Exploring children's ability to inhibit identity and location

Deborah L. Jonas-Renicky
Lehigh University

Follow this and additional works at: http://preserve.lehigh.edu/etd

Recommended Citation
Jonas-Renicky, Deborah L.

Exploring Children's Ability to Inhibit Identity and Location

October 8, 1995
Exploring Children's Ability to Inhibit Identity and Location

Deborah L. Jonas-Renicky

A Thesis

Presented to the Graduate and Research Committee

of Lehigh University

in Candidacy for the Degree of

Master of Science

in

Experimental Psychology

Lehigh University

July 1995
This thesis is accepted and approved in partial fulfillment of the requirements for
the degree of Master of Science.

Date
9/14/95

Susan E. Barrett, Ph.D.
Advisor

Barbara Malt, Ph.D.

Padraig O'Seaghdha, Ph.D.

Diane Hyland, Ph.D.
Chairperson, Department of Psychology
Author Notes

There are many people who helped to make this project a success. I would like to thank the members of my committee for their valuable comments throughout the writing of this thesis. I also wish to thank the parents, teachers and children of the Lehigh Valley Lutheran School, the Allentown Jewish Day School, the Swain School, the Jewish Community Center of Allentown, the Saucon Valley Community Center, and Moravian Academy for their participation and cooperation throughout the project. A special note of thanks goes out to Dean Nelson, Doug Reese, and other staff members at the Lehigh University Computer Center for their invaluable assistance during the data analyses. Most importantly, I wish to thank my husband for his unconditional support throughout this project.
# Table of Contents

Abstract ................................................................. 1

Chapter 1 ................................................................. 2

  Introduction ........................................................... 2

  Evidence for suppression of ignored information .......... 3

  What causes the negative priming effect? .................. 4

  Is inhibition the result of separate processes? ........... 8

  Inhibition in children ............................................. 12

Chapter 2 ................................................................. 16

  Experiment 1: Combining Location and Identity in a Localization Task .................................................. 16

  Method ................................................................. 18

  Results ................................................................. 21

  Discussion ............................................................ 24

Chapter 3 ................................................................. 27

  Experiment 2: Inhibition of Location and Identity in an Identification Task ............................................... 27

  Method ................................................................. 31

  Results ................................................................. 32
Inhibition in Children

Abstract

Past research on the development of visual selection in children clearly demonstrates strong age-related gains in the ability to focus attention on central information while simultaneously ignoring distracting information. The present research focused on the development of inhibitory mechanisms which aid in ignoring potentially distracting information. Two experiments using a negative priming paradigm indicate that children as young as age six are efficient inhibitors of location, even when the identity of the object changes from prime to probe trials. Since none of the participants demonstrated negative priming of identity, no definite conclusions were drawn about young children's ability to inhibit identity. Results were discussed in relation to previous findings that suggest that inhibition of identity and inhibition of location result from separate processes.
Chapter 1

Introduction

People's visual fields are constantly bombarded with information that is irrelevant to their desired goals. To effectively use this potentially unlimited information, people must focus and select specific information to which they wish to attend while ignoring all other information. Early theories of selective attention focused on the depth of analysis applied to irrelevant information before selection. Broadbent's filter theory (1958) postulated that during the selection process, simple features (e.g., color, location) of ignored stimuli are analyzed, but the ignored features are not identified as complete objects. Other theories postulated that ignored stimuli are fully analyzed and identified prior to selection (Deutsch & Deutsch, 1963). The primary theoretical difference among these major theories of attention is the stage of processing at which selection is based, either before or after complete identification. They are similar in that both assume that effects of ignored information dissipate rapidly (Van der Heijden, 1981).

More recently, research has shifted to focus on the issue of whether there are lasting effects of the analysis applied to ignored information, or whether these effects dissipate as rapidly as previously thought. To study this issue, researchers began to focus on whether the processing applied to distracting information affects future selection. If so, suppression of ignored information
Inhibition in Children
during or after selection may keep the distracting information from interfering with
task goals. If active suppression of ignored information continues after selection,
subsequent selection of previously ignored information may be more difficult
than selection of information that was not previously ignored.¹

Evidence for suppression of ignored information

Dalrymple-Alford and Budayr (1966) provided early evidence of active
suppression of distracting information. In a typical Stroop (1935) task,
Dalrymple-Alford and Budayr manipulated the relationship between the selected
color and the previously ignored word. They found that subjects' total time to
name color lists was slowed when the lists were designed so that each
subsequent color matched the previously ignored written word. For example,
subjects were slower to respond "red" to the word green printed in red ink if it
was preceded by the word red printed in blue ink, than they were if the response
was preceded by yellow printed in blue ink. This effect was replicated using
vocal naming latencies to Stroop words presented individually, (rather than in list
form; Neill, 1977) and using a key-press response (Neill, 1982).

Tipper (1985) labeled the effect of distracting information in a trial causing
slower response rates on a subsequent trial negative priming. In his initial work
on negative priming, Tipper (1985) presented subjects with superimposed
outlines of everyday objects drawn in red and green ink. In each trial, subjects
viewed a sequence of two displays. Instructions required subjects to remember
the picture of the target (the red picture) in the initial prime display and name the
target (again, the red picture) in the subsequent probe display. When the probe
target matched the identity of the ignored green picture from the previous prime
display (the distractor), subjects responded more slowly than they did to
unrelated probe drawings. Tipper also showed that relative to a control condition
in which there was no relationship between the prime and the probe, subjects
responded more slowly when the probe target was semantically related (e.g. dog
and cat) but not identical to the prime distractor (Tipper, 1985; Tipper & Driver,
1988). These data led Tipper to conclude that the mechanisms responsible for
negative priming inhibit abstract representations of ignored information.

What causes the negative priming effect?

The assumption that inhibition of distracting information is at least partially
responsible for efficient selection led to a great deal of research about the
negative priming effect. Studies over the past decade confirm that the negative
priming effect does not result from the inhibition of motor responses. Negative
priming persists in naming tasks when subjects respond vocally in the prime and
with a key-press in the probe, or vice versa (Tipper, MacQueen, & Brehaut,
1988), and during matching tasks when asking subjects to respond "same" in a

Negative priming also cannot be completely explained in terms of
inhibition of visual features of the object. Some research demonstrates that
perceptual similarities between the prime and the probe are not necessary for
negative priming to occur. For example, the Stroop task demonstrates negative
Inhibition in Children

priming effects (Neill, 1977; Neill & Westberry, 1987; Tipper, Bourque, Anderson, & Brehaut, 1989) when subjects ignore a color word on one trial and respond to its ink color on the next trial. Tipper and Driver (1988) found negative priming between non-target pictures and corresponding target words, and many studies have shown negative priming to generalize to semantic associates of pictures and words (Tipper, 1985; Tipper & Driver, 1988; Yee, 1991). Thus, it seems that under many circumstances abstract representations are inhibited.

