this competing hypothesis seems unlikely, as the analyses of order effects did not show any beneficial effect from being previously exposed to the distraction stimulus. Nonetheless, in future studies, it would be prudent to equate pretrial exposure across distraction conditions to rule out this possible confound.

The results of the current study also have a number of clinical implications. First, and perhaps most importantly, the findings support the use of interactive distraction in a young population. Even children as young as 3 years old appeared to benefit more from interactive distraction than from passive distraction. Moreover, the interactive distraction task used in this study is an inexpensive and easy-to-operate game system that could be easily accessed in medical settings. At present, passive distractor tasks, such as cartoons or books, are widely used in clinical settings to try to distract young children from acute clinical pain. This study demonstrates that interactive video games may be a viable and more effective alternative for preschoolers.

Although older children had higher pain tolerance scores overall, there was not a differential response to interactive versus passive distraction based on age. Age may not have influenced the child's response to the task because the task may have been age appropriate for all participants. The interactive technology allowing for the game to adapt to the individual child's level of performance may have negated any moderating effect of age. Age may be more relevant when the interactive distraction task is more developmentally challenging.

Contrary to predictions, parental ratings of their children's ability to adjust to changes in task demands (i.e., inhibit their behavior or to shift problem-solving strategies) were not related to their responses to interactive distraction or to the type of distraction that benefitted participants more. On the contrary, interactive distraction worked better for the majority of the participants, regardless of attentional skills. Because the BRIEF is typically used to identify executive functioning deficits in children, it is possible that this measure is not sensitive enough to detect differences among typically developing children. It is also possible that parents are not good judges of their young children's attentional skills. However, the lack of evidence for a moderating effect of attention, as assessed by the individually administered NEPSY, suggests that individual differences in selective attention were not relevant to performance on the interactive distraction task used in this study.

Strengths and Contributions to the Literature

This study contributes to the literature in several ways. Although distraction is commonly used in pediatric settings, there are limited data regarding the use of video game distraction in preschool and young school-aged children. Younger children are an important age-group to study because they are often fearful of medical procedures. Video games are now available for children of all ages and ability levels; this study demonstrates that young children can benefit from this technology.

The study results also demonstrate that developmentally appropriate interactive distraction can yield greater

benefits than passive distraction with young children, thus extending the applicability of neurocognitive and cognitive–affective models of pain to a much younger population of children. Finally, this is only the second study, to our knowledge, that demonstrates the applicability of the cold-pressor pain paradigm for preschool children. Children responded well to the procedure. Children did not appear fearful of the task. In addition, the cold pressor was portable and easily used with children of varying ages and sizes. This study, along with that by Weiss et al. (2011), supports the use of the cold pressor with young children.

Limitations and Future Directions

Considerable efforts were made to ensure that children were comfortable and understood that they were in control of how long they exposed themselves to the discomfort of the cold water. Generalization of the study findings to the inherently more chaotic clinical setting in which children are likely to be anxious and uncomfortable and not in control of painful events cannot be determined. The relatively homogenous composition of the sample in terms of social class and ethnicity also limits generalizability of the study findings.

Future research should attempt to test the relative utility of developmentally appropriate interactive video game distraction in managing preschoolers' ''real-world'' pain. Further research also should examine whether there are differences in how ethnically and socioeconomically diverse populations benefit from interactive distraction. Understanding the processes that underlie the effects of distraction on procedural pain across multiple settings and diverse populations of young children can help to refine coping interventions and our understanding of effective pain management.

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