

# The Effects of Interactive and Passive Distraction on Cold Pressor Pain in Preschool-aged Children

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**Objective** Using a mixed model design, this study examined the effects of interactive versus passive distraction on healthy preschool-aged children's cold pressor pain tolerance. **Methods** Sixty-one children aged 3–5 years were randomly assigned to one of the following: interactive distraction, passive distraction, or no distraction control. Participants underwent a baseline cold pressor trial followed by interactive distraction trial, passive distraction trial, or second baseline trial. One or two additional trials followed. Children originally assigned to distraction received the alternate distraction intervention. Controls participated in both interactive and passive distraction trials in counterbalanced order. **Results** Participants showed significantly higher pain tolerance during both interactive and passive distraction relative to baseline. The two distraction conditions did not differ. **Conclusions** Interactive and passive video game distraction appear to be effective for preschool-aged children during laboratory pain exposure. Future studies should examine whether more extensive training would enhance effects of interactive video game distraction.

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

## Introduction

A substantial body of evidence demonstrates that distraction is an effective intervention for acute pain management in children. Distraction has been shown to decrease children's behavioral distress and/or self-reported pain during a number of different medical procedures such as immunizations, intramuscular injections and port access, bone marrow aspirations and lumbar punctures, venipunctures, and burn wound care (Powers, 1999; Uman, Chambers, McGrath, & Kisely, 2006). Distraction also has been shown to affect children's experience of laboratory pain stimuli, such as cold pressor pain (e.g., Dahlquist et al., 2007; Dahlquist, Weiss, Clendaniel et al., 2009; Piira, Hayes, Goodenough, & von Baeyer, 2006).

However, emerging research suggests that the age of the child may affect how well distraction works as an acute pain management strategy. In a 1999 meta-analysis of pediatric distraction studies, Kleiber and Harper found that

intervention studies involving young children (3–7 years old) tended to have smaller effect sizes for reductions in pain (i.e., medium effect sizes, Cohen's  $d = .47$ ), compared to studies of older children, in which effect sizes tended to be medium-large (i.e.,  $d = .62$ ). It is unfortunate that distraction interventions do not have as powerful of effects for younger children because they report experiencing more pain and demonstrate more behavioral distress during medical procedures such as intravenous placements (e.g., Fanurik, Koh, & Schmitz, 2000). Therefore, investigating factors that may affect effectiveness of distraction for young children could aid development of interventions.

Recent research with older children suggests that age also may affect the relative effectiveness of different types of pain management interventions. For example, in a study of experimentally-induced cold pressor pain, Piira et al. (2006) found that 7–9-year-old children did not seem to benefit from a sensation-focusing intervention,

but did benefit from an imagery intervention, whereas 10–14-year-old children improved in both intervention conditions. Similarly, Dahlquist, Weiss, Clendaniel, et al. (2009) found that children over the age of 10 benefitted from the addition of VR technology to a video game distraction intervention, whereas 6- to 10-year-old children performed equally well with or without the addition of VR technology.

Although comparable moderation research with preschool-aged children is very limited, there is some evidence that age may affect how young children respond to different types of distraction as well. MacLaren and Cohen (2005), for example, compared interactive distraction (playing with a toy) and passive distraction (watching a cartoon movie) for 1- to 7-year-old children receiving venipunctures for surgery. In contrast to previous studies with preschoolers that had reported lower distress during interactive distraction (a musical storybook) compared to passive distraction (a cartoon movie) (Mason, Johnson, & Wooley, 1999), MacLaren and Cohen obtained lower self- and parent-reported distress in the passive distraction condition. Their findings also conflict with the results of a more recent laboratory study of passive versus interactive video game distraction with older children (aged 5–13 years) conducted by Dahlquist et al. (2007), which found that interactive distraction was more effective than passive distraction in improving cold pressor pain tolerance. Thus, it remains unclear whether interactive or passive distraction is more effective for preschool-aged children.

The current study builds on the work of Mason et al. (1999) and MacLaren and Cohen (2005) by examining the effectiveness of interactive and passive distraction with preschoolers. However, rather than comparing two different types of distraction activities that vary on many dimensions in addition to whether the distraction task is passive versus interactive, we compared two distraction tasks that varied only on the interactive-passive dimension. A modification of the procedure used by Dahlquist et al. (2007) was employed. A developmentally appropriate video game was used as the distractor and the child's ability to play with versus watch the video game was manipulated.

