Factors that Influence Priming in Young Children

by

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We accept this dissertation as conforming to the required standard

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ABSTRACT

An empirical exploration of factors that facilitate priming in young children was undertaken utilizing sequentially degraded pictures (fragpix) developed by Snodgrass and her colleagues. The identification of fragmented pictures was studied by 288 children across four experiments. In the first two experiments abbreviated sets of fragpix were generated for use with young children. Experiments 3 and 4 manipulated five attributes of the priming stimulus to measure their effect on direct and indirect tests of memory.

Experiment 3 was a scaling study that delineated age-associated identification thresholds for fragpix. It also examined hypotheses regarding the impact of prior exposure and perceptual closure on indirect and direct tests of memory. During the exposure and test condition, 3-, 4-, 5- and 8-year olds were shown fragpix in descending degrees of fragmentation until they correctly named the picture. Snodgrass proposed perceptual closure as an explanatory mechanism for identification of incomplete pictures. To explore this hypothesis, following identification of each fragpic, half the children were shown the completed picture. This manipulation had no facilitative effect on identification or recall of fragmented pictures. Two measures of prior exposure, priming and transfer, were also

computed. Age differences were found on picture identification, free recall, and picture recognition measures of discrimination and response bias. A linear trend was revealed on measures of priming for picture identification, and for picture recognition but not for recall.

A similar method was used for each of the first three experiments: Fragpix were presented in their most degraded form with pictorial information systematically added until the picture was named. Snodgrass and Feenan (1990) suggested that priming might be equally effective if only single levels of fragmentation were presented. They reported that exposing adults to moderately fragmented pictures promoted closure and was more beneficial for later identification, than exposure to maximally-fragmented or nearly completed pictures. Experiment 4 tested this "optimal level" hypothesis with 5- and 8-year olds. Scores from Experiment 3 were used to select age-specific levels of fragmentation that made fragpix easy, moderately easy, or difficult to identify.

Attributes of the priming stimulus were manipulated in Experiment 4 to examine the differential impact of varying exposure conditions on performance and on the magnitude of priming. Three manipulations occurred: One varied number of stimulus changes across levels of fragmentation, a second varied order of difficulty, and a third varied the nature of

stimulus change (random or systematic). Manipulating the priming stimulus influenced fragpix identification and priming, but had little definitive impact on free recall.

For both ages stimuli presented in a systematic rather than random order facilitated picture identification and the magnitude of priming. In addition, developmental differences emerged among systematic orders of presentation. Five-year-olds demonstrated optimal performance in picture identification and measures of picture recognition when there were multiple changes in temporal contrast, while order of difficulty (moderate to easy to hard) was more facilitative for 8-year-olds. A finding for a quadratic function for 8-year-olds on picture identification and magnitude of priming supported a moderately fragmented stimulus being an optimal prime, while for 5-year-olds, the relationship was monotonic. This pattern was not observed on the direct memory tests.

It is argued that both perceptual and cognitive components of the task influence performance in an integrative manner on indirect and direct memory tests. A modified form of transfer appropriate processing is proposed as a reasonable explanation of the findings.

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Factors that Influence Priming in Young Children

Chapter I: Priming in Young Children

In its broadest interpretation priming is defined as the effect on performance of prior exposure to a stimulus. In more specific terms, it refers to performance facilitated by a prior stimulus without the subject necessarily having conscious awareness of the influence of that stimulus (Graf & Schacter, 1985; Schacter, 1987). The prior stimulus is said to establish a "determining tendency" that sets, or primes, the subject to respond in one way rather than another, but "whose presence in consciousness is not a necessary (or even actual) part of the response process" (Lockhart, 1989, p. 6). Priming is said to be demonstrated, for example, if in comparison with similar measures of response to control items, the probability for identification of the previously encountered target is increased, or alternately, latency in identification is decreased. The difference in performance at test between target (exposed) items and not-previously exposed items provides a measure of the magnitude of priming.