At the same time, inhibition of abstract qualities cannot explain the results of all negative priming experiments. For example, DeSchepper and Treisman (1991) demonstrated negative priming with abstract shapes. As subjects did not have pre-existing labels or representations for these shapes, the negative priming effects were attributed to inhibition of perceptual features. Furthermore, while letter naming tasks do not require identical perceptual features to elicit negative priming effects (e.g. Allport, Tipper, & Chmiel, 1985), letter matching tasks seem to rely on perceptual similarities. Neill et al. (1990) required subjects to respond "same" or "different" based on the identity of the second and fourth letters in a string of five. In their studies, negative priming effects occurred when the case of the letters was the same in the prime and probe trials (ABABA-DADAD), but not when the letter case differed (ABABA-dadad).

One explanation of why the results differ across tasks focuses on a theoretical hierarchy of processing. According to this theory (Neill, Valdes, & Terry, 1994), those properties of the stimuli that require analysis to meet task
goals will be inhibited. Differences occur between tasks which elicit negative priming effects only when perceptual features match and tasks that do not require perceptual similarities because of the different levels of processing that are required to meet task goals. Letter naming tasks require abstract representations to meet task goals. Thus, these tasks should not require identical perceptual features for inhibition to be evident; although if perceptual features are identical, inhibition may be more robust as a result of inhibition from both perceptual and abstract qualities. Alternatively, when task goals focus on perceptual similarities, as they do in letter matching tasks, negative priming should occur only where perceptual features are identical because only feature recognition, not abstract recognition, is required for the task.

Some researchers have hypothesized that differences found among the different negative priming tasks are a result of the different task goals, without reference to the hierarchy of processing (e.g. Tipper, Weaver, & Houghton, 1994). According to this theory, only abstract representations (not perceptual features) should be inhibited during letter naming tasks, and only perceptual features should be inhibited during letter matching tasks. However, this theory cannot explain the data from studies that show that inhibition is not limited to those properties of the stimuli which are relevant to task goals (e.g. Connelly & Hasher, 1993; Milliken, Tipper & Weaver, 1994; see Fox, 1995 for a review).

The most prominent class of tasks which elicit negative priming effects of stimulus aspects that are not relevant to behavioral goals are those that
Inhibition in Children

manipulate the location of stimuli along with other aspects such as color and identity of stimuli. Tasks using the negative priming paradigm consistently show that subjects actively ignore locations of distracting information (Connelly & Hasher, 1993; Tipper, Brehaut & Driver, 1990; Tipper, Weaver, Kirkpatrick, & Lewis, 1991). In localization tasks using the negative priming paradigm, subjects respond to the location of a target object while a second object appears in a different location. Results show that when the location of the distractor in the prime trial is the same as the target in the probe trial, response times are slower than they are if the two locations are unrelated. Inhibition of location also occurs when the identity of the object changes from the prime to the probe trials (Connelly & Hasher, 1993; Tipper et al., 1994). Apparently, the location itself is inhibited, possibly independently of the identity of the object. Interestingly, this inhibition of location occurs in identification tasks, in which localization is not directly relevant (Connelly & Hasher, 1993; Tipper et al., 1994). Between the two theories posed so far, only the hierarchy of processing theory (Neill, et al., 1994) accounts for data showing negative priming effects of location during identification tasks.

An alternative view is that inhibition of location and inhibition of identity are the result of separate processes (Connelly & Hasher, 1993; May, Kane, & Hasher, in press). This theory came about because researchers found that populations that often have difficulties with selective attention tasks (adults over age 60 and elementary school children) seem to have no difficulties inhibiting

**Is inhibition the result of separate processes?**

If inhibition were a single process affecting both identity and location simultaneously, one would expect identity and location based inhibition to co-occur. Furthermore, interruption of one type of inhibition should disrupt the other. Thus, if inhibition were the result of one process, task demands affecting identity inhibition should affect location inhibition, and vice versa. If both types of inhibition were the result of one process, one would expect that groups of individuals who have difficulties with one type of inhibition would also have difficulties with the other. Research shows that this is not the case. As discussed briefly above, studies not only show that task demands such as localizing versus identifying target objects lead to different features of the stimuli being inhibited, (Connelly & Hasher, 1993; Tipper et al., 1994), but also that abilities regarding inhibition of location and inhibition of identity differ between age groups (Connelly & Hasher, 1993; Hasher et al., 1991; McDowd & Oseas-Kreger, 1991; Tipper, 1991).

Clearly, theories that focus only on behavioral goals cannot account for these data. If behavioral goals determined which stimulus properties were inhibited (Tipper et al., 1994), inhibition should not occur for locations during identification tasks. However, experiments which manipulate both the identity
and location of objects within the same task show that college-age participants responding on the basis of identity demonstrate the negative priming effect for both the identity and location of distracting information (Connelly & Hasher, 1993; Tipper et al., 1994). When the task requires a location-based response, only the location of information is inhibited (Connelly & Hasher, 1993; Milliken et al., 1994; Tipper et al., 1994).

Age differences also occur in negative priming tasks, but apparently only for inhibition of identity. In a variety of negative priming tasks, neither older adults (over age 60) nor young children (age 6-8) demonstrate the ability to inhibit identity even when identity is directly relevant to task goals (Connelly & Hasher, 1993; Hasher et al., 1991; Kane, Hasher, Stoltzfus, Zacks, & Connelly, 1994; Tipper et al., 1989). These same populations, and often the same subjects, consistently demonstrate the ability to inhibit location (Connelly & Hasher, 1993; Tipper & McLaren, 1990). The above differences can be explained by theories which postulate that inhibition occurs in a hierarchical fashion (Neill et al., 1994), or by models which postulate separate processes (Connelly & Hasher, 1993; May et al., in press). The separate processes model and processing hierarchy model both assume that the processing of location-based information occurs before identity-based information. Therefore, both location and identity would be inhibited in identification tasks, but only location would be inhibited in localization tasks. The hierarchy of processing model can explain age differences by postulating that older adults and young children have
difficulties inhibiting higher level information, such as abstract representations. The model that postulates separate processes accounts for age differences by postulating that different neural pathways are responsible for different types of inhibition. These pathways mature and decline at different rates, causing the ability to inhibit identity to develop and decline earlier than the ability to inhibit location.

One of the most compelling arguments for separate processes stems from the work of Connelly and Hasher (1993). In their task, both the identity and the location of the stimuli were manipulated within an identification task. Three experimental conditions were created such that in the identity suppression condition, the identity of the probe target matched the identity of the prime distractor but occupied a different location, in the location suppression condition, the location of the probe target matched that of the prime distractor but had a different identity, and in the location and identity condition, both the location and identity of the probe target matched that of the prime distractor. In this task, subjects were asked to name the target letter, which was identified by color. Connelly and Hasher not only found that college-age participants inhibited location and identity, but they demonstrated an additive effect of the two. That is, the magnitude of negative priming effects demonstrated by young adults in the location and identity condition was approximately equal to the sum of the magnitude of the effects in the location and the identity conditions. Importantly, older adults only demonstrated negative priming of location, and the magnitude
of this effect was similar in the location and the location and identity conditions.

While the hierarchy of processing model may be able to account for these data by postulating that older adults cannot inhibit higher level information such as abstract representations, data from other sources lend support to the argument that inhibition of location and inhibition of identity result from separate, additive processes. For example, neurophysiological evidence shows that at least two pathways, one for information about identity and one for spatial information, carry visual information from receptors through the cortex (Ungerleider & Mishkin, 1982). Furthermore, computational analyses support the separate processes model by demonstrating that separate location and identity pathways result in more efficient processing than a single pathway for both location and identity information (Rueckl, Cave, & Kosslyn, 1989).