Although distraction using video game play has been shown to increase children's cold pressor pain tolerance (Dahlquist et al., 2007; Dahlquist, Weiss, Clendaniel et al., 2009; Dahlquist, Weiss, Law et al., 2009), and reduce children's subjective and behavioral distress during chemotherapy (Kolko & Rickard-Figueroa, 1985), nausea related to chemotherapy treatment (Redd et al., 1987), and pre-operative anxiety (Patel et al., 2006), to our knowledge, only one video game distraction study to date (Patel et al.) included any preschool-aged children in the

sample. Patel et al. found that roughly 50% of the 4- to 5-year-olds who were allowed to play with a hand-held video game during anesthesia induction appeared to benefit from the distraction intervention. However, their preschool sample was small ( $n = 12$ ), the specific type of video game used by the preschoolers was not specified, and children under the age of 4 years were not included. The current study adds to the literature by examining the efficacy of video game distraction for children between the ages of 3- and 5 years with a larger sample.

Given the limited information available about use of video game distraction with preschool-aged children, a laboratory pain task, rather than clinical pain stimulus (e.g., needle stick) was studied, thus allowing for greater control and standardization of the location, duration, and intensity of the pain stimulus and the measurement of the child's response (Edens & Gil, 1995; von Baeyer, Piira, Chambers, Trapanotto, & Zeltzer, 2005). To our knowledge, there have only been a few cold pressor studies that have included children as young as 4 years old (e.g., Roupe van der Voort, Heijnen, Wulffraat, Kuis, & Kavelaars, 2000) and no negative events were been reported. For example, in a review by Birnie, Noel, Chambers, von Bayer, and Fernandez (2010) reported only 2 of 3,000 children ages 1–18 years reported adverse reaction to the cold pressor. They concluded the cold pressor is an acceptable experimental procedure for inducing pain in children. Furthermore, we chose the cold pressor test as the pain stimulus because it was expected to be less intimidating to young children than other pain-inducing devices (e.g., finger pressure, blood pressure cuff), experience with cold-induced pain is common in children's day-to-day experience (e.g., playing with snow or ice cubes; von Baeyer et al., 2005), and children are able to control when the cold-induced pain stops by taking their hand out of the water (LeBaron et al., 1989). We replicated the cold pressor experimental design previously used by Dahlquist et al. (2007) with older children, in that each participant served as his or her own control. However, because of the young age of our sample, assent procedures were substantially modified, instructions were pilot tested and simplified, repeated reminders that the child could terminate procedures at any time were added, and the cold pressor water temperature was increased.

In summary, although there is substantial data to indicate that distraction is an effective intervention for pediatric pain, effects sizes are smaller for younger children. What types of distraction activities are most efficacious for preschoolers remains inconclusive. Therefore, the purpose of this study was to examine the relative effectiveness of interactive and passive distraction for preschool-aged

children using a well-controlled experimental study. To our knowledge, this is the first study to examine both use of video games and the cold pressor task in a relatively large sample of preschool-aged children. The primary aims of this study were: (a) to investigate the efficacy of video game distraction for preschool-aged children undergoing acute cold pressor pain, and (b) to compare the relative efficacy of interactive versus passive video game distraction for preschool-aged children. We hypothesized that the children would benefit from both interactive and passive video game distraction, as demonstrated by significant increases in cold pressor pain tolerance when compared to a baseline (no-distraction) cold pressor trial. In addition, we expected the children to demonstrate significantly greater increases in pain tolerance during interactive video game distraction than during passive video game distraction.

## Methods

### Participants

We recruited children between the ages of 3 and 5 years from two daycare centers, a preschool, and from the community. We opted not to recruit children younger than 3 years because the V.Smile game system used in this study is designed for children ages 3 years and older. Children for whom exposure to cold temperatures is contraindicated (e.g., children with Raynaud's or sickle-cell disease), with diagnosed mental retardation, hearing or vision impairments, vestibular difficulties, fainting, seizures, heart conditions, or motor disability that would interfere with using the video game equipment were not eligible to participate. None of the children who agreed to participate in the study met any of these criteria.

Sixty-seven parents consented to having their children participate in this study. Seventeen of their children attended one daycare center, 13 attended another daycare center, 19 attended the preschool, and 18 were recruited from the community. Two children declined to participate. In addition, one child decided he no longer wanted to be in the study after the baseline assessment.

We eliminated four children from the analyses: (a) one child's baseline pain tolerance met the 4-min study limit, (b) one child's baseline pain tolerance was considered an outlier (204 s) relative to the sample mean (19.91 s), (c) one child's pain tolerance met the 4-min study limit during both intervention trials, thus making it impossible to identify differential responses to the two experimental conditions, and (d) one child did not understand the task instructions.

Of the final sample of 61 children, 31 were males. The ages of participants ranged from 37 to 67 months, with a

mean age of 50.53 months ( $SD = 7.58$ ). Thirty-seven participants (61%) were Caucasian, 7 (11%) were African American, 6 (10%) were biracial, and 5 (8%) were Asian. Six parents (10%) did not report the child's race/ethnicity. Nine children (14.8%) had the V.Smile game system at home and 5 (8.2%) had played the Winnie-the-Pooh game previously.