In addition to its links with unaware processes, priming has also been associated with mechanisms of conscious awareness and attention where the subject is specifically directed to attend to components of the stimulus for later testing. The association of conscious levels of awareness with a priming effect is sometimes underestimated when cognitive theorists attempt to disentangle conflicting research outcomes (Richardson-Klavehn & Bjork, 1988). The following brief review of priming studies in psychology exemplifies the divergent interpretations of the influence of prior experience on performance.

Historical Review: The Study of Implicit Processes on Performance

The nature of explicit or conscious forms of learning and memory was a predominant focus for early Greek and Egyptian philosophers. It was not until the 17th century that recorded evidence appeared regarding the exploration of "unconscious" or "unaware" learning and memory processes. A comprehensive review of unaware cognitive processes covering the three-hundred year period from the 1600s to the 1900s has been chronicled by Schacter (1987) and interested readers are referred to this work. Evidenced in Schacter's review are the variety of definitions that have been attributed to priming during this early period; for example, in Kulpe's laboratory in Wurzberg, priming was studied by introspectionists as "imageless thought." Nevertheless, the fundamental components of "prior exposure" and "an implicit response not mediated by conscious recollection" have generally endured.

Within the context of prior exposure, priming has been studied as both an explicit and implicit manipulation.

Experiments conducted during the first half of this century, and later in verbal learning, examined priming as an explicit condition utilizing, for example, Ebbinghaus' multiple-exposure trials-to-criterion training conditions (e.g., Gollin, 1960, 1961, 1966) or intentional instructions (e.g., Bransford, Franks, Morris, & Stein, 1979). Conscious or intentional priming was described by Bransford et al. as "the capacity of a stage-setting metaphor to pretune the cognitive system for automatized responding" (as cited in Lockhart, 1989, p. 8). As a consequence, in some areas of psychology (e.g., verbal learning and attention) priming has remained linked with over-learned or practiced behavior. Current theories of attention, for example, continue to explore priming as an explicit influence on performance. Labelled set-expectancy or attention-switching in this context, priming reflects the effect of trial-by-trial changes in cognitive strategy associated with responding to specific tasks (Enns & Cameron, 1987). Alternately, some learning theorists explored priming as an incidental instruction condition demonstrating that, under non-directive instructions, just a single prior exposure to a stimulus could alter or influence a response to its subsequent presentation. In this context, priming was said to reflect incidental learning (e.g., Postman, 1964).

Interest in priming has soared remarkably over the last decade and, although contemporary emphasis in cognitive psychology is on its implicit influence on memory processing, some terminology from verbal learning theory endures. The term priming is sometimes used interchangeably with implicit memory (Tulving, Schacter, & Stack, 1982), incidental learning (Neill, Beck, Bottalico, & Molloy, 1990), and implicit learning (Snodgrass, 1989a; Snodgrass & Feenan, 1990). While it is likely that these implicit phenomena share similar processing mechanisms and that no definitive boundaries clearly distinguish one implicit phenomenon from the other (Seger, 1994), some clarity in the utilization of these terms is advisable.

Implicit learning, as defined by Reber (1989), is the incidental consequence or process by which rule-governed complexities of the stimulus environment are acquired independently of conscious attempts to do so. Thus, implicit learning is said to involve unconscious processes, but is distinct from other forms of implicit phenomenon in that it yields abstract knowledge. This implicit knowledge, often of a novel pattern or rule of grammatical structure, is acquired in the absence of conscious, reflective strategies to learn, and further, after its acquisition, participants are not necessarily able to articulate what they have learned. However, whereas deliberate attention to task is not believed to be necessary for the function of implicit memory, it is important for implicit learning to occur (Seger, 1994). Some of the controversy surrounding implicit learning is the contention by some (e.g., Perruchet & Pacteau, 1990) that implicit learning is not truly an unconscious process.

Incidental learning also refers to the effects of recent prior experience on performance, but is typically associated with procedures employed during encoding that manipulate degrees of elaborative processing (Postman, 1964; Jacoby, 1984). To illustrate, subjects may be directed to elaborate on the meaning of the study stimulus, e.g., "would this item be useful on a desert island?" or merely asked to "count the number of vowels in this word." Performance on indirect tests that do not make direct reference to a specific prior episode, such as a word-fragment completion test, is not differentially affected by these manipulations (Neill et al., 1990). Alternately, direct tests of memory, such as free recall, are facilitated by elaborative processing manoeuvres.