From a developmental perspective, the difference between inhibition of identity and inhibition of location is particularly interesting. Children show marked improvement across a broad range of selective attention tasks over the elementary school years. These same abilities show declines in old age. Assuming inhibition is an important part of the selection process, it is likely that at least some inhibitory mechanisms develop over the elementary school years and diminish in old age. Work by Hasher and her colleagues (e.g. Connelly & Hasher, 1993; Hasher et al., 1991) strongly suggests that the ability to inhibit object identity declines in older adults, while the ability to inhibit location remains intact. As older adults tend to experience more intrusions than young adults in
Inhibition in Children

attention tasks, the inability to inhibit identity-based information supports the hypothesis that many cognitive deficits that occur in old age are a result of decreased inhibitory functioning (Hasher & Zacks, 1988).

Inhibition in children

While it seems clear that older adults have difficulty inhibiting identity-based information but no difficulty inhibiting location-based information, the evidence regarding children's abilities is less clear. Research demonstrates that up to early adolescence, there are rapid increases in children's overall ability to selectively attend, with rapid decreases in the amount of interference caused by distracting information (see Lane & Pearson, 1982, for a review). This period of rapid change in attentional abilities asymptotes such that by early adolescence (approximately age 11), children's attentional abilities are close to full maturity. A vast amount of literature explores what types of information cause distraction to children, and how the level of distraction changes through the course of development. However, less research focuses on what specific abilities, such as inhibition, change over time which yield declines in interference.

Available evidence regarding the development of inhibitory processes in attention tasks suggests that the ability to inhibit locations develops to a level of maturity similar to that of adults at least by the age of six (Tipper & McLaren, 1990). However, evidence about children's ability to inhibit the identity of objects is limited and unclear. In a series of experiments, Tipper et al., (1989) used the negative priming paradigm to explore inhibitory mechanisms in second grade
children (ages 7 to 8.5 years). In a Stroop (1935) task in which both children and adults showed typical Stroop interference effects, adults demonstrated negative priming whereas children did not. Tipper et al. hypothesized that Stroop words may have posed particular difficulties for children not afforded by other stimuli because the Stroop color words may have been perceived holistically by children. That is, children may have had difficulties separating the "to be ignored" word from the "to be selected" color, since they often perceive information that is not spatially separated as holistic (Shepp & Barrett, 1991). Consequently, in a follow up experiment, Tipper et al. (1989, Experiment 3) tested children's abilities to inhibit pictures of everyday objects in which target and distractor objects were presented in distinct locations. This should have allowed both adults and children to avoid perceiving the information holistically (Shepp & Barrett, 1991; Shepp, Barrett, & Kolbet, 1987). The results of Tipper's (1989, Experiment 3) study were unclear. Once again, adults demonstrated the negative priming effect. However, while seventy percent of the children demonstrated the negative priming effect (approximately the same percent as adults), the effect was not statistically significant. It is unclear from the data reported why the difference occurred between adults and children. Thus, the possibility remains that children can inhibit identity, but no reliable data have been reported to demonstrate such abilities.

Based on the seventy-percent of the children in the sample that demonstrated negative priming in Experiment 3, Tipper et al. (1989) concluded
that under certain conditions children may actually demonstrate negative priming of identity, but in some situations task demands mask any inhibitory mechanisms that may be at work. In later work, Tipper and McLaren (1990) used the negative priming paradigm to explore children's abilities to inhibit locations. They used a typical localization task in which the target and the distractor remained constant throughout the task. Children responded with a key-press to the location of the target while ignoring the distractor. In this task, children as young as six-years demonstrated the ability to inhibit locations. In their conclusions, Tipper and McLaren (1990) neglected the possibility that location-based and identity-based inhibition result from separate processes. They interpreted the significant negative priming effects demonstrated by children during the localization task as evidence that children are capable of inhibition, and that previous inconclusive findings (Tipper et al., 1989) stem from children's inability to use their inhibitory mechanisms efficiently in different task situations.

Clearly, attributing the discrepancy between results from localization and identification tasks to children's inability to skillfully execute their attentional resources is premature. These conclusions neglect the likelihood that different processes underlie inhibition of spatial location and inhibition of object identity. Based on work that demonstrates there are likely to be two different processes for inhibition (e.g. Connelly & Hasher, 1993), and the differences found in existing literature exploring location- and identity-based negative priming effects in children, it seems likely that children acquire the ability to inhibit location at an
earlier age than they acquire the ability to inhibit identity. The research presented here was designed to explore children's inhibitory abilities using a task that allows responses based on both identity and location.
Chapter 2

Experiment 1: Combining Location and Identity in a Localization Task

This experiment was designed to replicate and expand on Tipper and McLaren's (1990) findings that children as young as six years are able to inhibit the locations of unselected information. In that study, children viewed a prime display in which they were asked to respond to the location of the "+", while ignoring the distractor "0". They subsequently viewed a probe display and responded in the same manner. Inhibition was assessed by the difference in participants' reaction times in a control condition, in which there was no relationship between the target and distractor in the prime and probe presentations, and the reactions times in the experimental condition, in which the location of the target in the probe was the same as the location of the distractor in the prime.

This experiment was designed to expand on these findings by manipulating the identity and the location of the targets and distractors. Thus, this experiment tested whether children inhibit locations regardless of the identity of the stimuli. The abilities of first-grade, fifth-grade, and college-age students were compared to see whether first- and fifth-grade children inhibit locations when both the identity and locations changed across prime and probe trials. These age groups were chosen because first-grade children typically show large amounts of interference, while fifth-grade children's performance in selective attention tasks is generally at levels similar to that of adults. If children as young
as six years inhibit locations regardless of identity, it is likely that the ability to inhibit locations develops early in life, possibly separately from the ability to inhibit identity. Also, if children in fact inhibit locations regardless of object identity, it will be clear that the larger amount of interference young children experience during attention tasks is not caused by an inability to inhibit locations.

The arrangement of the stimuli in this experiment was based on that of the Connelly and Hasher task described earlier (1993, Experiment 3). Connelly and Hasher arranged the stimuli into four possible locations, such that the target and distractor occupied two of the four locations. Rather than configuring the possible locations to correspond to the C, D, M and K keys on a keyboard (as did Connelly & Hasher), the four possible locations in this experiment corresponded to the 2, 4, 6, and 8 keys on the numerical keypad of the computer keyboard. The terminology used to describe this experiment (and Experiment 2) followed that of the majority of experiments employing the negative priming paradigm. As demonstrated in Figure 1, in the identity ignored repetition condition, the prime distractor and probe targets were the same, but occupied different locations. In the location ignored repetition condition, the prime distractor and the probe target were different, but occupied the same location. In the location + identity ignored repetition condition, the identity and the location of the prime distractor were the same as that of the probe target. In the control or unrelated condition, there was no relationship between the location or the identity of the stimuli in the prime and probe conditions.²
In previous research, adults and first-grade children have demonstrated the ability to inhibit locations when the targets and distractors remained constant throughout the task. Thus, all subjects were expected to demonstrate negative priming effects in the location ignored repetition, and in the location + identity ignored repetition conditions. As localization tasks typically do not elicit negative priming effects based on identity, presumably because location-based responses do not require pre-selection analysis of identity information, no differences were expected between the unrelated condition and the identity ignored repetition condition for any age group. In addition to measuring response times, error rates were assessed to see if more errors were committed in the two conditions in which location-based negative priming effects were expected.