### Design

Using a modified version of the Dahlquist et al. (2007) experimental design, we stratified participants by age (3, 4, or 5 years old) and gender and randomly assigned them to one of the following experimental conditions using the urn randomization method described by Wei and Lachin (1988): (a) interactive distraction ( $n = 19$ ); (b) passive distraction ( $n = 18$ ); or (c) no distraction control ( $n = 24$ ) (Figure 1). All participants underwent a baseline cold pressor trial in which no distraction was provided followed by an interactive distraction trial, passive distraction trial, or second baseline trial (control subjects).

During interactive distraction, participants used a joystick to play a developmentally appropriate video game displayed on a television. During passive distraction, participants watched prerecorded game output from the same video game segment used in the interactive distraction condition on the television screen but did not manipulate the video game controls. The game starting point was identical in both conditions. Thus, the visual and auditory stimuli were almost identical in both conditions. Other than slight differences that might occur during game play such as taking a different route, only the child's ability to interact with the game varied across the two distraction conditions. This design allowed us to examine whether either distraction condition resulted in improved pain tolerance over and above the effects of repeated exposure to the cold pressor test.

In order to compare the relative effectiveness of interactive and passive distraction with optimal power, each child participated in one or two additional trials. Children originally assigned to one of the two distraction conditions participated in a second distraction trial in which the distraction intervention they had not yet received was provided. Children originally assigned to the two-baseline control condition participated in both an interactive and a passive distraction trial presented in randomly assigned order. This design component allowed us to compare the children's pain tolerance scores during both of the experimental distraction conditions with their pain tolerance during the last baseline trial (Figure 1).

		Cold Pressor Trial			
Experimental Condition	<i>n</i>	1	2	3	4
Interactive Distraction (Order 1)	19	Baseline	Interactive Distraction	Passive Distraction	
Passive Distraction (Order 2)	18	Baseline	Passive Distraction	Interactive Distraction	
Two-Baseline Control	24	Baseline	Baseline	(Order 1) Interactive Distraction	Passive Distraction
				(Order 2) Passive Distraction	Interactive Distraction
Total	61				

**Figure 1.** Experimental design.

*Note.* Trials within the dotted lines were used for  $3 \times 2$  (condition  $\times$  trial) ANOVA; trials within the shaded blocks were used for within-subjects ANOVA.

## Equipment

### Cold Pressor

The cold pressor apparatus was similar to ones used in previous studies of cold pressor pain (e.g., Piira et al., 2006; Tsao et al., 2004). A 12-quart (31.12 cm  $\times$  31.12 cm  $\times$  29.85 cm) Igloo® (Houston, TX, USA) plastic ice cooler (Model: Ice Cube 14) was equipped with a Model K-19002 AquaClear® (Italy) pump in order to circulate the water and prevent localized warming around the hand, thus increasing standardization of water temperature across participants. A waterproof thermometer with a suction cup was attached to the inside surface of the cold pressor apparatus to monitor water temperature. Prior to each cold pressor trial, ice cubes were added to the water to cool and maintain the water at a temperature of  $10 \pm 1^\circ\text{C}$ . This temperature is considered safe and has been widely used without negative effects in cold pressor studies in children (von Baeyer et al., 2005). A mesh divider separated ice cubes so that they were not in contact with participants' hands.

### Stopwatch

An Emerson® (St Louis, MO, USA) Sport model stopwatch was used to measure pain tolerance to one-tenth of a second.

### Thermal Feedback System

A digital biofeedback monitor, purchased from Bio-medical.com (Model CLF SC911), was used to measure the child's finger temperature.

### Video Game Equipment

A V-Tech® (Arlington Heights, IL, USA) V.Smile TV Learning System (Model 80-61220) was used to provide distraction. This game system is similar to other popular video games systems in that it consists of a small electronic

unit that connects to a television, is manipulated via a handheld controller, and can be used to play a variety of different games. Specifically designed for children between the ages of 3 and 7 years, the V.Smile has an oversized, easily grasped controller and large, simple to use buttons. Visual and audio output for both the interactive and passive distraction was delivered via a Samsung® (Ridgefield Park, NJ, USA) 19-inch television (Model LN-T1954HA) that was mounted on a portable audiovisual cart approximately 71.1 cm high. The controller was attached to a lap desk via Velcro® to stabilize the controller for one-handed use.

We chose the "Balloon Ride" segment of the Winnie-the-Pooh V.Smile Smartridge video game for the distractor in this study because it can be played with one hand, lasts longer than 4 min, and is appropriate for preschoolers. In this game, the player navigates Winnie-the-Pooh through a forest by riding on a balloon. Along the way, the player can collect honey and should avoid pitfalls such as spiders and squirrels.