Implicit memory, and its adjunct explicit memory, rather than being specifically associated with the encoding process, is more appropriately connected with different forms or functions of memory during cognitive processing. Explicit memory is said to be consciously controlled and facilitated by intention to learn, whereas implicit memory is not mediated by conscious intentions. Measured by indirect tasks, implicit memory is revealed when performance on these tests is facilitated in the absence of conscious recollection (Graf & Schacter, 1985).

In summary, for the purposes of this paper, implicit learning, incidental learning, implicit memory, and priming may be viewed as descriptive variations in the "primacy of the implicit". More specifically, implicit learning and incidental learning reflect similar but unique phenomena of empirical processes that occur during encoding, while implicit memory reflects the way memory responds to implicit processes. To avoid confusion, the term priming will be retained and applied in the broader sense reflecting "the facilitative effects of an encounter with a stimulus on the subsequent processing of that stimulus" (Tulving et al., 1982, p. 336) and subsequent improvement in one's ability to identify or generate the stimulus during test (Masson & MacLeod, 1992, 1996). A consequence of this decision is that factors believed to distinguish between specific forms of implicit phenomena, for example, level of attention, might be less definitive markers when examining the broader context of priming.

The above review of implicit processes suggested that several factors contribute to our ability to discriminate among these phenomena. Three factors (a) the role of attention and awareness in what is being processed, (b) the nature of what is learned, that is, conceptually and data-driven attributes of the exposure (study) task and subsequent test, and (c) processing similarities between study and test are considered further. Research examining each factor in relation to priming follows and is linked with the impact of these factors on proposed explanatory mechanisms for the effect of prior exposure on performance.

Selective Attention versus Preattentive Processes

When priming was explored within the context of explicit exposure, subjects were directed to pay specific, that is, conscious attention to the stimulus. Their subsequent performance was said to reflect an associative strength between a stimulus and response, the magnitude of priming being correlated with amount of practice (Braly, 1933; Leeper, 1935). Alternately, when priming was examined as an implicit influence, especially in its association with implicit memory, the absence of directed or selective attention during stimulus presentation was offered as support for the role of automatic or preattentive encoding during exposure. Studies such as those carried out by Zajonc and colleagues (e.g., Kunst-Wilson & Zajonc, 1980) suggested that the priming effect was present even when one's level of attention or awareness during encoding was dramatically reduced. For example, words presented briefly with a tachistoscope and only recognized at chance level during a subsequent memory test received higher affective ratings than new stimuli. Similarly, words presented in a sentence to an unattended ear during a dichotic listening task received preferential spelling during later homophone spelling tests (Eich, 1984).

A limitation of the above and similar studies, however, was their failure to manipulate the condition of attention during exposure (Richardson-Klavehn & Bjork, 1988). Parkin and Russo (1989) and Russo and Parkin (1993) examined priming using divided and focused attention conditions. Subjects in the divided attention condition were expected to attend simultaneously to two tasks--identifying fragmented pictures while attending to a tone detection task; other subjects gave their full attention to the picture task. It was revealed that, while divided attention interfered with a test of recall for previously seen pictures, there was no difference in priming for level of fragmentation in picture identification as a function of attention. An unattended effect of priming was also demonstrated in studies where stimuli were high- or low-frequency words. When the prime was masked, and therefore barely available to conscious processing, low- and high-frequency words benefitted equally from the prime, neutralising the frequency-attenuation effect typically seen with high-frequency words (e.g., Jacoby & Dallas, 1981).