**Method**

**Participants.** Nineteen first-grade children (mean age 7 years 0 months) and 14 fifth-grade children (mean age 11 years 2 months) from Lehigh Valley, Pennsylvania private schools, as well as 20 Lehigh University undergraduate students (mean age 20 years 7 months) participated in this experiment. Data from two first-grade children were not analyzed as they did not complete the task. All subjects were pre-screened for color-blindness.

**Design and Materials.** This experiment used a 3 (age) X 4 (presentation
type) design. Forty trials for each of the following presentation types were created to total 160 trials. The possible presentation types were: identity ignored repetition in which the prime distractor and probe target were the same but occupied different locations; location ignored repetition in which the prime distractor and the probe target were different but occupied the same location; location + identity ignored repetition in which the identity and the location of the prime distractor and probe target were the same; unrelated condition in which there was no relationship between the location or the identity of the stimuli in the prime and probe displays (see Figure 1).

The stimuli consisted of the numbers 1, 2, 3, and 4, drawn in 36 point Chicago style font. The targets were always red, and the distractors were green. The stimuli were presented on a white screen and followed a cross-like arrangement. The four possible locations were marked with tape, such that the stimuli appeared just above the location markers. The distance between both the top and bottom locations and the left and right locations was nine cm.

A Macintosh Quadra 840AV equipped with a 14 inch, .28 dot pitch Apple Color Plus monitor was programmed to run the experiment. The experiment consisted of 16 practice trials, followed by 144 experimental trials, broken down into 4 blocks of 36. The trials were run in random order.

Procedure. Subjects were run in a quiet room either at their school or at Lehigh University. Before the practice trials, subjects were given explicit instructions about the task and the correspondence between the locations on the
screen and the response keys. They were told that two numbers would appear on the screen, and their job was to locate the red number, while ignoring the green number. Subjects responded to target locations using the numeric keypad numbers 2 (down), 4 (left), 6 (right), and 8 (up). These keys were clearly marked with tape. The rest of the keyboard was covered so the numeric keys were the only salient features. Speed and accuracy were emphasized.

At the beginning of each trial, the word "Ready" appeared on the screen. To initiate each trial, the experimenter said "Go" and pressed the appropriate key on the keyboard. Fifteen hundred ms after the experimenter initiated the trial, a black fixation cross appeared on the center of the screen for 500 ms. Immediately after the fixation offset, the prime display appeared for 200 ms, followed by a blank screen which remained on until the subject responded with a key-press. Immediately after the response, another fixation cross appeared for 500 ms, followed by the probe display for 200 ms. Again, a blank screen appeared until the subject responded. After this response, the word "Ready" appeared, and the experimenter initiated the next trial.

Throughout the session subjects were given positive feedback about their performance. Participants were always told they were doing a good job, and to keep up the good work. They were also encouraged to go as fast as possible without making mistakes, however no specific reaction times were given. All subjects were given short breaks between blocks. The procedure lasted between 15 and 30 minutes for each participant.
Inhibition in Children

Results

Reaction time. The reaction times for probe targets were recorded by the computer. The median reaction times for each subject in each condition were used in the analyses. In calculating the median reaction times, only responses in which subjects responded correctly in both the prime and the probe trials were used.

An analysis of variance revealed a significant main effect of age group, $F(2, 47) = 57.47, p < .0001, \text{MSe} = 79229.49$. As Table 1 shows, adults responded more quickly than fifth-grade children, who responded more quickly than first-grade children. The main effect of presentation type was also significant, $F(3, 141) = 5.35, p < .002, \text{MSe} = 728.54$. Responses in the unrelated condition were faster than those in the location and the location + identity conditions for all age groups (see Table 1).

To test the specific predictions regarding the different age groups, separate planned contrasts were conducted for each age group. It should be noted that, as predicted, the omnibus test did not reveal an age X presentation type interaction, $F < 1$. For each age group, it was predicted that inhibition of location should occur regardless of the identity of the stimuli. Thus, reaction times in the location and in the location + identity conditions were expected to be
Inhibition in Children

slower than in the unrelated condition for adults, fifth-grade, and first-grade children. Furthermore, the localization task was not expected to require pre-selection analysis of object identity, eliminating inhibition of object identity. Therefore, the reaction times in the identity condition were not expected to differ from those of the unrelated condition for any age group.

The data from the adult subjects revealed no difference between response times in the identity condition and the unrelated condition, $F < 1$, consistent with the idea that identity is not inhibited during localization tasks. Results confirm the predicted pattern for the location and the location + identity conditions, where response times were significantly slower than those of the unrelated condition, $F (1, 19) = 30.60, p < .0001$, and $F (1, 19) = 15.43, p < .001$ respectively.

Analyses from the fifth-grade children's data also followed the predicted pattern. Again, there was no difference between the unrelated and identity conditions, $F (1, 13) = 2.15, \text{ns}$. Responses in the location condition were significantly slower than in the unrelated condition, $F (1, 13) = 5.30, p < .05$. Responses in the location + identity condition were marginally slower than those of the unrelated condition, $F (1, 13) = 2.83, p = .10$.

As expected, first-grade children showed no differences between the identity and the unrelated conditions, $F < 1$. In contrast to the predictions, the contrasts revealed that responses were not significantly slower in either the location or the location + identity condition when compared to the unrelated
Error rates. If inhibition makes it more difficult to retrieve and respond to previously ignored information, error rates should be greater in the conditions in which inhibition occurred. Importantly, more errors should be in those conditions which elicited the slowest reaction times. This pattern of data will show that the negative priming effects seen in the above reaction time data were not caused by a speed/accuracy trade-off. Thus, error rates should be greater in the location and the location + identity conditions relative to the unrelated condition.

The error rates presented reflect the percent of trials in each condition in which the subject made a correct response in the prime, and an incorrect response in the probe. These percents were subjected to a 3 (age) X 4 (presentation type) ANOVA. The analysis revealed a main effect of age $F(2, 46) = 5.10, p = .01, MSe = 68.68$. Adults committed a smaller percent of errors ($M = 1.25$) than fifth-grade children ($M = 2.92$), who committed a smaller percent of errors than first-grade children ($M = 5.65$).

There was also a main effect of condition $F(3, 138) = 6.74, p < .0003, MSe = 10.95$, which follows the predicted pattern in that the largest number of errors occurred in the conditions in which negative priming was demonstrated in the reaction time data. Subjects made the most errors in the location condition ($M = 4.81$), followed by the location + identity condition ($M = 3.09$), followed by the identity condition ($M = 3.01$), and finally, the smallest percent of errors occurred in the unrelated condition ($M = 1.96$). The age X condition
The error data were subjected to separate planned contrasts for each age group. As shown in Table 1, all of the age groups, including first-grade children whose reaction time data did not reveal any significant negative priming effects, made significantly more errors in the location condition than in the unrelated condition, $F(1, 16) = 3.92, p < .05$, $MSe = 20.81$, $F(1, 12) = 11.18, p < .01$, $MSe = 10.03$, $F(1, 18) = 10.30, p < .01$, $MSe = 2.79$, for first-grade, fifth-grade, and adult participants respectively. None of the other comparisons reached significance.