### DVD Player

We used a Sony® Precision Cinema Progressive (Model DVP-NS710H/B, San Francisco, CA, USA) DVD player to play the video game footage during the passive condition.

## Measures

### Demographic and Video Game Experience Questionnaire

Parents provided demographic information regarding the child's age, sex, ethnicity, and SES (assessed via parental employment and education), and indicated whether the child had a history of hearing difficulties, vision problems, car/motion sickness, seizures, circulation disorders, coordination problems, heart conditions, or fainting. In addition, parents reported previous video game experience.



## Setting

In three of the settings (both daycare centers and the community), we conducted the experiment in a quiet room. In the preschool setting, due to policy restrictions, we conducted the experiment in the school hallway at a time when the children were in their classrooms. To standardize the experimental setting across sites and minimize unwanted visual distractions, we used three 121.9 cm × 160 cm Adesso® (Model HX1111, Walnut, CA, USA) privacy screens. One screen was placed behind the audio-visual cart, one on the left side of the participant, and one on the right side of the participant, resulting in a three-sided, 121.9 cm × 182.9 cm enclosure. Children sat facing the audio-visual cart, with the cold pressor apparatus on their left or right side.

## Procedure

### Pilot Testing

Although the study design and procedures were based on those used by Dahlquist et al. (2007), pilot testing with two 4-year-old children was conducted to help identify where procedures should be modified for the younger sample. Based on the pilot testing, we shortened and simplified the cold pressor and distraction instructions so children would be able to understand and easily recall the instructions. We also increased the water temperature to 10°C (von Bayer et al., 2005). At this temperature, the pilot participants were able to keep their non-dominant hand submerged in the water for 18 and 26 s during baseline and 38 and 54 s during distraction. These pain tolerance times were comparable to data obtained at colder temperatures with older children (Dahlquist et al., 2007). Pilot participants did not demonstrate negative reactions to the cold water (i.e., no verbal or nonverbal hesitancy, no uncomfortable looking facial expressions, no expressed desire to discontinue). On the contrary, they appeared to enjoy the procedures and were eager to begin each trial.

### Recruitment and Parental Informed Consent

The University Institutional Review Board approved this study. We recruited participants from daycare and preschool sites during times when parents were picking up or dropping off their children. We recruited community participants via word of mouth and flyers distributed at neighborhood functions. We explained study procedures to parents and obtained informed consent at the time of recruitment.

### Child Assent

Because of the young age of participants, we took special care to ensure that children understood their right to refuse

to participate in the study and their right to stop participation at any time. The procedures described below were discussed at length with the chair of the University IRB committee, who is a developmental psychologist, and with the first author's dissertation committee, which was comprised of child clinical psychologists and a developmental psychologist.

First, we explained the basic concept of refusal (i.e., saying "no" to an adult's request). The experimenter read the following script (adapted from Dahlquist et al., 2007). Before we start playing games, I have a question for you. Do you like to eat bugs? [Child should say no.] If I asked you to eat bugs, what would you say to me? [The child was expected to say "no" or "I don't want to."]

After ascertaining that the child could verbalize that he/she would tell an adult they did not want to do something that they found unpleasant, we explained that they did not have to play the games involved in the current study and that no one would be upset with them if they wanted to stop the study procedures. We then assessed their comprehension of the fact that they could say they did not want to participate in the current research task.

The experimenter read the following script. "Okay, just like you said no to eating bugs, it is o.k. for you to say no to playing any games today. I will not be mad at you if you decide to not play any games, and nobody else, like your mom or dad, will be mad at you if you decide not to play any games." The experimenter then asked the following questions to determine the child's comprehension. "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?" All participants understood these questions and answered "no" appropriately to the questions. Although plans were in place to clarify this concept if the child expressed any confusion or could not correctly respond to probes for understanding, all children demonstrated comprehension when probed.

We then explained that the child would be playing two types of games—a water game and a video game. We explained that the goal of the water game was to try to keep his/her hand in cold water as long as possible, but that they should remove their hand from the water when it was "too cold" or "hurt too much." We reminded participants before each trial that they should withdraw their hand from the cold water whenever they chose to do so, thus reinforcing the notion of their right to terminate at any time. Finally, before each trial, the child was asked if he/she was ready to proceed, giving them an easy opportunity to stop.

