Developmental Psychology
2009, Vol. 45, No. 1, 272–283

0012-1649/09/$12.00 DOI: 10.1037/a0014168

Avoiding the Potential Pitfalls of Using Negative Priming Tasks in Developmental Studies: Assessing Inhibitory Control in Children, Adolescents, and Adults

Verena E. Pritchard and Ewald Neumann
University of Canterbury

Despite being ignored, visual distractors often produce traceable negative priming (NP) effects that can be used to investigate inhibitory processes. Robust NP effects are typically found with young adults, but not with children. Using 2 different NP tasks, the authors compared NP in 5 different age groups spanning 5 to 25 years of age. The 1st task revealed comparable NP between all age groups, but a linear decrease in NP through childhood to early adulthood. In the 2nd task, NP decreased linearly into adulthood, with children actually showing larger NP than adults. This Age Group × NP interaction was eliminated, however, when reaction time data were log transformed to control for age differences in overall processing speed. When appropriately transformed data were used, both experiments showed that NP was intact and comparable between children, adolescents, and adults, and suggested that an inhibitory process is fully developed by early childhood. The results highlight how potential pitfalls might be avoided when comparing NP in children and adults.

Keywords: negative priming, inhibition, selective attention, general processing speed, cognitive development

A wide array of suppression tasks have been used to examine the development of inhibitory control processes in children. Although it is well recognized that certain inhibitory abilities evolve over a prolonged developmental trajectory, there is increasing evidence that others emerge functionally intact in early childhood (Lechuga, Moreno, Pelegrina, Gomez-Ariza, & Bajo, 2006). For instance, studies within the go/no-go, task-switching, stop-signal, and Simon paradigms show that children's abilities to prevent a prepotent response and to suppress one reaction and activate another undergo considerable improvement during the age span of 3 to 14 years (Davidson, Amso, Anderson, & Diamond, 2006; Johnstone et al., 2007; Zelazo, Craik, & Booth, 2004), whereas work within the retrieval-induced-forgetting (RIF) paradigm (Anderson, Bjork, & Bjork, 1994) shows an inhibition-based effect in memory that is comparable in 7-year-old children and adults (Ford, Keating, & Patel, 2004; Lechuga et al., 2006).

The negative priming (NP) procedure is believed to index an inhibitory process in selective attention similar to that involved in suppressing response-competitive but task-irrelevant items during the retrieval of a targeted item from memory (Anderson & Spellman, 1995; Neumann, Cherau, Hood, & Steinnagel, 1993; Neumann & DeSchepper, 1992). Recent evidence suggests that children are capable of producing intact inhibitory effects in NP tasks (Pritchard & Neumann, 2004); however, little is known about the comparability of NP between children and adults. In the present study, we question the long-held view that the magnitude of inhibition children produce in an identity-based NP task is substantially less than that produced by adults (Tipper, Bourque, Anderson, & Brehaut, 1989).

The majority of research on suppression abilities in children is compatible with the assertion that the ability to inhibit task-irrelevant information increases throughout the middle childhood years and beyond (Dempster & Corkill, 1999; Harnishfeger & Bjorklund, 1994; Kail, 2002; Wilson & Kipp, 1998). However, multiple constructs of inhibition can be discerned in a burgeoning literature on the role of inhibitory ability in cognitive development (see Kok, 1999, for a review). Several authors have drawn distinctions between conscious or deliberate cognitive inhibitory processes and more automatic or less intentional inhibitory processes that function with no awareness on the part of the individual (Harnishfeger, 1995; Nigg, 2000). Lechuga et al. (2006) argued that the ability to suppress unwanted and interfering memories in a RIF task involves an unintentional type of inhibitory control process. To account for the increasing evidence of comparable inhibitory effects in children and adults in the RIF literature, these authors concluded that less deliberate inhibitory control processes, such as those accessed by the RIF procedure, might reach adult-like function early in development. To date, however, research on such processes is limited, and conclusions are restricted to the memory domain.

A means to study the developmental course of a relatively automatic inhibitory control process in visual selective attention is the NP procedure (Tipper, 1985). Typically indexed over a series of sequential trials containing simultaneous target and distractor displays, NP refers to slowed or less accurate responses to a target stimulus on a probe trial when that stimulus or close categorical

---

Verena E. Pritchard and Ewald Neumann, Department of Psychology, University of Canterbury, Christchurch, New Zealand.

Correspondence concerning this article should be addressed to Ewald Neumann, Department of Psychology, University of Canterbury, Private Bag 4800, Christchurch, New Zealand. E-mail: ewald.neumann@canterbury.ac.nz

relation was ignored as a distractor on the preceding prime trial (i.e., the ignored repetition [IR] condition) relative to trials where probe target and prime distractor are unrelated (i.e., the control condition). The magnitude of NP is gauged by subtracting the time taken to respond to target stimuli on control probe trials from the time taken to respond on IR probe trials. Young adults typically produce robust NP effects across a wide range of stimulus types, including Stroop items, pictures, letters, words, and novel shapes, suggesting that the processing of irrelevant information plays an integral part in visual selection (see Fox, 1995, for a review).

Extensively studied in adults, NP is believed to reflect an inhibitory component of selective attention that operates to suppress the mental representations of potentially distracting information (Grison, Tipper, & Hewitt, 2005; Tipper, 2001). This process seems dedicated to suppressing the severest competitor to a concurrent target, thereby producing a cost when such an item is re-presented as a target. The inhibition-based account of NP incorporates dual process models of attention in which the internal representations for target and distractor items are activated in parallel during initial perceptual exposure. To facilitate a task-relevant response, an excitatory process acts to enhance target information, whereas an inhibitory process acts to suppress distractor information (Houghton & Tipper, 1994; Neumann & DeSchepper, 1991, 1992; Neumann, McCloskey, & Felio, 1999). By this account, NP reflects an automatic inhibitory process in the sense that it can be an emergent by-product of responding to a target stimulus in the presence of a response-competitive distractor.

NP effects based on stimulus identity are widely seen as an index of inhibitory efficiency, with reduced or exaggerated effects often coinciding with cognitive difficulties or even psychopathology (MacQueen, Galway, Goldberg, & Tipper, 2003; Sullivan, Faust, & Balota, 1995; Tipper & Baylis, 1987). Despite the important role this selective inhibitory process may play in everyday cognition, very little is known about its developmental course. In fact, although empirical research is beginning to establish the existence of reliable NP effects associated with location in infants and children (Amso & Johnston, 2005; Simone & McCormick, 1999),[1] the position of identity-based NP in children remains tenuous. This issue rests largely on direct discrepancies between the results of the only two studies to date to investigate identity NP in young children (Pritchard & Neumann, 2004, vs. Tipper et al., 1989); the earlier study showed reduced or even absent NP in children compared to adults, and the later study showed intact NP in children. Therefore, an important issue to address is whether or not there are developmental differences in NP.

If inhibitory control processes track a general developmental pathway, as most research seems to suggest, one indicator should be age-related increments in NP. Alternatively, if children produce larger NP effects than adolescents and adults, this may suggest that because children typically encounter greater distractor interference than adults (see Harnishfeger & Bjorklund, 1994), they may also require a stronger level of inhibition to overcome this difficulty. For instance, a study by Bub, Masson, and Lalonde (2006) examining children's ability to switch between different task demands found that 8-year-old children took longer than older children to re-respond to information that had been previously ignored as task-irrelevant information. To account for the increased response delay in younger children, Bub et al. suggested that this age group might have resorted to greater levels of inhibition than older children to combat an increased susceptibility to interference from distracting stimuli, with the result that it took longer for this age group to overcome inhibition when responding to a previously task-irrelevant item (see also Muller, Dick, Gela, Overton, & Zelazo, 2006).

In the present study, we tracked NP effects associated with stimulus identity across an age range more extended than any previously investigated. A potential finding that NP increases during childhood and adolescence and levels off in early adulthood may help to delineate the brain regions subserving the underlying inhibitory process and may also provide some insight into when developmental improvement in that aspect of inhibition occurs. In particular, the main goal of this study was to provide further empirical assessment of developmental NP effects in light of the discordant findings in this literature.