Discussion

This experiment was designed to replicate and expand on the findings of Tipper and McLaren (1990) who showed that children as young as six years inhibit locations. In this experiment, both the identity and location of the stimuli changed between prime and probe trials. It was expected that first-grade, fifth-grade and adult participants would inhibit spatial locations regardless of the identity of the objects in those locations.

Adults and fifth-grade children demonstrated inhibition of location even when the identity of the ignored distractor changed from the prime to the probe trials. Thus, for these age groups, inhibition of location persists even when the object in the ignored location changes identity. The error data lend further support to this proposition, in that both adult and fifth-grade participants committed the most errors in the location condition.
Interestingly, no negative priming effects were found in the first-grade children's reaction time data. Thus, this study failed to replicate Tipper and McLaren's (1990) finding that first-grade children inhibit locations. It is important to note that in this experiment, the omnibus test did not reveal an age X condition interaction. This absence of an interaction coupled with a significant effect in the error data suggest that first-grade children are not different from older children and adults in their abilities to inhibit locations. Instead, the results in this study may reflect weaker effects that may stem from children having difficulties mapping their responses onto the appropriate keys. If so, their responses would vary considerably within each condition, leading to median reaction times that are poor reflections of children's true inhibitory abilities.

This experiment also tested whether inhibition of identity would occur when the task required subjects to locate the targets. Results confirm that inhibition of identity does not occur when task goals focus on locating targets. Since it is presumed that locating a target does not require full analysis of the identity of objects, inhibition is assumed to occur only for those properties of the stimuli that are required by the task.

This experiment was designed to demonstrate that children as young as six years can inhibit locations even when the stimuli change from trial to trial. As there were no significant differences in the response latencies for first-grade children, no definite conclusions can be drawn from this experiment regarding children's abilities to inhibit locations. However, considering the lack of an
interaction, and the error data which support the hypothesis that responses were more difficult in the location condition, it possible that children in this experiment were inhibiting locations, but the effects of inhibition were masked by response variability resulting from difficulties mapping response keys.
Chapter 3

Experiment 2: Inhibition of Location and Identity in an Identification Task

This experiment was designed to test the hypothesis that the development of children's ability to inhibit identity lags behind their ability to inhibit locations. By asking subjects to identify the numbers rather than locate them, they should analyze both the location and the identity of target and distracting objects. Therefore, fifth-grade children and adults, who are capable of inhibiting identity, are expected to show negative priming effects of both identity and location. If the ability to inhibit identity lags behind the ability to inhibit locations, first-grade children should not show any negative priming of identity. In addition to assessing children's abilities to inhibit identity, this experiment should offer some insight as to whether children in Experiment 1 had difficulties with the key-press response, or if the null results of that experiment reflect a reduced ability to inhibit locations.

Currently, there is no reliable evidence that children are successful inhibitors of identity information during selection tasks. As discussed earlier, in the only published study which addresses this issue (Tipper et al., 1989), second-grade children consistently failed to demonstrate reliable negative priming effects. However, caution needs to be taken when drawing conclusions from the Tipper et al. study. They report that in one experiment, seventy-percent of the children demonstrated negative priming effects, though the effect was not
Inhibition in Children

statistically significant. The information reported by Tipper et al. (1989) is insufficient to draw any clear inferences about statistical reasons for the null results, such as the possibility that the children's responses were more variable than those of adults. This experiment was designed to provide more reliable evidence that young children in fact develop the ability to inhibit identities later than the ability to inhibit locations. Thus, first-grade children are not expected to produce negative priming effects in the identity ignored repetition condition.

This experiment also tests whether first-grade children can inhibit locations in a task which eliminates the need to map onto response keys. This should lend some clarification to the results of Experiment 1, which were inconclusive regarding first-grade children's ability to inhibit locations. Recall that in Experiment 1, first-grade children did not demonstrate significant negative priming effects of location. However, the lack of an interaction coupled with a significantly larger percent of errors in the location condition when compared to the unrelated condition lends support to the hypothesis that there was at least some inhibition of location demonstrated by first-grade children. If difficulty mapping onto the response keys masked children's demonstration of their mature abilities to inhibit location, the vocal response used in Experiment 2 (which eliminates children's need to map onto response keys) should allow the first-grade children to demonstrate mature abilities to inhibit locations. This simplified procedure requires participants to name the target number. It is expected that children actually can inhibit locations and thus will produce
negative priming effects in both the location ignored repetition condition and the location + identity ignored repetition condition.

It should be noted that both the goal of the task and the response type have been changed from Experiment 1 to Experiment 2. While it is possible that either of these changes may be the cause of any differences found between the two experiments, the majority of the literature using the negative priming paradigm interprets negative priming effects of location as resulting from the same inhibitory process whether they are produced during identification tasks or localization tasks (e.g. Connelly & Hasher, 1993; Tipper et al., 1994). In addition, research demonstrates that the pattern of results for identification tasks is the same for a key-press as it is for a voice response, but the effects are more robust using a vocal response (Connelly & Hasher, 1993; Tipper et al., 1991). Using a vocal response should, therefore, maximize the likelihood that young children will demonstrate negative priming effects of location, which may have been masked in Experiment 1 due to the complicated key-press response.

This experiment also focuses on whether inhibition of identity and inhibition of location involve the same underlying processes, or whether two separate inhibitory processes, each with a different developmental time course, are responsible for the inhibition of the two distinct sources of information. As reported earlier, there is ample evidence suggesting that the ability to inhibit identity- and location-based information are the results of different underlying processes. Recall that young adults inhibit location during an identity task
Inhibition in Children

(Connelly & Hasher, 1993; Tipper et al., 1994), the effects of identity and location negative priming are additive for young adults during identification tasks (Connelly & Hasher, 1993), and that identity is not inhibited during localization tasks across age groups (Connelly & Hasher, 1993; Milliken et al., 1994). While these data may be accounted for by theories which postulate that inhibition occurs for features of stimuli that require analysis to meet the goals of the task (e.g. Milliken et al., 1994; Neill et al., 1994; Tipper et al., 1994), differences found between age groups in identification tasks coupled with the neurophysiological data strongly suggest that there are two separate processes that result in inhibition (see May et al., in press for review). Although it remains unclear whether children's abilities to inhibit identity differ from those of adults, older adults typically fail to inhibit identity information in identification tasks which consistently elicit negative priming effects from young adults (Connelly & Hasher, 1993; Hasher et al., 1991; Kane et al., 1994). Furthermore, older adults continue to inhibit locations during identification tasks, while in those same tasks, they fail to inhibit identity (Connelly & Hasher, 1993).

To partially replicate previous findings, adult participants will be tested to establish that young adults in fact inhibit object identity in this task. In addition to demonstrating negative priming effects for identity, fifth-grade children and adult subjects should demonstrate an additive effect of location- and identity-based negative priming, such that the magnitude of negative priming in the location + identity condition is approximately equal to the sum of the magnitude of negative
Inhibition in Children

priming demonstrated in the location and the identity conditions. Since first-grade children are not expected to demonstrate negative priming effects of identity, the magnitude of negative priming is expected to be approximately equal in the location and the location + identity conditions.