On some tasks, when attention/non-attention conditions were manipulated, an association between the magnitude of the priming effect and attention emerged, with evidence favouring a role for selective attention in priming. For example, in a dichotic listening condition, biasing primes were presented to either an attended or unattended channel while subjects completed a lexical decision task. While the effect of the priming stimulus facilitated performance on a later homophone spelling test, the effect was larger for conditions favouring the attended channel (Eich, 1984). Forster and Davis (1984) reduced the role of attention for the initial encoding of an item by masking the study presentation of repeated stimuli in a lexical decision paradigm. The greater the number of items that intervened between the first and second presentations of the word, the greater the degree of decay in priming. When 17 items intervened, performance at test was only at chance. Such a decline over a short interval contrasts with other reports of the persistence of priming over long intervals (e.g., for 2 weeks, Parkin & Streete, 1988) and suggests a role for attention at the time of encoding.

In summary, although prior exposure is known to be beneficial to later performance, the role of attention as a factor influencing priming appears to be variable. Most--but not all--of the priming effect may be explainable by preattentive encoding. As well, as was noted with implicit learning, there appears to be a relation between type of task and degree of awareness, such that conceptually driven tasks are more likely to require greater degrees of selective attention. This association, however, is not unequivocal as has been demonstrated by theorists who have examined priming as a function of the similarity in processing operations between study and test, referred to as transfer-appropriate processing.

Conceptual versus Data-driven Measures in Processing

Morris, Bransford, and Franks (1977) proposed a model for transfer-appropriate processing in which context-similarity between exposure and test enhanced performance. Jacoby (1983), Roediger and Blaxton (1987), and others modified this theory to emphasize a distinction between conceptually driven and data-driven tests and their association as measures of implicit and explicit memory. The differences between tests are a function of how well the input and test processes engaged in by the participant correspond with each other. Explicit memory tests are believed to be more conceptually driven than implicit memory tests and therefore benefit more from meaningful elaboration during input. Implicit tests are less sensitive to such manipulations; they are said to be data-driven and to benefit from an emphasis on the physical surfaces of the stimulus during processing.

Roediger, Srinivas, and Weldon (1989) define the transfer appropriate processing approach in terms of four primary tenets. First, they propose that memory tests benefit to the extent that processing operations required at test recapture, or duplicate, the encoding operations applied during the original learning. Second, they assume that implicit and explicit memory tests generally require different retrieval operations, and thus differentially benefit from different types of processing during study. Third, they proposed that explicit memory tests rely on the encoding of concepts, or on semantic processing, or elaborative coding, and other similar conceptually driven information. Finally, they suggest that most implicit memory tests rely heavily on the match between perceptual processing of information at study and its retrieval at test. Blaxton (1989) emphasizes, however, that there is no necessary correlation between explicit memory tests and conceptually driven processing, or between implicit memory tests and data-driven processing. One can develop implicit, conceptually driven tests and explicit, data-driven tests.

Evidence has favoured manipulations in which conceptual processes have large effects on conceptually driven tests while having little effect on data-driven implicit tests (e.g., Graf & Mandler, 1984; Jacoby, 1983). To illustrate, merely reading a list of words quickly flashed on a computer screen enhances the likelihood that the subject will complete a word-fragment task by unconsciously selecting words from these briefly studied stimuli. A similar correspondence applies to conceptually driven processes and conceptually based tasks. For example, when a recall test is to be administered for a list of words, subjects are directed to study the words in anticipation of a later test of their memory. Dissociations in performance between data-based and conceptually based tasks are expected in the theoretical account of transfer appropriate processing.

Because the expression of priming requires that some surface aspect of the exposure stimulus also be presented during test, a condition absent for conceptually based tasks such as free recall (Roediger & Blaxton, 1987), priming has typically been aligned with data-driven processing. A deluge of studies from the 1980s appeared to support the relevance of a distinction between the implicit and explicit attributes of study and test materials (e.g., Graf & Schacter, 1985; Light, Singh, & Cupps, 1986; Lorsbach & Worman, 1989; Naito, 1988; Schacter & Graf, 1986).

Other studies, however, revealed that priming was not the exclusive function of empirical conditions that either utilized perceptual components of a stimulus, called upon data-driven processes, or employed measures of implicit memory. Both parallel and dissociative effects have been demonstrated across a variety of measures and a range of stimulus manipulations. Hirshman, Snodgrass, Mindes, and Feenan (1990) found a parallel effect for priming in conceptually based tasks of fragment completion; words used as priming stimuli facilitated the identification of pictures and the completion of word fragments.