Considering Discrepant Findings in the Developmental Literature on Identity-Based NP

To date, the study by Tipper et al. (1989) remains the only published work that compares identity NP effects between children and adults.[2] In an effort to account for children's greater susceptibility to distractor interference, Tipper et al. used an NP variant of the Stroop task, in which participants name the print colors of incongruent color words (e.g., the word *blue* printed in yellow) in control and IR conditions, to compare NP between children and adults. In line with their hypothesis that NP would be smaller in children than adults, Tipper et al. found no evidence for intact NP in this age group relative to adults. A further experiment by these authors using pictorial stimuli produced a similar result, leading them to conclude that the inhibitory process underlying NP may not mature before late childhood. In direct contrast, however, a more recent study by Pritchard and Neumann (2004) using Stroop stimuli and colored flanker stimuli found intact NP in children as young as 5 years old.

In an attempt to resolve this discrepancy, Pritchard and Neumann (2004) suggested that NP may not be developmentally mediated. Instead, they proposed that variation between experimental designs may modulate NP in children more than adults. To support this idea, Pritchard and Neumann (2004) pointed toward seemingly minor but potentially pertinent differences in methodology between their experiments and Tipper et al.'s (1989) Stroop NP experiment. Although both experiments used control and IR trials in which the distractor stimuli were highly response competitive with target stimuli, Tipper et al.'s experiment also included neutral and repeated-distractor (RD) trials where the distractors were significantly less response competitive with targets. Because NP failed to emerge in children in an experiment including neutral and RD trials but emerged intact in an experiment excluding such trials, Pritchard and Neumann (2004) proposed that children may

---

[1] See Houde & Guichart (2001), Muller et al. (2006), and Perret, Paour, & Blaye (2003) for findings of intact NP in children in knowledge level transition and attention-switching paradigms.

[2] During the review process, we became aware of another study comparing identity NP effects in children and adults (i.e., Frings, Feix, Röthig, Brüsser, & Junge, 2007).

be more likely to produce NP in experimental contexts where there is a high degree of target selection difficulty and where expectations of highly conflicting stimuli are maintained in an experiment-wide manner. They concluded that the NP effects children produce in such developmentally suited NP task designs may in fact be comparable to young adults.

The Present Experiments

In the current study, we had five aims. First, we revisited the experimental procedures involving NP variations on the Stroop and flanker tasks used by Pritchard and Neumann (2004) to determine whether the NP effects produced by 5- to 12-year-old children (see Pritchard & Neumann, 2004, from which the present 5- to 12-year-olds' data were derived) would in fact map directly onto NP produced by young adults. Our second aim was to provide some insight into the developmental trajectory of NP. We thus compared NP effects across five distinct age groups: 5- to 7-year-olds versus 8- to 9-year-olds versus 10- to 12-year-olds versus 13- to 17-year-olds versus 19- to 25-year-olds. Because we also wanted to determine the stability of any potential differences or similarities in NP obtained for the five different age groups, our third aim was to assess NP over the two tasks differing in stimulus type.

Fourth, and more generally, although there is general consensus that NP is the consequence of ignoring task-irrelevant information, there is less agreement on the precise process that underlies the effect. An alternative account suggests that NP may reflect episodic memory-based retrieval processes rather than inhibitory processes (e.g., Neill & Valdes, 1992; Neill, Valdes, Terry, & Gorfein, 1992). The existence of this anti-inhibitory account of NP makes conclusions concerning the development of inhibitory control processes less straightforward. However, to date, all theoretical accounts negating the role of inhibition in NP were generated on the basis of research involving adults. We therefore also wanted to briefly consider the implications of the outcomes concerning the comparability of NP in children and adults for the episodic retrieval account of NP in the General Discussion section.

Finally, because we predicted that children's overall response time (RT) would be slower than that of adolescents and adults, we also wished to insure that any age-related differences or similarities in NP were not attributable to slowed processing speed. A number of studies indicate that when RT is the major dependent variable, age-related differences in cognitive performance may not necessarily reflect changes within a particular cognitive domain but may rather be the result of general changes in processing speed (e.g., Cerella, 1990; Christ, White, Mandernach, & Keys, 2001; Hale, Lima, & Myerson, 1991; Salthouse, 1995).

Without transforming RT latencies to a standardized or additive constant via a *z*-score or log transformation to correct for age-related differences in overall response speed, an Age Group × Experimental Condition interaction observed with raw RT data may be a false positive (for detailed discussion of this issue, see Bush, Hess, & Wolford, 1993; Faust, Balota, Spieler, & Ferraro, 1999). For instance, Faust et al. (1999) ran a series of Monte Carlo simulations to evaluate the performance of analyses of raw and transformed response latencies. They demonstrated that when delayed response in experimental relative to baseline conditions is taken to reflect a particular cognitive process, an Age Group × Experimental Condition interaction obtained with raw RT data may sometimes be an overadditive one, whereby the slower group produces a larger experimental effect (for examples, see Christ et al., 2001; Pratt, Abrams, & Chasteen, 1997).

We therefore analyzed our data by comparing the results of analyses using raw and transformed response latencies. To anticipate, when raw RT data were used to compare performance in control and IR conditions, NP for Stroop stimuli in Experiment 1 was intact and comparable in children and adults, but there was a significant linear decrease in NP through childhood to early adulthood. Even more unexpectedly, NP for flanker stimuli in Experiment 2 was significant in children but not in adults. It is important to note, however, that in both cases when appropriately log-transformed RT data were used to control for the potentially confounding influence of age group differences in overall RT, the apparent Age Group × Priming Condition interactions were eliminated. The results of these analyses confirmed that NP was intact and comparable in children and adults for both the Stroop and flanker NP tasks. When transformed RT data were used, there was in fact no hint of any decrease in NP across childhood through adolescence to early adulthood for either stimulus type. These analyses are discussed in detail in the *Results* sections of Experiments 1 and 2.

General Procedure

The participants in Experiments 1 and 2 were recruited on a volunteer basis through advertising at local schools and community resources. Written consent was obtained from parents for children and adolescents (under 18) and from participants above consenting age (18 and over). All participants had normal color vision and normal or corrected-to-normal visual acuity. Experiments 1 and 2 were conducted on separate days, and the testing procedures for each took place either at the schools involved or at the laboratories of the Department of Psychology at the University of Canterbury, Christchurch, New Zealand.

Experiment 1

Experiment 1 used Pritchard and Neumann's (2004) NP experimental design to compare NP effects produced for Stroop stimuli in 5- to 12-year-old children and 19- to 25-year-old adults. Following the developmental premise that children are characterized by diminished inhibitory control, NP is expected to be larger in adults than children. The inclusion of the adolescent participants (ages 13 to 17) afforded the opportunity to track any potential age-related increments in NP.

Method

Participants. A total of 150 children, 54 adolescents, and 40 university-age adults participated in Experiment 1. They were grouped according to approximate age (i.e., fifty 5- to 7-year-olds, fifty 8- to 9-year-olds, fifty 10- to 12-year-olds, fifty-four 13- to 17-year-olds, and forty 19- to 25-year-olds). The average age for the first group (5- to 7-year-olds) was 6 years 3 months (range: 5 years 2 months to 7 years 1 month). The average age for the second group (8- to 9-year-olds) was 8 years 8 months (range: 8 years 0 months to 9 years 11 months); 1 child turned 10 between the two testing days. The average age for the third group (10- to 12-year-olds) was 11 years 9 months (range: 10 years 10 months to 12 years 11 months); 3 children turned 13 between the two testing days. The average age for the fourth group (13- to 17-year-olds) was 15 years 5 months (range: 13 years 1 month to 17 years 6 months). The average age for the fifth group (19- to 25-year-olds) was 22 years 7 months (range: 19 years 3 months to 24 years 11 months). No differences in the proportion of males and females were found between the groups (*p*s > .97). Data on the socioeconomic background of the participants were not collected.