Method

Participants. Nineteen first-grade and 14 fifth-grade children (mean ages 7 years 0 months and 10 years 9 months respectively) from area private schools, along with 19 Lehigh University undergraduate students (mean age 19 years 2 months) participated in this experiment. Data from three first-grade children were not analyzed as they did not complete the task. All subjects were prescreened for color-blindness.

Materials, Design, and Procedure. The materials and design were the same as in Experiment 1. The only change in the procedure was that subjects were asked to name the red number while ignoring the green number. A microphone triggered the computer to record response times. At times, the microphone picked up sounds other than speech (e.g. loud breathing). This occurred on an average of one-percent, three-percent, and 10 percent of the trials for adult, fifth-grade, and first-grade participants respectively. The experimenter recorded all verbal responses as well as any microphone errors throughout the testing.

Results

Reaction time. The reaction times for probe targets were recorded by the
computer. Trials in which microphone errors occurred, along with trials in which response errors occurred in either the prime or probe trials were eliminated from the analysis of reaction times. The median reaction times from the remaining probe trials for each subject in each condition were used in the analyses.

Results are shown in Table 2. The overall analysis of variance (ANOVA) revealed a significant main effect of age group, $F(2, 46) = 71.85, p < .0001, MSe = 20595.27$. As expected, adults responded more quickly than fifth-grade children, who responded more quickly than first-grade children. There was also a significant main effect of presentation type, $F(3, 138) = 22.47, p < .0001, MSe = 907.18$. In all age groups, the means of the location and the location + identity condition were greater than those of the unrelated condition (see Table 2). The presentation type X age group interaction was not significant, $F(6, 138) = 1.87, ns$. 

Insert Table 2 about here

Separate planned contrasts for each age group were conducted to test whether the reaction times of each experimental condition were significantly greater than those of the unrelated condition. If participants were inhibiting both the identity and the location of distracting information, reaction times for the location, the identity, and the location + identity conditions should all be greater than the reaction times in the unrelated condition. Furthermore, if the processes
are separate and additive, the amount of inhibition seen in the location + identity condition should be equal to the sum of the negative priming effects seen in the location condition and the identity conditions.

Contrary to the prediction that participants should demonstrate negative priming in all experimental conditions, adults did not respond significantly more slowly in the identity condition (287 ms) than they did in the unrelated condition (281 ms), $F (1, 18) = 1.75$, ns. However, results of the comparisons between the unrelated condition and the location condition and between the unrelated condition and the location + identity condition revealed that adults demonstrated strong negative priming effects when location was manipulated, $F (1, 18) = 29.36$, $p < .0001$ and $F (1, 18) = 20.19$, $p < .0001$, respectively (see Table 2). As would be expected if there was no inhibition of identity, the magnitude of negative priming in the location and the location + identity conditions were similar, 26 ms and 21 ms respectively.

Results from analyses of the fifth-grade data mirrored those of the adult data. As predicted, responses in both the location and the location + identity conditions were slower than those of the unrelated condition, $F (1, 13) = 11.68$, $p < .01$ and $F (1, 13) = 16.63$, $p < .0002$ respectively (see Table 2). Again, the magnitude of the negative priming effects in the location and the location + identity conditions were similar, 39.71 ms and 47.35 ms respectively. Since the mean reaction time in the identity condition was slightly faster than that of the unrelated condition, no statistical comparison was made.
The data from first-grade children also followed the same pattern as those of the adults. The comparison of the identity condition with the unrelated condition did not yield a significant difference, $F < 1$. Results comparing the location condition with the unrelated condition, and the location + identity condition with the unrelated condition, yielded significant negative priming effects, $F (1, 15) = 14.77$, $p < .001$, and $F (1, 15) = 5.27$, $p < .05$, respectively (see Table 2). The magnitude of negative priming demonstrated by first-grade children was 23 ms longer in the location condition when compared to the location + identity condition, although this difference failed to reach statistical significance, $F (1, 15) = 2.40$, ns.

**Error rates.** Each adult participant committed less than two errors in the probe trials throughout the experiment, thus their error rates were too low for analysis. First- and fifth-grade children committed, on average, less than three errors in the probe trials throughout the experiment. There were no significant results with either age group when these error rates were analyzed.

**Discussion**

The results indicated that children as young as six years inhibited locations even when they did not inhibit identity. This was true even though the identity of the targets and distractors changed throughout the task, and task goals did not directly involve locating targets. Based on results obtained in Experiment 2 in which few errors were committed by participants, it is likely that children in Experiment 1 experienced difficulties mapping onto the key-press
response. This would weaken or eliminate negative priming effects typically caused by inhibition in that task.

It is interesting to note that none of the age groups demonstrated significant negative priming of identity. This is especially notable for the college-age participants, as this age group has consistently demonstrated the negative priming effect for object identity in identification tasks (e.g. Connelly & Hasher, 1993; Tipper, 1985; Tipper et al., 1994). This lack of negative priming effects in the identity condition for all age groups may be attributable to the large distances between targets and distractors in the task. Current research with young adults shows that increasing the distance between the target and the distractor reduces the strength of inhibition (Fox, 1994; Neumann, 1993; see Fox, 1995 for a review). Pilot data from a study in this lab using adult subjects confirmed that when the distance between the top and bottom locations, and the left and right locations was reduced to two and three-quarters centimeters (as opposed to the nine cm used here), negative priming effects were evident for identity information. This idea will be elaborated upon in the General Discussion.

Even though there was no indication that participants inhibited identity, there are some important factors that lend support to the argument that inhibition of location and inhibition of identity result from separate processes. Consistent with the separate process hypothesis (although not decisive) the effects of inhibition were of similar magnitudes even though the experimental manipulations differed in the location+ identity condition and in the location
condition. Additionally, inhibition of location remained robust even when there was no evidence of inhibition of identity for participants of any age group. This is consistent with the separate processes model because it suggests that factors (such as distance between targets and distractors) that influence inhibitory processes may affect identity-based inhibition differently than these same factors affect location-based inhibition. It would be interesting to discover whether other factors, such as ease of discrimination between target and distractor locations and identities, affect location- and identity-based negative priming differently.

The results of this experiment then, support the notion that the ability to inhibit locations is well developed at an early age. In addition, these data are consistent with the hypothesis that identity- and location-based inhibition result from separate processes. Clearly, no definite conclusions can be made about young children's abilities to inhibit identities.
Chapter 4

General Discussion

The studies presented here suggest that young children have the ability to inhibit locations during attention tasks regardless of the identity of the objects in those locations. While first-grade children in Experiment 1 did not demonstrate negative priming effects, they did commit more errors in the location condition. This greater difficulty responding when the ignored location was subsequently responded to, coupled with significant negative priming effects of location in Experiment 2, strongly support the hypothesis that by the age of six, children have mature abilities to inhibit locations. Furthermore, these studies are consistent with the hypothesis suggested by Connelly and Hasher (1993) that inhibition of identity and inhibition of location result from separate processes, as location and identity inhibition seem to be affected by different stimulus changes. While Experiment 2 was designed to test the hypothesis that children develop the ability to inhibit identity later than the ability to inhibit location, the experiment offered no evidence to support or to reject this hypothesis because no age group showed significant negative priming effects of identity.