In contrast, a data-based task of reading a list of words facilitated performance for fragmented-word completion but not for recognition memory (Tulving et al., 1982). A levels-of-processing manipulation was shown to have a null effect for priming on word completion tasks (Graf & Mandler, 1984) and for perceptual identification of pictures (Carroll, Bryne, & Kirsner, Experiment 1 & 2, 1985), but to have a large effect for elaborative processing on conceptually driven tasks of implicit memory.

The increasing report of dissociations within implicit tests and within explicit tests as well as parallel effects across types of tasks prompted modifications of the transfer appropriate processing account. First was the recognition that these within-test dissociations might be accounted for by a continuum of tests within the implicit-explicit dimension. Data-driven tests might require more perceptual information than those requiring knowledge of meaning, that is conceptually based tests, but could still benefit from some level of conceptual encoding or explicit memory (Roediger et al., 1989). And expanding from this, it was reasonable to consider that when information was encoded, it was not exclusively data- or conceptually driven but might reflect both operations during processing. Some of these modifications are reflected in a theoretical account for fluency of processing.

<u>Perceptual Fluency: An Alternative Theoretical Account</u>

Examining priming as a function of attention, task attributes, and processing contexts illustrated the broad range of this phenomenon and its robustness, but yielded no definitive theoretical explanation of its function. Richardson-Klavehn and Bjork (1988), at the time of their review of this dilemma, concluded that no single theoretical position satisfactorily accounted for all the existing findings concerning priming. Neill and his associates (1990) argued that dissociations across measures are inevitable, their occurrence merely reflecting differences in the informational requirements between particular tests. Snodgrass and Feenan (1990) agreed--as have others. Finding the transfer appropriate processing view insufficient, Jacoby and Dallas (1981) suggested an alternative view they termed perceptual enhancement, and reflected the increase in ease or speed of perception conferred on an item by its prior exposure. Fluency was assumed to be a function of data-driven processes at encoding. The more similar perceptual characteristics of the stimulus are for study and test, the greater role fluency is expected to play in mediating memorial processes during retrieval.

Masson (1989), Masson and MacLeod (1992, 1996), and Neill et al. (1990) modified the fluency hypothesis even further. Labelled fluency reprocessing, they conceptualized that a priming effect on memory simply depends on whether the information required at test is made more available by the encoding processes at the time of study. What is relevant is not the specific level of attention, nor whether the processes are conceptually driven or data-driven, but rather that there exists similarity in the attended information processed during study and test.

Along similar lines, Johnston, Hawley, and Elliott (1991) proposed a perceptual-fluency-cue hypothesis. In these theoretical contexts, priming effects are said to reflect the transfer of property-sharing characteristics of the stimulus to the retrieval task. Fluency is a function of priming, and a measure of fluency is the priming effect (Snodgrass & Feenan, 1990; Snodgrass & Hirshman, 1994). These theoretical accounts will be revisited in more detail in the final discussion of research outcomes from the present experiments.

Developmental Processes

Studies exploring developmental components of prior exposure have been carried out with preschool and school-aged children since at least the 1940s (e.g., Verville & Cameron, 1946) with the "effect of coaching" studied typically as a trials-to-criterion condition or as a series of training trials. Only on rare occasions was prior exposure treated as a single-exposure episode. As a consequence, most of the studies examining the developmental nature of priming have been carried out within the last decade--paralleling the resurgence of interest in priming.

Current opinion generally favours developmental invariance for the magnitude of the priming effect. Tulving and Schacter (1990) evaluated published literature and declared that "...priming effects can be as large in 3-year-olds as in college students...priming effects (for elderly) are indistinguishable from those of young adults" (p. 302); this suggests that priming is established early, and once established, is age invariant. Graf (1990) examined four studies that "to my knowledge...includes all published studies on the development of priming" (p. 356). Although the magnitude of priming was reported to be age invariant under many conditions, he also noted that with some tasks priming effects present in children were revealed to be small or absent in adults (Sharps & Gollin, 1985). Graf, being more cautious than Tulving, concluded that priming was likely functional by preschool age (3 to 5 years of age) and once established, remained intact well into late adulthood for many, but not all tasks.