Design. A mixed design was used. The between-subjects variable was age group (5.2–7.1 years vs. 8.0–9.9 years vs. 10.8–12.9 years vs. 13.1–17.4 years vs. 19.3–24.9 years). The within-subject variable was priming condition (control vs. IR). Trials consisted of 50% control (where neither the print color nor distractor color word in a Stroop NP stimulus were related to the subsequent Stroop NP stimulus) and 50% IR (where the distractor word in the previous Stroop NP stimulus named the subsequent target print color*)*.

Stimuli and apparatus. The stimuli were presented on 26 × 18 cm cards and consisted of the words *GREEN, PINK, BROWN, BLACK, GRAY, YELLOW, WHITE, RED, BLUE, ORANGE,* and *PURPLE*. On each control and IR card all color words were arranged as a single vertical column against a light gray background. The print of each word was presented in one of the 11 corresponding colors, with the constraint that the print color and color word were incongruent (see Figure 1). Each Stroop item measured 1.0 cm in height, with each display spaced at 1.0 cm intervals down the list. The first two items on each IR card were unrelated, to reduce the potential saliency of this condition. The 12 cards used in the experiment consisted of 6 control cards and 6 IR cards. Four additional control cards were used for practice trials. Presentation orders in the experiment proper were counterbalanced so that half of the participants began with an IR card and the remaining half with a control card. Subsequent cards were presented in regular alternation of the two conditions.[3] A stopwatch was used to record the response latencies to complete color naming for each card, and error scores were tabulated by the experimenters.

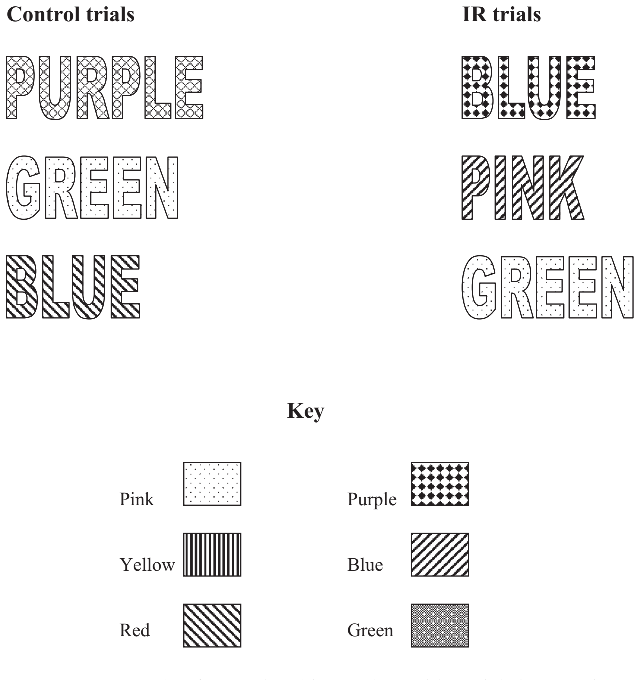

Figure 1. Example of control and ignored repetition trials in Experiment 1. Participants were asked to name the print color of the Stroop items in each list.

Procedure. All participants completed a preliminary color identification task to ensure familiarity with the 11 colors used in the experiment. No participants reported any difficulty with this task. Before the experimental cards were administered, each participant encountered four control practice cards. They were told to name as quickly and accurately as possible the print color of each color word from the top to the bottom of the column on each card. They were also asked not to cease color naming if an error was made, but rather continue to complete the card. Participants were then given the 12 experimental cards (6 per priming condition, presented in alternation). Each card was covered with a blank sheet that was removed by the experimenter on the word “Go.” The stopwatch was started with the removal of the blank sheet and stopped in synchrony with the naming of the last color print on a card. Error scores, defined as either an omission or a verbalization of an absent or incorrect color, were tabulated for each card.

Results

RT data were analyzed from two perspectives: raw response latencies and log-transformed latencies. Error scores were also examined. Table 1 presents means and standard deviations for each of these variables. In addition, for both raw and transformed response latencies, a one-way analysis of variance (ANOVA) and polynomial trend analysis was used to determine if there were any significant linear or curvilinear relationships between age group and overall RT scores (i.e., mean RTs across control and IR priming conditions) and between age group and NP scores (i.e., mean IR minus control RTs).

Raw RTs. Mean raw RTs were entered into a two-way mixed-design analysis of variance (ANOVA). Priming condition (control vs. IR) was the within-subject factor, and age group (5.2–7.1 years vs. 8.0–9.9 years vs. 10.8–12.9 years vs. 13.1–17.4 years vs. 19.3–24.9 years) was the between-subjects factor. The results showed a significant main effect of age group, $F(4, 239) = 127.97$, $p < .01$. A one-way ANOVA and polynomial trend analysis indicated significant linear and quadratic trends in overall RT: $F(1, 239) = 439.16$, $p < .01$, and $F(1, 239) = 43.73$, $p < .01$, respectively. The effect for the cubic and quartic trends combined was not significant, $F(2, 239) = 0.15$, $p = .86$, accounting for less than 0.8% of the variance. Thus, the relationship between overall RT and age group was best explained by linear and curvilinear relationships, accounting for 90% and 9% of the variance, respec-

---

[3] Presenting control and IR cards pseudo-randomly runs the risk that a number of cards in the IR condition may present sequentially. In such situations, participants are more likely to become aware of the systematic relationship between prime distractors and probe targets on IR trials. Studies show that participants who become aware of the IR manipulation can sometimes use this knowledge to predict IR targets. This may result in a trend toward positive priming (see May, Kane, & Hasher, 1995, for a review).

Table 1
Experiment 1: Means (ms per Item) and Standard Deviations of Raw Scores, Log Scores, and Error Rates

Score	Age group (years) 5.2–7.1 *M* (*SD*)	8.0–9.9 *M* (*SD*)	10.8–12.9 *M* (*SD*)	13.1–17.4 *M* (*SD*)	19.3–24.9 *M* (*SD*)
Control raw score (ms)	2,125 (577)	1,444 (333)	1,119 (254)	905 (210)	765 (141)
IR raw score (ms)	2,269 (616)	1,528 (369)	1,189 (279)	962 (211)	812 (176)
Control log score	3.12 (0.26)	2.74 (0.22)	2.49 (0.21)	2.27 (0.23)	2.11 (0.17)
IR log score	3.18 (0.26)	2.79 (0.23)	2.55 (0.22)	2.34 (0.22)	2.17 (0.20)
Control error rate (%)	4.2 (4.79)	2.3 (2.44)	2.9 (3.01)	2.3 (3.17)	4.1 (6.48)
IR error rate (%)	5.2 (5.36)	2.8 (2.13)	3.8 (2.81)	2.0 (3.18)	4.3 (5.92)

Note. IR = ignored repetition.

tively. The results of the trend analysis indicate that the slope is changing with age. Bonferroni post hoc analyses showed that although overall RT decreased between 5 and 12 years of age, with 5.2- to 7.1-year-olds taking longer to respond overall than all other age groups (all *p*s $< .01$), it did not change significantly between the age groups of 13.1- to 17.4-year-olds and 19.3- to 24.9-year-olds ($p = .44$).

More critically, the results of the two-way ANOVA also showed a significant main effect of priming condition, $F(1, 239) = 44.16$, $p < .01$. An NP effect was indicated, with naming latencies longer for IR trials than control trials. The percentage of participants indicating an NP effect in each age group was 64% for 5.2- to 7.1-year-olds, 76% for 8.0- to 9.9-year-olds, 78% for 10.8- to 12.9-year-olds and 13.1- to 17.4-year-olds, and 68% for 19.3- to 24.9-year-olds.

It is interesting that we observed no significant interaction between age group and priming condition, $F(4, 239) = 2.01$, $p = .09$. NP effects were comparable across the five age groups tested. However, the one-way ANOVA and polynomial trend analysis showed a significant linear relationship between age group and NP, $F(1, 239) = 6.41$, $p < .01$, showing that NP was heightened in children and decreased linearly with increasing age. There were no significant effects for either the quadratic term, $F(1, 239) = .006$, $p = .94$, or the cubic and quartic trends combined, $F(2, 239) = .158$, $p = .85$; the linear trend accounted for 80% of the total variability due to age group. This indicates that NP decreased in a simple progressive way with age.