Developmental issues in negative priming research

The primary motivation for this research was to explore the developmental progression of children's abilities to inhibit both objects' identities and their locations. The present findings suggest that young children can inhibit locations regardless of the identity of the ignored object. The issue of whether children
inhibit identity at a similarly early age remains unclear. Since no age group demonstrated inhibition of object identity, it is difficult to interpret the lack of identity inhibition in children as evidence of immature inhibitory abilities. Clearly more research needs to look at children's abilities to inhibit the identity of information before definite conclusions may be drawn.

In pursuing answers about children's abilities to inhibit object identity, the issue of distance between targets and distractors should to be addressed. These experiments were designed as a modification of the task used by Connelly and Hasher (1993), in which inhibition of identity occurred in the identity task for college-age participants. The primary difference between the two experiments was the different set-up of the stimuli on the screen. Rather than organizing the stimuli to correspond to the D, C, K, and M on the keyboard as did Connelly and Hasher, the stimuli in this experiment were arranged to correspond to the 2, 4, 6, and 8 on the numeric keypad of the keyboard. In Connelly and Hasher's experiments, the widest horizontal distance between the targets and distractors was half of the widest horizontal distance in the presentations of this experiment. Furthermore, the arrangement of stimuli which followed the D, C, M, and K on the keyboard allowed for a vertical distance between targets and distractors (12 mm) which was almost eight times smaller than the largest vertical distance between targets and distractors used in this experiment. Thus, in the experiments presented here it is possible that the large distance between the targets and distractors contributed to the lack of identity-based negative
Inhibition in Children

priming, at least in adult participants.

To add to the likelihood that the distance and not the set up of the stimuli caused the lack of identity-based negative priming effects, other studies have found negative priming effects using the numeric keypad set up (Milliken et al., 1994; Tipper et al., 1994). Furthermore, previous research has demonstrated that the strength of identity inhibition increases as the distance between targets and distractors decreases (Neumann, 1993; Fox, 1994). Neumann, for example, showed that when the target and distractor were abutted, negative priming effects were strong. However, when the target and distractor were separated by only 1/2 centimeter, negative priming effects decreased to statistically non-significant levels. Fox (1994; see Fox, 1995 for a review) also shows that decreasing the distance between targets and distractors reduces the strength of negative priming. These effects, however, may not be a result of proximity per se, as Neumann (1993) also showed that increasing the difference in the size of the target and the distractor also decreased negative priming effects. He concluded that the more difficult it is to discriminate between a target and a distractor, the more potential it has for interference, resulting in stronger inhibition.

Regardless of whether ease of discrimination (Neumann, 1993) or proximity per se (Fox, 1994) causes a decrease or even elimination of negative priming effects, it seems reasonable to suggest that the same factors that contribute to the level of inhibition in adults would also contribute to levels of
inhibition in children. However, since young children are typically distracted by information that spans a greater surface area than are adults (e.g. Enns & Grgus, 1985), it may be interesting for researchers to systematically manipulate target and distractor distance to see whether children demonstrate inhibition at distances which do not elicit negative priming effects from adults.

Evidence for separate inhibitory processes

Although the lack of negative priming of identity across age groups does not completely clarify whether children have the ability to inhibit object identity, this same evidence is consistent with the hypothesis that there are two different mechanisms responsible for inhibition. If inhibition results from one process, both identity- and location-based inhibition would be expected to appear at the same point in development and should be affected by the same factors. As discussed previously, both older adults and young children reliably inhibit locations in negative priming tasks. Neither older adults (e.g. Connelly & Hasher, 1993; Kane et al., 1993) nor young children (Tipper et al., 1989) reliably inhibit identity; recall however, the data regarding children’s ability is less clear (Tipper et al., 1989, Experiment 3). Thus, older adults and possibly children, show developmental changes in their abilities to inhibit identities that are not evident in their abilities to inhibit locations.

More importantly, assuming that inhibition of identity requires either close proximity (Fox, 1994) or low discriminability between targets and distractors (Neumann, 1993), the persistence of robust effects of location-based inhibition
when neither of these factors was present further supports the notion that separate processes are responsible for location- and identity-based inhibition. This is especially convincing considering the same stimuli produced inhibition of location yet failed to produce inhibition of identity across three age groups.

However, the issue of separate processes is far from resolved. As discussed earlier in this paper, much of the behavioral data in support of separate processes can be explained by the hierarchy of processing model. Even age differences can be explained by this model, if one accepts that developmental changes reflect the maturation (or decline for older adults) of the ability to climb the processing hierarchy suggested by Neill et al. (1994). Thus, while the data from these experiments are consistent with the separate processes argument, they certainly do not end the debate, nor do they rule out other interpretations.

**How negative priming research relates to broad theories of attention**

Historically, selective attention research focused on supplying evidence for and against early or late models of selection. Negative priming studies may shed some light on this argument. Inhibition appears to be hierarchical, occurring for those features that require analysis for correct selection. That is, location is inhibited regardless of task demands (posed thus far), abstract representations are inhibited only when selection requires identification at a representational level (e.g. cross-category negative priming, see Tipper & Driver, 1988), and perceptual features are inhibited when responses require matching of
perceptual features (e.g. letter matching tasks) or when there are no pre-existing abstract representations. If late selection theories were correct, inhibition should occur for all features of stimuli that cause interference since they would be analyzed prior to selection, and therefore would be likely to cause distraction. If early selection models were appropriate, inhibition would seem unnecessary because very little irrelevant information would be analyzed and retained. More importantly, early selection models cannot account for inhibition of abstract representations without separating inhibition from selective attention or discrediting negative priming as an effect caused by inhibition. Thus, negative priming research suggests that a combination of early and late selection models is the only appropriate way to view attention. It is likely that some features of both relevant and irrelevant information are analyzed prior to selection. Those features that are required to make the selection are analyzed, while features that are not necessary for selection are not analyzed. Selection then takes place which allows the processed information to proceed in meeting task goals. Subsequently, inhibition suppresses the analyzed features of the unselected information to keep this information from interfering with goals.

The question of how and when these processes develop in children remains for future research. Evidence from negative priming research, coupled with physiological data (e.g. Ungerleider & Mishkin, 1982) suggests that researchers should be aware that separate neural pathways may be responsible for different aspects of inhibition. These may mature at different rates in
Inhibition in Children

children, producing differential selection and attentional abilities. This may be especially important when conducting research with populations who have attentional problems, such as children with Attention Deficit Disorder.

Development towards mature inhibitory processes

In many areas of cognitive development, the maturation of inhibitory processes is thought to be an important part of cognitive development as a method of dealing with intrusions. For example, research by Posner and his colleagues (e.g. Clohessy, Posner, Rothbart, & Vecera, 1991) shows that the ability to inhibit motor responses of the visual system to locations previously focused upon (inhibition of return) rapidly develops between three and six months of age. This allows infants to avoid repeatedly focusing on locations they previously explored. Diamond proposes that inhibition of motor responses, such as inhibition of reflexive actions, also develop in infancy (see Diamond, 1991). The acquired ability to inhibit motor responses, combined with other developmental progressions such as organizing action sequences, allows children to avoid distracting objects in, among other things, their reaching actions.