Hultsch, Masson, and Small (1991) countered this claim of invariance across adulthood, suggesting that previous studies may have lacked sufficient power to detect differences. In addition, they cautioned that tests of indirect memory may be contaminated by conscious memory retrieval strategies which has the potential to either facilitate or inhibit performance (Snodgrass & Hirshman, 1991). In their study, three age groups of adults (19-36 years, 55-69 years, and 70-86 years) were exposed to words during a lexical decision task. An indirect test of word-stem completion revealed small but reliable differences between the youngest group and the two older groups, who did not differ from each other. Light and La Voie (1993) supported this conclusion following a meta-analysis on 33 experiments with young and elderly adults, all of which utilized a verbal task. This suggests the potential for a quadratic function for the association between age and priming.

Three years after Graf's review, Mitchell (1993) identified 14 studies published from 1980 to 1992 that examined age differences in priming. A meta-analysis of the effect size for nine of these studies prompted him to conclude that the suggestion of insufficient power to detect age differences was nugatory. The fact that only four of the 14 studies reviewed by Mitchell included children younger than age 6 years highlights the need for lifespan psychology to direct research toward the very youngest-aged subjects as well as the older-aged ones. The remainder of this paper focuses primarily on children aged 3 to 8 years.

Although Graf (1990) encouraged further investigation of this phenomenon in children, in comparison to the now thousands of studies carried out with adults (PsycLIT data base, 1986-1996) surprisingly few published studies have explored priming in children. Approximately 30 articles published in the last decade were located. More than half of these studies included just a single age group with several focusing specifically on children with learning disabilities (e.g., Lorsbach & Worman, 1990). Five of the remaining studies used words as stimuli or some form of lexical decision task (e.g., Naito, 1990), which effectively limits the inclusion of younger children.

Table 1 summarizes the remaining 11 studies, each of which examined the developmental nature of priming. Studies selected for inclusion in this table met the following three criteria: first, at least two distinct age groups of children were studied; second, at least some of the age groups included subjects 8 years old or younger, and third, pictorial (or at least non-verbal) stimuli were utilized. The majority (seven of eleven) investigated priming as a demonstration of the dissociation between implicit and explicit memory. All but one of the studies reported an effect of priming for all subjects, regardless of the type of stimulus, type of test, or how the stimulus was manipulated. The only exception was Sharps and Gollin (1985); their manipulation of a categorization task at study was facilitative for child subjects but not for adults.

Age differences in the magnitude of priming were reliable only when the prime (either the priming condition or the stimulus) was manipulated at study. For example, when the priming condition was held constant (i.e., same stimulus and study condition for all subjects) priming appeared to have an equal effect across age (Lorsbach &

Table 1

Eleven Developmental Studies Examining Priming on Picture Identification

Study	Age Groups	Stimulus	Manipulation(s)	Outcome
Gollin (Exp 2) (1960)	3½, 5 yrs Adult	Fragmented pictures	Level of fragmentation	Age difference in priming.
Sharps & Gollin (1985)	4-6 yrs Adults	Pictures	Taxonomic vs functional categorization	Age difference in priming.
Carroll et al. Exp 3-4 (1985)	5, 7, 9 years Adult	Pictures	Levels of processing	Age differences for level of processing.
Parkin & Streete (1988)	3, 5, 7 years Adults	Fragpix	None (Delay of test 1 day/2 weeks)	Age differences for 2 week time delay only.[a]
Greenbaum & Graf (1989)	3, 4, 5, 6 years	Pictures	Category naming: adult- vs child-normed pictures	Age difference as a function of normed pictures.
Lorsbach & Worman (1989)	8, 12 years	Fragmented Pictures	None	No age differences.
Wippich et al. (1989)[b]	5, 8 years	Incomplete pictures	None	No age differences.
Ellis et al. (1993)	5, 8, 11 Adults	Faces	None	No age differences.
DiGuilio et al. (1994)	8, 12 yrs	Fragmented pictures	None	No age differences.
Bullock-Drummey & Newcombe (1995)	3, 5 yrs Adults	Serially blurred pictures	None (delay of test none/3 months)	Age differences for delay only.
Russo et al. (1995)	4, 6 yrs Adults	Fragmented pictures	None	No age difference for 4, 6 yr olds.