Log-transformed RTs. As noted earlier, a potential explanation for the decrease in NP through childhood to early adulthood is the age-group differences in overall RT. Consistent with this explanation, the youngest age group (5.2- to 7.1-year-olds), who had the slowest overall RTs, also showed the largest NP difference between the control and IR conditions ($M = 144$ ms per item). Young adults, the fastest respondents, showed the smallest NP difference between the two priming conditions ($M = 47$ ms per item). To circumvent the potential confound, the RT data were log transformed to obtain overall latencies that differed by an additive constant. The resulting RT data were then analyzed using a two-way mixed-design ANOVA. Similar to the results of the analysis with untransformed raw RT data, there were significant main effects of age group, $F(4, 239) = 156.63$, $p < .01$, and priming condition, $F(1, 239) = 75.21$, $p < .01$. More critical, and consistent with our analysis using raw RT data, there was no significant Age Group × Priming Condition interaction, $F(4, 239) = 0.10$, $p = .98$. NP effects for Stroop stimuli were intact and comparable across the five age groups tested. Unlike our analysis using untransformed RT data, however, there was no hint of a linear relationship between NP and age group when the one-way ANOVA and polynomial trend analysis was performed, $F(1, 239) = 0.10$, $p = .77$. There was no evidence for any significant decrease or increase in the amount of NP produced in early childhood through adolescence to young adulthood. The trends for quadratic and higher order polynomial terms combined were not significant, $F(3, 239) = 0.108$, $p = .96$. This clearly indicates that the heightened NP observed in children with raw RT data can be explained in terms of slower overall response latencies.

Error scores. Error scores were also submitted to analysis. Results showed a significant main effect of age group, $F(4, 239) = 5.52$, $p < .01$, and priming condition (control vs. IR), $F(1, 239) = 6.17$, $p < .01$. The latter indicates that participants tended to make more errors on IR trials than control trials. Finally, no significant Age Group × Priming Condition interaction was observed, $F(4, 239) = 1.44$, $p = .22$. Thus, the error data do not appear to compromise the interpretation of the RT results by way of a speed–accuracy trade off.

Discussion

Experiment 1 found that NP was comparable in five age groups spanning 5 to 25 years of age. In fact, NP was similar even between 5- to 7-year-olds and 19- to 25-year-olds. There was no evidence for any age-related increase in NP. If inhibitory control processes improve in a general manner throughout development (e.g., Dempster & Corkill, 1999; Harnishfeger & Bjorklund, 1994), then NP should increase with developmental age, which was not the case. This result extends previous research by Pritchard and Neumann (2004) in an important way, indicating that young children show evidence of an adult-like inhibitory control process when participating in what may be a developmentally suited NP task. The results clearly contradict what was widely assumed in the NP literature on the basis of the findings reported by Tipper et al. (1989). Although a numerically greater overall error rate for the youngest children in Experiment 1 might suggest that the efficiency with which distractor inhibition processes are engaged may improve with age, by virtue of their intact NP, even the very youngest children tested showed clear evidence of adult-like inhibitory ability in a Stroop-based NP task.

Experiment 2

To enhance confidence in our results showing comparable NP in the youngest and oldest age groups in Experiment 1, Experiment 2 aimed to assess NP in children, adolescents, and adults for a different stimulus type. In this experiment, Pritchard and Neumann's (2004) flanker NP task was used, in which the stimuli consist of a central target color blob flanked on either side by incongruently colored distractor blobs. This provides a more vigorous test of Pritchard and Neumann's hypothesis that children may produce adult-like NP effects when distractor competition is held constant in the experimental context. It is widely established that young adults produce robust NP effects for a range of stimulus types. However, NP in children might be more variable, with some stimulus types more likely to elicit age-group differences in NP than others.

Method

Participants. The same 150 children and 54 adolescents who participated in Experiment 1 were included in Experiment 2. A different group of 50 young adults, 19 to 25 years old, participated in Experiment 2. The mean age of this age group was 19 years 7 months (range: 19.0–25.1 years). No differences in the proportion of males and females were found between the groups ($ps > .75$). Data on the socioeconomic background of the participants were not collected.

Design. A mixed design was used. The between-subjects variable was age group (5.2–7.1 years vs. 8.0–9.9 years vs. 10.8–12.9 years vs. 13.1–17.4 years vs. 19.0–25.1 years), and the within-subject variable was priming condition (control vs. IR). Trials consisted of 50% control (where there was no relationship between the colors of distractor blobs in the previous display and the color of the subsequent target blob color) and 50% IR (where the color of the distractor blobs in the previous display matched the subsequent target color blob).

Stimuli and apparatus. The stimuli consisted of 11 unique sets of color blobs in three different shapes presented as a column on a 32 × 22 cm manila card. There were 12 cards, and the sequential arrangement of color blob sets differed for each card. In addition, each set was randomly staggered to either the left or right in an attempt to reduce the saliency of the IR condition. Visual distances between individual blob sets were the same for both control and IR cards. The outer blobs in each set were the distractors, and the center blob was the target. The 11 colors used in Experiment 1 were used again as colors for blobs in Experiment 2. The color for the target blob always differed from the color shared by the flanking distractor blobs (see Figure 2). Six control cards and 6 IR cards were used in the experiment. Four additional control cards were used for practice trials. Presentation orders were handled as in Experiment 1. A stopwatch was used to record the time taken to complete color naming for each card. Error scores were tabulated by the experimenters.

Procedure. After the initial color identification task, participants were given verbal instructions for the color blob NP task. They were told to name as quickly and accurately as possible the color of each middle blob while ignoring the outer blobs, from the top to the bottom of the column on a given card. Again, it was emphasized that they should not cease color naming if an error was made but rather continue to complete color naming for the card. After completing the four practice control cards, participants were given the 12 experimental cards (6 per priming condition presented in alternation). Timing procedure was handled as in Experiment 1. Error scores for each card were recorded.

Results

Consistent with our approach to control for age-related differences in overall processing speed, the RT data were examined from two perspectives: raw RT latencies and log-transformed RT latencies. Error scores were also examined. Table 2 shows means

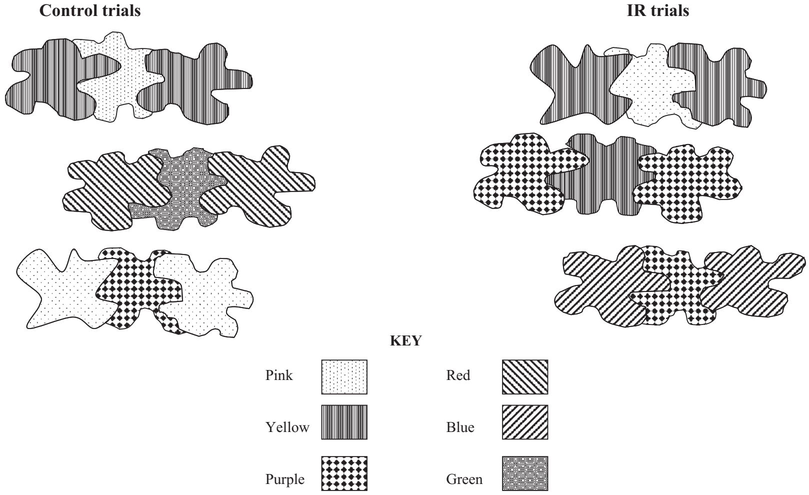

Figure 2. Example of control and ignored repetition trials in Experiment 2. Participants were asked to name the color of the central blob in each row.