The experimenters were instructed to halt study procedures if a child appeared in any way to be reluctant to

proceed (e.g., was reluctant to accompany the experimenter, sit down or place his/her hand in the water when instructed, showed an apprehensive or unhappy facial expression, cried, or expressed any verbal resistance). Any such reactions also were noted on data record sheets. Two children declined to participate. One child said “I don’t want to,” when asked to accompany the experimenter to the cold pressor set-up. The other child walked with the experimenter to the cold pressor set-up, sat down, listened to instructions, but did not move her hand toward the water when instructed. The experimenter immediately asked if she wanted to stop and stopped the study procedures when she said “yes.” A third child completed two baseline trials, listened to the explanation of the video game, but when asked if he was ready to begin the cold pressor trial, he said “no.” He showed no visible facial expression of discomfort, but seemed uninterested in the game and said he wanted to go play in the sandbox instead of doing another trial. The trial was stopped immediately. None of the other participants showed any verbal or non-verbal signs of hesitancy or unhappiness during the study procedures. The experimenters met with teachers daily and with the child’s parent at the end of the day they participated in the study. No concerns were expressed by parents or teachers.

### **Experimenters**

Two advanced child clinical graduate students with several years of supervised clinical training and eight undergraduate research assistants served as experimenters. One of the graduate students supervised each trial. One experimenter read instructions to the participant and the other took their finger temperature and recorded pain tolerance. All experimenters had completed university and university hospital research ethics training programs; the graduate students also had extensive didactic training in research and clinical ethics.

### **Cold Pressor Trials**

We assessed hand dominance by asking the child which hand they write with or by asking them to draw something. Only one participant was left-handed. We measured finger temperature of their nondominant hand with the biofeedback sensor.

The experimenter read the following instructions (adapted from Dahlquist et al., 2007). “First, 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 is too cold or hurts too

much. Each time you play the cold water game, you can get one sticker. When we put your hand in the water, make sure to keep your hand open (modeled by experimenter) and the water should reach your wrist (modeled by experimenter).”

As a comprehension check, we then asked the following questions. “So, let’s make sure you understand. I’m going to put your hand in the water. What are you going to try to do? (child should reply, ‘keep it in’) ‘When are you going to take your hand out of the water?’ (child should reply, ‘when it is too cold or hurts too much’). Okay, are you ready to begin? [Wait for child to say ‘yes.’] Great! Let’s see how long you can keep it in.” If the child’s answers did not demonstrate understanding of the directions, we repeated the directions and reassessed comprehension. We excluded one child from the study because he was not able to communicate that he understood the instructions.

The chair and water cooler were positioned so that the participants could comfortably place their hand in the water. We then instructed the child to put his/her nondominant hand in the water (so that the dominant hand would be available to play the video game) and assisted the child if necessary. The amount of time participants kept their hand in the water was measured to the tenth of a second. Participants were not allowed to keep their hand in the water for more than 4 min, which is the ceiling most commonly used in cold pressor studies (von Baeyer et al., 2005). Participants were not informed of the ceiling. After participants removed their hand from the water, a researcher placed the temperature sensor on their finger of their non-dominant hand in order to assess their finger temperature. Then, we asked participants to place their hand in a warm water bath of  $\sim 35^{\circ}\text{C}$  in order to warm their hand within  $2^{\circ}\text{C}$  of their baseline finger temperature. Re-warming typically took around 5–10 min.

After the baseline trial(s), participants either experienced the interactive or passive distraction trial, dependent upon random assignment. For interactive distraction, we told participants that they were going to play a video game at the same time as they played the cold water game. We demonstrated how to use the joystick. Then, participants were allowed up to three minutes to practice playing the game, since most participants were unfamiliar with the game equipment and how to play video games in general. After practicing, we told them that they were going to put their hand in the cold water again while they played the game. We repeated the instructions regarding taking their hand out of the water. At the start of the trial, participants played the game for 10 s before the research assistant helped them put their hand in the water. We then

Table 1. *Descriptive Statistics for Raw and Transformed Pain Tolerance Scores*

Variable	Raw scores				Transformed scores (log)		
	<i>n</i>	<i>M (SD)</i>	Range	Skew	<i>M (SD)</i>	Range	Skew
Baseline	61	19.91 (22.19)	2.00–149.08	3.83 <sup>a</sup>	1.15 (0.35)	0.30–2.17	0.30
Interactive distraction	60	33.48 (44.55)	1.78–240.00	3.19 <sup>a</sup>	1.32 (0.40)	0.25–2.38	0.41 <sup>a</sup>
Passive distraction	60	29.12 (29.17)	3.02–160.06	2.80 <sup>a</sup>	1.32 (0.36)	0.48–2.20	0.01

<sup>a</sup>Significant skew.

measured pain tolerance, assessed finger temperature, and re-warmed participants' hands.