The ability to suppress irrelevant information from working memory is also crucial to development. From pre-school up through the elementary school years, children become increasingly competent in keeping disrupting and irrelevant thoughts out of working memory. Harnishfeger and her colleagues (Harnishfeger, Digby, Scott, Nicholson, & Liberty, 1992; Harnishfeger, Scott,
Nicholson, 1993; see Hamishfeger, 1994 for a review) showed that children's ability to avoid intrusions from previously memorized but irrelevant words develops over the elementary school years. The increased tendency to suppress irrelevant information from working memory allows a larger proportion of the available cognitive resources to be used for relevant tasks.

In attention, inhibition serves to enable both selection of target information and greater concentration without disruption from distracting information in the visual field. Inhibition appears to be especially important in aiding attention when the distracting information is in close proximity or is particularly similar to the targets. With age, children develop the ability to avoid interference, and their ability to attend to relevant information improves.

Inhibition in attention, therefore, is one of several inhibitory processes developing throughout childhood. Inhibition enables children to avoid undesired motor responses, information that competes for attention, and intrusions into working memory. This in turn increases children's ability to focus, concentrate, and achieve their goals without serious disruptions from distracting information. The studies presented demonstrate that by the age of six, children are fully capable of inhibiting locations regardless of those objects' identities. Whether or not six-year-old children can inhibit identity, however, remains unclear. The research presented is consistent with the existing body of evidence that shows identity- and location-based inhibition result from separate processes. Negative priming studies suggest that task goals affect the amount of information that is
Inhibition in Children

processed before selection. This provides a theoretical framework to combine early and late selection theories of selective attention.
References


Inhibition in Children

Southeastern Psychological Association, New Orleans.


Experimental Child Psychology, 43, 159-180.


Inhibition in Children

Table 1. Means of median reaction times, standard deviations, and percent of errors committed in Experiment 1.

<table>
<thead>
<tr>
<th>Presentation type</th>
<th>Age</th>
<th>Unrelated</th>
<th>Identity</th>
<th>Location</th>
<th>Location + Identity</th>
</tr>
</thead>
<tbody>
<tr>
<td>adults</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>232.13</td>
<td>233.48</td>
<td>257.30***</td>
<td>250.00***</td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>95.15</td>
<td>104.82</td>
<td>102.38</td>
<td>102.68</td>
<td></td>
</tr>
<tr>
<td>Error rates</td>
<td>.74</td>
<td>1.04</td>
<td>2.48**</td>
<td>.75</td>
<td></td>
</tr>
<tr>
<td>fifth-grade children</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>391.10</td>
<td>381.96</td>
<td>405.64*</td>
<td>401.61*</td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>160.26</td>
<td>161.39</td>
<td>143.25</td>
<td>150.67</td>
<td></td>
</tr>
<tr>
<td>Error rates</td>
<td>1.34</td>
<td>2.28</td>
<td>5.49**</td>
<td>2.56</td>
<td></td>
</tr>
<tr>
<td>first-grade children</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>735.41</td>
<td>739.53</td>
<td>746.35</td>
<td>739.38</td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>164.24</td>
<td>165.07</td>
<td>172.40</td>
<td>173.96</td>
<td></td>
</tr>
<tr>
<td>Error rate</td>
<td>3.80</td>
<td>5.78</td>
<td>6.90*</td>
<td>6.12</td>
<td></td>
</tr>
</tbody>
</table>

Note: Asterisks indicate significant differences when compared to the unrelated condition.

+ $p = .10$, * $p < .05$, ** $p < .01$, *** $p < .001$, **** $p < .0001$
Table 2. Means of median reaction times and standard deviations for Experiment 2.

<table>
<thead>
<tr>
<th>Presentation type</th>
<th>Age</th>
<th>Unrelated</th>
<th>Identity</th>
<th>Location</th>
<th>Location + Identity</th>
</tr>
</thead>
<tbody>
<tr>
<td>adults</td>
<td>M</td>
<td>281.21</td>
<td>287.45</td>
<td>306.79**</td>
<td>302.42****</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>55.57</td>
<td>53.24</td>
<td>54.59</td>
<td>55.33</td>
</tr>
<tr>
<td>fifth-grade children</td>
<td>M</td>
<td>355.36</td>
<td>351.82</td>
<td>395.07**</td>
<td>402.71***</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>69.04</td>
<td>68.74</td>
<td>102.37</td>
<td>84.10</td>
</tr>
<tr>
<td>first-grade children</td>
<td>M</td>
<td>556.59</td>
<td>566.38</td>
<td>612.78***</td>
<td>590.16*</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>91.69</td>
<td>90.57</td>
<td>102.28</td>
<td>81.55</td>
</tr>
</tbody>
</table>

Note: Asterisks indicate significant differences when compared to the unrelated condition.  * p < .05,  ** p < .01,  *** p < .001,  **** p < .0001
Footnotes

1. If it is possible to anticipate that the suppressed information must be subsequently selected, it may actually be more easily accessed than other information resulting in facilitated selection. There is some evidence supporting this hypothesis, however, it is beyond the scope of this paper.

2. The identity ignored repetition condition is the equivalent of Connelly and Hasher’s (1993) identity suppression condition. The location ignored repetition condition is the equivalent of their location suppression condition, and the location + identity ignored repetition condition is the equivalent of their identity and location suppression condition.
Figure Caption

Figure 1. Example of the stimuli used in Experiments 1 and 2. Targets are printed in solid type, distractors are printed in outlined type. In Experiment 1, subjects responded to the location of the target number. In Experiment 2, subjects responded to the identity of the target number.
Possible Prime

1

Location Ignored Repetition

2

Identity Ignored Repetition

3

Location and Identity Ignored Repetition

3

Unrelated

2

4
CURRICULUM VITAE

BIOGRAPHICAL

Name: Deborah Lynne Jonas-Renicky
Date of Birth: February 5, 1971
Place of Birth: Teaneck, New Jersey
Parent's Names: Peter Jonas, Judith Jonas

Current address: Office

Duke University Psychology Department
Durham, NC 27708

Home

4800 University Drive, #29D
Durham, NC 27707

EDUCATION


1993-1995 Lehigh University, Bethlehem, PA. Master of Science, Experimental Psychology, July 1995

1992 Johns Hopkins University, Baltimore, MD. Graduate courses in education.


MEMBERSHIP IN PROFESSIONAL ORGANIZATIONS

Psi Chi Honor Society
Golden Key National Honor Society

PROFESSIONAL EXPERIENCE

1993- 1995 Graduate research, Lehigh University, Bethlehem, PA. Research focused on the
development of inhibitory processes used for selective attention.

1994-1995 Teaching Assistant, Lehigh University, Bethlehem, PA.
Upper level experimental psychology laboratory

1994-1995 Adjunct Instructor, Lafayette College, Easton, PA.
Introductory laboratory in psychology

1992-1993 Research Assistant, Laboratory of Socio-Environmental Studies, National Institute of Mental Health, National Institutes of Health, Bethesda, MD. Assisted in design, implementation, scoring and data analysis of experiments in psychology and aging, cognitive inhibition, and longitudinal research focusing on socio-economic factors contributing to mental illness.

1992 Research Assistant, COMSIS Corporation, Silver Spring, MD.
END
OF
TITLE