Table 2

Experiment 2: Means (ms per Item) and Standard Deviations of Raw Scores, Log Scores, and Error Rates

	Age group (years)				
Score	5.2–7.1 *M* (*SD*)	8.0–9.9 *M* (*SD*)	10.8–12.9 *M* (*SD*)	13.1–17.4 *M* (*SD*)	19.0–25.1 *M* (*SD*)
Control raw score (ms)	1,412 (425)	963 (225)	765 (167)	619 (145)	561 (110)
IR raw score (ms)	1,488 (403)	1,007 (216)	810 (165)	640 (142)	575 (97)
Control log score	2.70 (0.28)	2.33 (0.23)	2.11 (0.20)	1.89 (0.23)	1.80 (0.19)
IR log score	2.76 (0.26)	2.38 (0.21)	2.17 (0.20)	1.93 (0.21)	1.83 (0.16)
Control error rate (%)	1.6 (2.86)	1.1 (1.78)	1.2 (1.27)	1.1 (1.83)	1.2 (1.61)
IR error rate (%)	4.2 (3.22)	2.3 (1.74)	2.9 (1.96)	0.6 (1.05)	1.0 (1.46)

Note. IR = ignored repetition.

and standard deviations for each of these variables. A one-way ANOVA and polynomial trend analysis was used to test for linear or curvilinear relationships between age group and overall RT scores and between age group and NP scores.

Raw RTs. Mean raw RTs were analyzed using a two-way mixed-design ANOVA. Priming condition (control vs. IR) was the within-subject factor, and age group (5.2–7.1 years vs. 8.0–9.9 years vs. 10.8–12.9 years vs. 13.1–17.4 years vs. 19.0–25.1 years) was the between-subjects factor. There was a significant main effect of age group, $F(4, 249) = 119.71$, $p < .01$. The one-way ANOVA and polynomial trend analysis detected a significant linear relationship between age and overall RT, indicating a decrease in overall RT with increasing age, $F(1, 249) = 425.14$, $p < .01$. This accounted for 89% of variability due to age group. The quadratic term was also significant, $F(1, 249) = 48.48$, $p < .01$, accounting for 10% variance. The effect for cubic and quartic trends combined was not significant, $F(2, 249) = 1.93$, $p = .15$, accounting for less than 1% variance. Bonferroni post hoc analyses revealed that overall RTs decreased between 5 and 12 years, with 5.2- to 7.1-year-olds taking longer to respond overall than all other age groups (all ps $< .01$), and did not change significantly between 13.1- to 17.4-year-olds and 19.0- to 25.1-year-olds ($p = .99$). More critically, however, the results of the two-way ANOVA also revealed a significant main effect of priming condition (control vs. IR), $F(4, 249) = 49.85$, $p < .01$. An NP effect was indicated, with naming latencies longer on IR trials than on control trials. The percentage of participants indicating a NP effect in each age group was 80% for 5.2- to 7.1-year-olds, 72% for 8.0- to 9.9-year-olds, 82% for 10.8- to 12.9-year-olds, 54% for 13.1- to 17.4-year-olds, and 68% for 19.0- to 25.1-year-olds.

Finally, and of particular interest, there was a significant interaction between age group and priming condition, $F(4, 249) = 3.70$, $p < .01$. Bonferroni post hoc tests revealed that adolescents and adults produced significantly less NP than children (all ps $<.02$), with a follow-up dependent sample t test showing that NP was not significant for adults, $t(49) = -1.81$, $p = .10$. These data are shown in the top panel of Figure 3. The ANOVA and polynomial trend analysis revealed a significant linear decline in NP with increasing age, $F(1, 249) = 13.42$, $p < .01$. The linear term accounted for 91% of variability due to age group. There was no evidence for a departure from a linear trend over age, $F(3, 249) = .438$, $p = .73$, with the quadratic and higher order polynomial trends combined accounting for less than 5% variance.

Log-transformed RTs. The observed Age Group × Priming Condition interaction may be an overadditive one, whereby NP was greater for the youngest children ($M = 76$ ms per item) than adults ($M = 14$ ms per item) as a direct result of the overall slower responses of children. To rule out this possibility, the data were log transformed to produce RT latencies that differed by an additive constant. The transformed RT latencies were then analyzed using a two-way mixed-design ANOVA. Consistent with our findings from the untransformed RT data, there were significant main effects of age group, $F(4, 249) = 150.09$, $p < .01$, and priming condition, $F(1, 249) = 60.69$, $p < .01$. However, unlike our findings from the untransformed RT data, there was no evidence for a significant Age Group × Priming Condition interaction, $F(4, 239) = 0.95$, $p = .44$. NP was intact and comparable between children, adolescents, and adults. These findings were supported by a one-way ANOVA and polynomial trend analysis that showed no significant linear decrease in NP through childhood to early adulthood, $F(1, 249) = 2.72$, $p = .10$ (see bottom panel of Figure 3). Quadratic and higher order polynomial trends were not significant, $F(3, 249) = 0.108$, $p = .96$. This suggests that the apparent age-related differences in NP that were seen with raw RT data may be attributed to age differences in general processing speed rather than inhibitory control.

Error scores. Error scores were also submitted to analyses. There were significant main effects of age group, $F(4, 249) = 7.87$, $p < .01$, and priming condition (control vs. IR), $F(1, 249) = 5.65$, $p < .02$, showing that 5- to 12-year-olds made more errors overall and that participants made fewer errors on control trials than on IR trials. Finally, there was a significant Age Group × Priming Condition interaction, $F(4, 249) = 3.92$, $p < .05$. Bonferroni post hoc analyses contrasting error scores on control trials with those on IR trials revealed that the age groups had similar error rates on control trials (all ps $> .05$) and that 5.2- to 7.1-year-olds and 10.8- to 12.9-year-olds made more errors on IR trials than 8.0- to 9.9-year-olds and 13- to 25-year-olds (all ps $< .04$). Because decreased accuracy in responding to a target stimulus in an IR trial can also be evidence for NP, it appeared that there was some evidence for larger NP in the accuracy data for 5.2- to 7.1-year-olds and 10.8- to 12.9-year-olds relative to adolescents and adults. However, the extent to which this may be due to greater variability in children's response accuracy is not certain, given that the rate of errors for IR trials produced by the second youngest age group (i.e., 8.0- to 9.9-year-olds) did not differ from those pro-