For the passive distraction trial, we told children that they would watch the TV to see what happened when another person played the Winnie-the-Pooh video game while they put their hand in the cold water. We repeated the instructions regarding taking their hand out of the water. Participants watched the video for 10 s before we helped them put their hand in the water. We measured pain tolerance, assessed finger temperature, and re-warmed participants' hands.<sup>1</sup>

When participants were finished with the experiment, we asked them about previous experience with the game, if they liked the game, specific things they liked or disliked about the game, if the game was difficult, and if they would play it again if they had the chance. Children received a sticker after each cold pressor trial and a small prize valued at no more than \$5.00 for their participation; parents received a \$20 Target© gift card.

### Data Analytic Plan

First, we examined the data to establish if distributions were normal. We conducted appropriate transformations as necessary according to Tabachnick and Fidell (2001). Second, we examined if there were differences between groups for gender (chi-square), ethnicity (chi-square) and SES [analysis of variance (ANOVA)]. Third, to test if changes in pain tolerance from baseline to distraction trials were significantly greater than changes resulting simply from repeated exposure to the cold pressor (i.e., two baseline trials), we conducted a  $3 \times 2$  (experimental condition  $\times$  Trial) ANOVA. Fourth, we conducted two  $2 \times 2$  (order  $\times$  Trial) repeated measures ANOVAs to determine whether the order in which children participated in the two distraction interventions affected their pain condition scores. Fifth, after collapsing across order, we conducted within-subjects ANOVA to compare each child's last baseline trial pain tolerance with pain tolerance during interactive and passive distraction trials. Finally,

<sup>1</sup>Training instructions for the distraction conditions are available from the first author.

we utilized univariate regression to examine effects of age on the magnitude of change in pain tolerance observed during the two distraction conditions relative to the child's last baseline trial.

## Results

### Preliminary Analyses

Pain tolerance scores evidenced significant positive skew (Table 1). In accordance with Tabachnick and Fidell's (2001) guidelines, we conducted both logarithmic and square root transformations. The logarithmic transformation resulted in a more normal distribution; therefore, we used these transformed pain tolerance scores in all analyses. We presented untransformed pain tolerance scores in figures in order to facilitate interpretation.

### Demographic Variables

There were no differences between the three experimental groups (control, interactive distraction, and passive distraction) in gender, ethnicity, or SES ( $p$ 's  $> .6$ ). Independent  $t$ -tests indicated that there were no differences in baseline pain tolerance between boys and girls ( $p = .76$ ), between Caucasian ( $n = 37$ ) and non-Caucasian ( $n = 19$ ) children ( $p = .49$ ), or between children recruited from daycare, pre-school, and the community,  $F(2, 58) = 1.19$ ,  $p = .31$ .

### Effects of Interactive and Passive Distraction

#### Preliminary Analyses

To test whether interactive or passive distraction resulted in improved pain tolerance over and above the effects of repeated exposure to the cold pressor test, we conducted a  $3 \times 2$  (experimental condition  $\times$  Trial) ANOVA to examine changes in pain tolerance from Trials 1 to 2. Experimental condition (two baseline control, interactive distraction, passive distraction) was the between subjects factor and trial was the within-subjects factor. The results revealed a significant experimental condition by trial interaction,  $F(2, 58) = 3.65$ ,  $p = .03$ ,  $\eta_p^2 = 0.11$ , power = .65. According to Bakeman (2005), this effect size can be considered small. A series of paired  $t$ -test post hoc analyses revealed that, when compared to their baseline pain

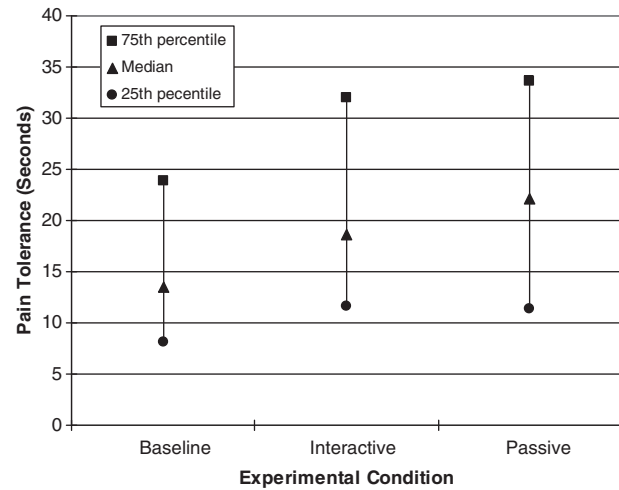
tolerance scores, children who received the passive distraction intervention demonstrated a significant increase in pain tolerance,  $M (SD)$  for Trials 1 and 2 = 1.20 (0.30) versus 1.39 (0.38),  $t(18) = 2.64$ ,  $p = .02$ . However, although the Trial 2 pain tolerance scores of the children who received interactive distraction also appeared to improve,  $M (SD)$  for Trials 1 and 2 = 1.19 (0.39) versus 1.30 (0.40), the magnitude of improvement was not significant,  $t(18) = 1.32$ ,  $p = 0.20$ . The pain tolerance scores of the control participants who underwent two cold pressor trials without distraction did not change significantly,  $M (SD)$  for Trials 1 and 2 = 1.11 (0.32) versus 1.04 (0.33),  $t(22) = 1.12$ ,  $p = 0.27$ .

### Order Effects

To determine whether the order in which children participated in the passive distraction intervention affected their pain tolerance scores, we conducted a  $2 \times 2$  repeated measures ANOVAs in which order (passive distraction first vs. passive distraction second) was the between-subjects variable and trial (last baseline vs. passive distraction) was the within-subjects variable. A similar  $2 \times 2$  (order trial) ANOVA was conducted to test for order effects for the interactive distraction intervention. Neither the main effect of Order nor the Order by Trial interaction was significant for either the passive distraction or the interactive distraction condition (all  $p$ 's > .29). Therefore, we collapsed the data across the two orders of presentation for the subsequent within-subjects analyses.

### Relative Efficacy of Interactive and Passive Distraction

In order to compare the relative efficacy of interactive and passive distraction with maximum power, we compared each child's last baseline pain tolerance score (i.e., Trial 1 for single baseline participants; Trial 2 for two baseline participants) with his or her pain tolerance scores during interactive distraction and during passive distraction. The results of this within-subjects ANOVA revealed a significant main effect for experimental condition,  $F(2, 118) = 11.52$ ,  $p < .001$ ,  $\eta_p^2 = .16$ , power = .99 (Figure 2). This effect size is medium (Bakeman, 2005). Paired  $t$ -tests indicated that when compared to baseline [ $M = 1.14$ , 95% confidence interval (CI) 1.05–1.23], pain tolerance was significantly higher during both the interactive distraction ( $M = 1.32$ , 95% CI 1.22–1.42),  $t(59) = 4.26$ ,  $p < .001$ , and the passive distraction ( $M = 1.32$ , 95% CI 1.23–1.41) conditions,  $t(59) = 3.82$ ,  $p < .001$ . The interactive and passive distraction conditions did not differ significantly,  $t(59) = .03$ ,  $p = .98$ .



**Figure 2.** Medians and inter-quartile ranges for untransformed pain tolerance scores across experimental conditions ( $n = 61$ ).

### Age Analyses

In order to examine possible age effects in children's responses to the two distraction interventions, we calculated residualized change scores by regressing the pain tolerance score obtained during the respective distraction trial on the baseline pain tolerance score. Age was positively correlated with the magnitude of change in pain tolerance in the interactive condition,  $r(58) = .26$ ,  $p = .02$ . Older children demonstrated greater improvement from baseline in the interactive condition than younger children. However, the relation between age and change in pain tolerance in the passive condition was only marginally significant,  $r(58) = .20$ ,  $p = .06$ .

### Qualitative Data

Of the 60 participants who completed the study and were asked several qualitative questions, 43 (70.5%) reported they had not played the Winnie-the-Pooh game previously, 16 (26.2%) reported they had played the game before, and 1 did not respond. All 60 participants reported they liked the game, although 27 (44.3%) reported it was "hard". When asked what they liked about the game, the majority of children reported aspects of the game such as using the joystick, seeing Winnie-the-Pooh move around, the balloons, the honey, and the different colors of balloons and honey pots. Twenty-three (54.1%) participants reported there were some aspects of the game they did not like. Examples included things such as obstacles in the game and trying to get the honey. Although some children did report the game was difficult and there were things about the game they did not like, 51 (83.6%) reported they



would play the game again if they had the chance. Of those who said they would not play again, reasons included the game was too hard and they would prefer to play a different game.

## Discussion

The results of this study demonstrate that developmentally appropriate video game distraction is a potentially efficacious acute pain management technique for preschool-aged children. Participants demonstrated higher cold pressor pain tolerance during both interactive and passive video game distraction when compared to baseline. Effect sizes were comparable to that found in Kleiber and Harper's (1999) meta-analysis. These improvements did not appear to be merely the result of repeated exposure to the cold pressor. To our knowledge, this is the first study to demonstrate the efficacy of video game distraction specifically for preschoolers.

The present study also adds to the literature by carefully controlling the stimuli used to provide interactive and passive distraction, such that the two distractive conditions varied only in terms of the degree of interaction involved in the distraction. In contrast to the results obtained by Dahlquist et al. (2007), however, the interactive and the passive distraction conditions tested in this study did not differ in efficacy. Several factors may account for this discrepancy. First, the children in the current study were much younger than the 5- to 13-year-old children in the Dahlquist et al. study. It is possible that interactive distraction does not offer the same added benefit over and above passive distraction for children under the age of 5 years. Although the small number of 5-year-olds in the present study ( $n = 10$ ) hampered the testing of age effects, the modest correlation between age and the magnitude of the child's improvement in pain tolerance during interactive distraction suggests that the older preschoolers benefitted from the interactive distraction interaction to a greater extent than the younger children.