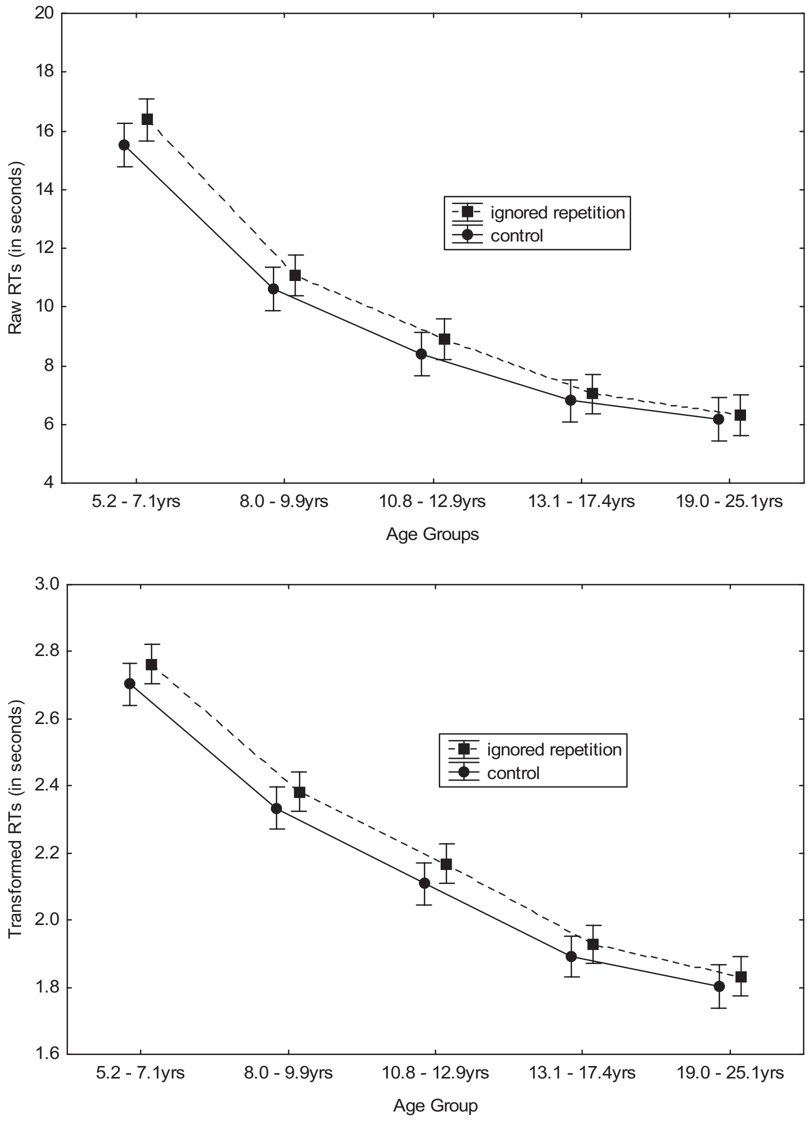

Figure 3. Mean raw reaction times (top) and log-transformed reaction times (bottom) on the flanker NP task in Experiment 2. Results are shown as a function of age group and priming condition (control vs. ignored repetition). Vertical bars denote .95 confidence intervals. RT = reaction time.

duced by the two oldest age groups (i.e., 13.1- to 17.6-year-olds and 19.0- to 25.1-year-olds), $ps > .28$.

Discussion

Experiment 2 assessed whether the intact and comparable NP effects between children, adolescents, and adults observed for Stroop stimuli in Experiment 1 would extend to a different stimulus type. Unexpectedly, results from analyses using raw RT data showed that the flanker stimuli used in Experiment 2 produced significantly greater NP in children than adolescents and adults and that NP actually failed to reach significance in adults. This pattern was the opposite of what would be generally anticipated from the premise that inhibitory control improves across childhood and beyond. It was also contrary to findings that adults produce robust identity NP effects over a range of stimulus types, whereas children do not. This apparent reversal was resolved, however, when the data were reanalyzed following a log transformation to correct for the possibility of an Age Group × Condition interaction that was overadditive, whereby the slower age group produces a larger experimental effect. Consistent with the majority of studies reporting intact NP in adults, the results of the analyses performed using transformed RT data showed intact NP in adults. Most important, they also provided converging support for the NP results obtained for a different stimulus type in Experiment 1. NP was intact and comparable between children, adolescents, and adults, with even the youngest children showing clear evidence of adult-like NP for flanker stimuli.

General Discussion

In this study, using two NP procedures, we tracked the development of an inhibitory process in children, adolescents, and adults. In light of increasing evidence indicating that some inhibitory processes may develop earlier than others (Lechuga et al., 2006), our primary goal was to test the claim that general ability in inhibitory control follows a protracted developmental pathway (e.g., Dempster & Corkill, 1999; Harnishfeger & Bjorklund, 1994). Specifically, the study was designed to determine if children and adults might exhibit comparable NP when engaged in experiments deemed favorable to eliciting intact NP in children (Pritchard & Neumann, 2004). Given the dearth of data on NP in developmental samples to date, it was hoped that this study might help to either verify or disconfirm the findings of an earlier study suggesting that NP in children is substantially diminished relative to adults (Tipper et al., 1989).

Several important findings emerged from the current investigation. Most important, and inconsistent with previous research (i.e., Tipper et al., 1989), we found no difference between children's and adults' NP effects. Children as young as 5 and 7 years old produced NP that was intact and comparable to adolescents and adults for two different stimulus types. However, at first glance it appeared that NP was heightened in children, suggesting that children might have required a greater degree of inhibition to combat distractor interference than adults did. Initial analyses in Experiment 1 showed a systematic decline of NP with advancing age, whereas in Experiment 2, NP was actually intact for children but not for adults. Both results seemed questionable, given extensive research documenting that of all the age groups that have been investigated, young adults are the most likely to produce robust NP effects (Mayr & Buchner, 2007). As it turned out, this discrepancy was indeed illusory, resulting from age differences in overall processing speed.

Analyses following log transformations to correct for age differences in overall RT latencies produced results indicating that differences in processing speed rather than inhibitory control were driving the initial results. When the more appropriate log-transformed RT latencies were used, there was no hint of a significant decrease in NP from childhood to early adulthood in either experiment.

Taken together, these findings provide compelling evidence for an inhibitory control process that operates comparably in children and adults. Our results also illustrate that any observed developmental differences in NP, where the slower respondents produce larger NP, should be interpreted with extreme caution unless supported by the results of analyses using RT data corrected to account for age differences in overall processing speed. In the sections that follow we consider how the results of the present investigation bear more generally on issues regarding the development of inhibitory control processes.

Toward the Resolution of Discrepant Findings Concerning NP in Children and Adults

Using Pritchard and Neumann's (2004) developmentally suited NP task design, we found that NP in adults matched children's (see also Frings et al., 2007, who reported intact and equivalent NP in 6- to 11-year-old children and adults on a version of Pritchard and Neumann's flanker NP task).[4] This may help begin to resolve the evident discrepancies between the NP findings of Tipper et al. (1989) and Pritchard and Neumann (2004). Although the different NP designs of these studies both produced intact NP in adults, such similarities were not observed for children. This suggests that distractor inhibition in children may be more susceptible to variations in experimental design. It remains to be established why Tipper et al. did not observe NP in children.

In particular, and given that neutral and RD trials included in the Stroop NP experiment by Tipper et al. (1989) eased inhibitory demand across 50% of their experimental trials, it appears that consistency in inhibitory demand may be critical for maintaining a concentrated selective attention processing set in children. A subsequent series of NP experiments by Pritchard and Neumann (2007) provides some preliminary support for this hypothesis, revealing that the presence of neutral and RD trials in an NP task reduced distractor inhibition in children, but not adults (see Pritchard & Neumann, 2007).

The Development of Intentional Versus Automatic Inhibitory Control Processes

Most studies of inhibitory control show that this ability improves during childhood and adolescence. This is widely believed to relate to the protracted development of the prefrontal cortex, a brain region thought to play a central role in higher level cognition and the mediation of inhibitory control (Dagenbach & Carr, 1994). However, the current NP study produced results that differed from most findings of inhibitory control in children. We did not identify any developmental increase or decrease in the level of inhibition produced in an NP task beyond early childhood. This suggests to us that NP may reflect an inhibitory control process that is distinct from those mediated by the prefrontal cortex.

As emphasized in the introduction, inhibition is not a unitary construct. In terms of neural or cognitive processes, there appears to be no single source of inhibition, but rather a constellation of sources of inhibitory processing (Harnishfeger, 1995; Kok, 1999; Nigg, 2000). Whereas age-related improvements in inhibition documented with go/no-go, task-switching, stop-signal, and Simon tasks may well parallel the development of the prefrontal cortex, the adult-like inhibitory effects found here in children with our NP tasks mirror similar results reported in the RIF literature (Ford et al., 2004; Lechuga et al., 2006). Because NP and RIF procedures are believed to tap a relatively similar automatic inhibitory process (Anderson & Spellman, 1995; Neumann & DeSchepper, 1992), our findings may be accommodated by considering Lechuga et al.'s (2006) proposal that the neural systems for automatic inhibitory processes develop earlier than those for more intentional or effortful inhibition.

The concept of inhibition in the NP and RIF literatures differs from that generally termed inhibition in the developmental literature where the focus is usually on more executive or deliberate

---

[4] Frings et al. (2007) reported results similar to those in the current study, finding intact flanker NP effects that did not differ between 152 children (ages 6–11) and 136 adults (ages 20–47).

forms of inhibition. In this literature there is little mention of more automatic or unintentional inhibitory processes. As exemplified by the results of the current investigation, the general developmental premise that inhibitory control is diminished in children relative to adults does not appear to extend to the inhibitory process indexed by NP. This implies that a specific neural process or inhibitory system may be directly responsible for mediating the type of NP effects we report. Its function is to suppress the mental representations of potentially distracting information, and as such it may engage various loci in the stream of information processing operations (see also Neumann et al., 1993; Neumann & DeSchepper, 1991; Vuilleumier, Schwartz, Duhoux, Dolan, & Driver, 2005). Using fMRI indices in an NP task, for example, Vuilleumier et al. (2005) obtained evidence that heightened inhibitory neural activity for recently ignored visual objects was situated in the bilateral lingual gyri of the posterior visual cortex.