Rapid changes in the development of the prefrontal cortex occur between the ages of 2 and 7 years (Sinclair & Taylor, 2008). It is possible that children may need more fully developed cognitive abilities, such as the selective attention or sustained attention skills that emerge during this developmental period, in order to engage in the "top-down" central attentional control processes hypothesized to be involved in interactive distraction (Eccleston, 1995; Legrain et al., 2009). Future studies should include larger samples and more equal numbers of 3-, 4- and 5-year-old children, and include measures of attention or

other cognitive skills, in order to determine if there is a developmental point at which interactive distraction becomes more effective than passive distraction.

It is also possible that the novelty of the interactive distraction task used in this study limited its effectiveness. Only nine of the parents reported that their children had a V.Smile at home and an additional four parents reported that their children had played the V.Smile at a friend's house. By parent report, only one child had played the Winnie-the-Pooh game previously. Although all of the children demonstrated the ability to use the game system and reported enjoyment playing the game, it is possible that they were not yet adept enough with the game to maintain optimal engagement with it. Additional training and practice with the video game system or the video game itself may be necessary in order to maximize its effectiveness as an interactive distractor for preschool-aged children. Alternatively, it is also possible that we allowed children too much time playing the video game. After 3 min of practice prior to the interactive trial, children might have lost interest in the game and discontinued prematurely.

On the other hand, it is also plausible that the novelty of the cold pressor task interfered with the children's ability to direct attentional resources towards interacting with the video game (Eccleston and Crombez, 1999). Anecdotally, the children in this study were noticeably more interested in the cold pressor task compared to older children who have engaged in very similar tasks in our research lab. Future research could allow more practice with the cold pressor task and assess if this results in better engagement with distraction for young children.

Finally, the passive distraction task might have been more enjoyable and elicited more positive affect than we had expected given our previous experience with older children. Anecdotally, the children in this study appeared much more interested in watching the video game footage than the older children in our previous studies. This is reasonable given that children of this age often enjoy watching cartoons and the video footage was similar to what they might see on an animated show.

To our knowledge, this is also the first study to employ an experimental pain paradigm using the cold pressor task with an entirely preschool-aged sample. Our experience suggests that the cold pressor task is well suited to young children. The children did not appear to be afraid of putting their hand in the cold water. In fact, most children expressed amusement with the cold pressor and were very interested in looking at their hands while they were in the water. Nearly all of the children seemed to enjoy the experimental tasks and did not object to undergoing the three or four repeated cold pressor trials. Only three

children (aged 41–58 months) were uncomfortable enough to terminate or refuse procedures.

The generally positive responses of these young children to the cold pressor may have been facilitated by the careful efforts on the part of the experimenters to establish rapport and the fact that all consent procedures and instructions were specifically geared to the developmental level of the subjects. The clinical skill of the experimenters and the careful efforts to ensure that the child demonstrated understanding of any instruction also likely contributed to making the experience nonthreatening.

### **Limitations and Future Directions**

Since most participants reported they enjoyed playing the game, would play it again, and were able to describe details of the game that they liked and disliked, it seems that the majority were engaged with the distraction tasks. However, it would have been helpful to videotape the experiment or have another research assistant available to record behavioral observations such as how much time during the task participants were actually looking at the television screen versus around the room or at the water cooler as a more precise measure of engagement. Also, it is possible that a longer pre-immersion acclimation period might facilitate response to distraction.

We opted not to measure pain intensity in this study due to concerns that this could interfere with the distraction task and influence performance by drawing attention to the pain (Eccleston, 1995). In addition, we were concerned that young children would not be able to reliably distinguish between the sensations experienced during the cold pressor trial and the sensations experienced after they withdrew their hand (which can be quite different) in order to make a reliable retrospective rating of pain intensity experienced during the cold pressor trial. However, future researchers could measure pain intensity retrospectively to examine if children this age can be reliable retrospective reporters of pain intensity when using the cold pressor.

Although the results of this study suggest that both passive and interactive distraction can be efficacious for acute pain management in preschool-aged children, the degree to which the current findings would generalize to the clinical environment remains to be tested. The very procedures that emphasized the children's right to terminate the study at any time most likely also gave children a heightened sense of control over the noxious (cold water) stimulus. In a clinical setting, however, children are less likely to have control over painful events, which may heighten fear and alter their responses to distraction. Future research is needed to determine the potential moderating effects of anxiety on young children's ability to

benefit from interactive and passive distraction while undergoing acutely painful medical procedures.

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