Is Comparable NP Between Children and Adults Evidence for the Early Development of an Intact Inhibitory Control Process? Considering the Anti-Inhibitory Theory of NP

Finally, although our findings of comparable NP in children and adults appear incompatible with the assertion that inhibitory control has a prolonged development, this conclusion is made less straightforward by the existence of the anti-inhibitory account of NP (e.g., Neill & Valdes, 1992; Neill et al., 1992). Arguably, the major opponent to the inhibition account of NP is the episodic retrieval theory proposed by Neill and colleagues.[5] This theory explicitly rejects the idea that NP reflects an inhibitory process, and instead emphasizes the role of the probe target as a memory-retrieval cue. By this account, NP is retrospective. Slowed response to a target stimulus in the IR condition is attributed to the implicit retrieval of a memory trace containing prime trial response information (a "do not respond" tag) that is incompatible with the response required in the probe trial (i.e., respond). Resolving the conflict between these incompatible tags during the processing of the probe target is assumed to produce the NP effect.

The results of the present study, when taken in combination with those of Tipper et al. (1989), provide a pattern of NP that places a strain on the episodic retrieval account but might be predicted by the inhibition-based account. To clarify, both accounts of NP predict that reliable NP should occur in the IR condition when target selection is difficult across the prime and probe trials. For example, in the inhibition account, increased target selection difficulty is predicted to induce a selective attentional processing set, whereas in the episodic account such difficulty is predicted to encourage the retrieval of prior information to help initiate a correct response. However, relative to NP in children, NP in adults appears to depend less critically on experimental factors influencing target selection difficulty beyond that in control and IR trials. For example, although the degree of target selection difficulty in Stroop control and IR trials of the current study was comparable to that in Tipper et al.'s study, the magnitude of NP for children differs between these two studies. Yet such differences were not observed for the adults in either study.

It would be difficult for an episodic retrieval model to account for such between-study differences in children's NP without some modification to include the influence of the wider experimental context on inhibition and its role in the formation of episodic memories. Both children and adults in the current study and in Tipper et al.'s (1989) study were exposed to highly similar Stroop NP stimuli, which offered the same retrieval cues across IR prime and probe trials. Episodic retrieval theory can accommodate these findings less persuasively than the inhibition-based account. That is, there appears to be no apparent reason why NP should have differed between the children and adults in Tipper et al.'s study, yet be comparable for both age groups in the current study, unless the additional inclusion of neutral and RD trials in Tipper et al.'s study modulated children's selective attentional processing set more than adults (see Pritchard & Neumann, 2007). Findings such as these join a growing body of research that questions the exclusion of inhibition in NP accounts (e.g., Grison et al., 2005; Tipper, 2001).

Summary and Conclusions

To summarize, we obtained evidence to suggest that NP is directly comparable between children, adolescents, and adults. The use of appropriately log-transformed response latencies provided no evidence to indicate that NP in children was either decreased or increased relative to adults. Although the artifactually inflated NP we initially found for children seemed to indicate a developmental difference in inhibitory control levels, results with the log-transformed latencies suggest that such conclusions would have been erroneous. Thus, a major contribution of the present study is a more detailed understanding of how to avoid the potential pitfall of interpreting possible developmental differences in NP before controlling for overall differences in processing speed.

To conclude, the present NP study provides compelling evidence to indicate that the inhibitory component of selective attention matures to an adult-like level by early childhood. Although this result is incompatible with the majority of research on inhibitory control abilities in children, it is not inconsistent with the claim that more automatic inhibitory processes develop early.

References

Amso, D., & Johnston, S. P. (2005). Selection and inhibition in infancy: Evidence from the spatial negative priming paradigm. *Cognition, 95,* B27–B36.

Anderson, M. C., Bjork, R. A., & Bjork, E. L. (1994). Remembering can cause forgetting: Retrieval dynamics in long-term memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 20,* 1063–1087.

Anderson, M. C., & Spellman, B. A. (1995). On the status of inhibitory mechanisms in cognition: Memory retrieval as a model case. *Psychological Review, 102,* 68–100.

Bub, D. N., Masson, M. E. J., & Lalonde, C. E. (2006). Cognitive control in children: Stroop interference and suppression of word reading. *Psychological Science, 17,* 351–357.

Bush, L. K., Hess, U., & Wolford, G. (1993). Transformations for within-

---

[5] It is important to note that a third theoretical approach has been proposed to explain NP. However, the temporal discrimination account of NP (Milliken, Joordens, Merikle, & Seiffert, 1998) faces mounting empirical counter-evidence (e.g., Frings & Wuhr, 2007). A recent review suggests that only the inhibition and the episodic retrieval accounts of NP have survived empirical testing thus far (Mayr & Buchner, 2007).

subject designs: A Monte Carlo investigation. *Psychological Bulletin, 113,* 566–579.

Cerella, J. (1990). Aging and information processing rates in the elderly. In J. E. Birren & K. W. Schaie (Eds.), *Handbook of the psychology of aging* (3rd ed., pp. 201–221). New York: Academic.

Christ, S. E., White, D. A., Mandernach, T., & Keys, B. A. (2001). Inhibitory control across the life span. *Developmental Neuropsychology, 20,* 653–669.

Dagenbach, D., & Carr, T. H. (Eds.). (1994). *Inhibitory processes in attention, memory, and language.* San Diego, CA: Academic Press.

Davidson, M. C., Amso, D., Anderson, L. C., & Diamond, A. (2006). Developments of cognitive control and executive functions from 4 to 13 years: Evidence from manipulations of memory, inhibition, and task switching. *Neuropsychologia, 44,* 2037–2078.

Dempster, F. N., & Corkill, A. (1999). Individual differences in susceptibility to interference and general cognitive ability. *Acta Psychologica, 101,* 395–416.

Faust, M., Balota, D. A., Spieler, D. H., & Ferraro, F. R. (1999). Individual differences in information-processing rate and amount: Implications for group differences in response latency. *Psychological Bulletin, 125,* 777–799.

Ford, R. M., Keating, S., & Patel, R. (2004). Retrieval-induced forgetting: A developmental study. *British Journal of Developmental Psychology, 2,* 585–603.

Fox, E. (1995). Negative priming from ignored distractors in visual selection: A review. *Psychonomic Bulletin and Review, 2,* 145–173.

Frings, C., Feix, S., Röthig, U., Brüser, C., & Junge, M. (2007). Children do show negative priming: Further evidence for early development of an intact selective control mechanism. *Developmental Psychology, 43,* 1269–1273.

Frings, C., & Wuhr, P. (2007). On distractor repetition benefits in the negative priming paradigm. *Visual Cognition, 15,* 166–178.

Grison, S., Tipper, S., & Hewitt, O. (2005). Long-term negative priming: Support for the retrieval of prior attentional processes. *Quarterly Journal of Experimental Psychology, 58*A, 1199–1224.

Hale, S., Lima, S., & Myerson, J. (1991). General cognitive slowing in the nonlexical domain: An experimental validation. *Psychology and Aging, 6,* 512–521.

Harnishfeger, K. K. (1995). The development of cognitive inhibition: Theories, definitions and research evidence. In F. N. Dempster & C. J. Brainerd (Eds.), *Interference and inhibition in cognition* (pp. 175–294). San Diego, CA: Academic Press.

Harnishfeger, K. K., & Bjorklund, D. F. (1994). A developmental perspective on individual differences in inhibition. *Learning and Individual Differences, 6,* 331–355.

Houde, O., & Guichart, E. (2001). Negative priming effect after inhibition of number/length interference in a Piaget-like task. *Developmental Science, 4,* 119–123.

Houghton, G., & Tipper, S. P. (1994). A model of inhibitory mechanisms in selective attention. In D. Dagenbach & T. Carr (Eds.), *Inhibitory mechanisms in attention, memory and language* (pp. 53–112). San Diego, CA: Academic Press.

Johnstone, S. J., Dimoska, A., Smith, J. L., Barry, R. J., Pleffer, C. B., Chiswick, D., & Clarke, A. R. (2007). The development of stop-signal and go/no-go response inhibition in children aged 7–12 years: Performance and event-related potential indices. *International Journal of Psychophysiology, 63,* 25–38.

Kail, R. (2002). Developmental change in proactive interference. *Child Development, 73,* 1703–1714.

Kok, A. (1999). Varieties of inhibition: Manifestations in cognition, event-related potentials and aging. *Acta Psychologica, 101,* 129–158.

Lechuga, M. T., Moreno, V., Pelegrina, S., Gomez-Ariza, C. J., & Bajo, M. T. (2006). Age differences in memory control: Evidence from updating and retrieval-practice tasks. *Acta Psychologica, 123,* 279–298.

MacQueen, G. M., Galway, T., Goldberg, J. O., & Tipper, S. P. (2003). Impaired distractor inhibition in patients with schizophrenia. *Psychological Medicine, 33,* 121–129.

May, C. P., Kane, M. T., & Hasher, L. (1995). Determinants of negative priming. *Psychological Bulletin, 118,* 35–54.

Mayr, S., & Buchner, A. (2007). Negative priming as a memory phenomenon: A review of 20 years of negative priming research. *Zeitschrift für Psychologie/Journal of Psychology, 215,* 35–51.

Milliken, B., Joordens, S., Merikle, P. M., & Seiffert A. E. (1998). Selective attention: a reevaluation of the implications of negative priming. *Psychological Review, 105,* 203–229.

Muller, U., Dick, A. S., Gela, K., Overton, W. F., & Zelazo, P. D. (2006). The role of negative priming in preschoolers' flexible rule use on the dimensional change sort task. *Child Development, 77,* 395–412.

Neill, W. T., & Valdes, L. A. (1992). Persistence of negative priming: Steady state or decay. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 18,* 565–576.

Neill, W. T., Valdes, L. A., Terry, K. M., & Gorfein, D. S. (1992). Persistence of negative priming: II. Evidence for episodic trace retrieval. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 18,* 993–1000.

Neumann, E., Cherau, J. F., Hood, K. L., & Steinnagel, S. L. (1993). Does inhibition spread in a manner analogous to spreading activation? *Memory, 1,* 81–105.

Neumann, E., & DeSchepper, B. G. (1991). Costs and benefits of target activation and distractor inhibition in selective attention. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 17,* 1136–1145.

Neumann, E., & DeSchepper, B. G. (1992). An inhibition based fan effect: Evidence for an active suppression mechanism in selective attention. *Canadian Journal of Psychology, 46,* 1–40.

Neumann, E., McCloskey, M. S., & Felio, A. C. (1999). Cross-language positive priming disappears, negative priming does not: Evidence for two sources of selective inhibition. *Memory & Cognition, 27,* 1051–1063.

Nigg, J. T. (2000). On inhibition/disinhibition in developmental psychopathology: Views from cognitive and personality psychology and a working inhibition taxonomy. *Psychological Bulletin, 126,* 220–246.

Perret, P., Paour, J. L., & Blaye, A. (2003). Respective contributions of inhibition and knowledge levels in class inclusion development: A negative priming study. *Developmental Science, 6,* 283–288.

Pratt, J., Abrams, R. A., & Chasteen, A. L. (1997). Initiation and inhibition of saccadic eye movements in younger and older adults: An analysis of the gap effect. *Journals of Gerontology, Series B: Psychological Sciences and Social Sciences, 52,* P103–P107.

Pritchard, V. E., & Neumann, E. (2004). Negative priming effects in children engaged in nonspatial tasks: Evidence for early development of an intact inhibitory mechanism. *Developmental Psychology, 40,* 191–203.

Pritchard, V. E., & Neumann, E. (2007). *Adding nonconflict trials in Stroop negative priming tasks eliminates distractor suppression effects in children, but not adults.* Manuscript submitted for publication.

Salthouse, T. (1995). Differential age-related influences on memory for verbal-symbolic information and visual-spatial information. *Journals of Gerontology, Series B: Psychological Sciences and Social Sciences, 50,* P193–P201.

Simone, P. M., & McCormick, E. B. (1999). Effect of a defining feature on negative priming across the life span. *Visual Cognition, 6,* 587–606.

Sullivan, M. P., Faust, M. E., & Balota, D. A. (1995). Identity negative priming in older adults and individuals with dementia of the Alzheimer type. *Neuropsychology, 9,* 537–555.

Tipper, S. P. (1985). The negative priming effect: Inhibitory effects of ignored primes. *Quarterly Journal of Experimental Psychology: Human Experimental Psychology, 37*(A), 571–590.

Tipper, S. P. (2001). Does negative priming reflect inhibitory mechanisms? A review and integration of conflicting views. *Quarterly Journal of Experimental Psychology: Human Experimental Psychology, 54*(A), 321–343.

Tipper, S. P., & Baylis. G. C. (1987). Individual differences in selective attention: The relation of priming and interference to cognitive failure. *Personality and Individual Differences, 8,* 667–675.

Tipper, S. P., Bourque, T. A., Anderson, S. H., & Brehaut, J. C. (1989). Mechanisms of attention: A developmental study. *Journal of Experimental Child Psychology, 48,* 353–378.

Vuilleumier, P., Schwartz, S., Duhoux, S., Dolan, R. J., & Driver, J. (2005). Selective attention modulates neural substrates of repetition priming and "implicit" visual memory: Suppressions and enhancements revealed by fMRI. *Journal of Cognitive Neuroscience, 17,* 1245–1260.

Wilson, S. P., & Kipp, K. (1998). The development of efficient inhibition: Evidence from directed-forgetting tasks. *Developmental Review, 18,* 86–123.

Zelazo, P. D., Craik, F. I. M., & Booth, L. (2004). Executive functions across the life span. *Acta Psychologica, 115,* 167–183.

Received October 20, 2006
Revision received January 15, 2008
Accepted April 25, 2008 ■

Call for Nominations: *Psychology of Violence*

The Publications and Communications (P&C) Board of the American Psychological Association has opened nominations for the editorship of ***Psychology of Violence*,** for the years 2011–2016. The editor search committee is chaired by William Howell, PhD.

> ***Psychology of Violence***, to begin publishing in 2011, is a multidisciplinary research journal devoted to violence and extreme aggression, including identifying the causes and consequences of violence from a psychological framework, finding ways to prevent or reduce violence, and developing practical interventions and treatments.
>
> As a multidisciplinary forum, ***Psychology of Violence*** recognizes that all forms of violence and aggression are interconnected and require cross-cutting work that incorporates research from psychology, public health, neuroscience, sociology, medicine, and other related behavioral and social sciences. Research areas of interest include murder, sexual violence, youth violence, inpatient aggression against staff, suicide, child maltreatment, bullying, intimate partner violence, international violence, and prevention efforts.

Editorial candidates should be members of APA and should be available to start receiving manuscripts in early 2010 to prepare for issues published in 2011. Please note that the P&C Board encourages participation by members of underrepresented groups in the publication process and would particularly welcome such nominees. Self-nominations are also encouraged.

Candidates should be nominated by accessing APA's EditorQuest site on the Web. Using your Web browser, go to http://editorquest.apa.org. On the Home menu on the left, find "Guests." Next, click on the link "Submit a Nomination," enter your nominee's information, and click "Submit."

Prepared statements of one page or less in support of a nominee can also be submitted by e-mail to Emnet Tesfaye, P&C Board Search Liaison, at Emnet@apa.org.

Deadline for accepting nominations is January 31, 2009, when reviews will begin.