[a]Parkin (1993) reanalysed his data using a new formula and found age differences for the 1-hour delay condition. It is possible that applying that formula to all studies using the same fragmented pictures might change reported findings of developmental invariance.
[b]Published in German; translation summarized by Mitchell (1993).

Worman, 1989; Russo, Nichelli, Gibertoni, & Cornia, 1995). Manipulating the priming condition or the priming stimulus at study, as was done by Gollin (1960, Experiment 2), Carroll et al. (1985), Greenbaum and Graf (1989), and Sharps and Gollin (1985) produced differential outcomes across age with older subjects demonstrating a larger effect of priming than younger ones. Delaying the time of test revealed similar age-associated differences in priming (e.g., Bullock-Drummey & Newcombe, 1995; Parkin & Streete, 1988). In some studies, tasks with higher-level semantic and classification demands were more likely to find age-related differences (Greenbaum & Graf, 1989; Sharps & Gollin, 1985) than tasks requiring a low-to-moderate level of stimulus analysis.

A summary of priming. Priming is a robust phenomenon that can be demonstrated across a wide variety of stimulus and task manipulations. Although priming is more typically associated with preattentive encoding, its effect can be enhanced under conditions of direct attention, especially on conceptually based tasks. A priming effect can be reliably obtained in preschool-aged children and age invariant outcomes are reported, particularly if empirical conditions require a sensory-perceptual level of analysis or do not involve a manipulation of the prime. Differential age effects are more likely to be seen when the prime is manipulated at study, or when a more cognitive level of stimulus analysis is required.

The above observations dictate a judicious selection of stimulus materials for this project. The stimulus materials chosen for the present study were the fragmented pictures or "fragpix" developed by Snodgrass and her colleagues (Snodgrass, Smith, Feenan, & Corwin, 1987). The rationale for this decision follows.

Pictorial Stimuli and Fragmented Pictures

The inclusion of very young children in empirical studies entreats the selection of stimuli with minimal reliance on verbal language ability. The stimuli should be suitable (i.e., interesting) for the broad age range of subjects that potentially might be involved in developmental studies. In addition, the processing requirements of study and test should not have a heavy reliance on subject-controlled processing strategies (Mitchell, 1993). This is especially critical when the goal of the experimenter is to examine manipulations of the priming stimulus. The influence of varying meta-memory strategies and conscious processing and retrieval strategies could potentially obscure the differential influence of perceptually based mechanisms. The use of pictorial stimuli assists in levelling the developmental playing-field in what is also known as the picture superiority effect (Madigan, 1983). The available options for pictorial stimuli suitable for very young and middle-school children in terms of challenge, interest and potential for on-task success are limited, but from the turn of the century (e.g., Street, 1931) various forms of incomplete or fragmented pictures have been used successfully. A modern version of such stimuli are sequentially fragmented pictures known as "fragpix" (Snodgrass et al., 1987).

Fragpix (plural; "fragpic," singular) are pictures that have been submitted to a fragmentation algorithm using Microsoft Basic on an Apple Macintosh computer (see Snodgrass et al., 1987, for details of this procedure). As illustrated in Figure 1, the computer-generated fragmentation process created eight levels of fragmentation for each picture, with Level 1 representing the most fragmented picture and Level 8 representing the complete picture. Berman, Friedman, Hamberger, and Snodgrass (1987) established levels of name agreement and familiarity of pictures with 8-year-old subjects and adults. Based on the highest correlations for agreement between these two age groups, five sets of fragpix (Picset 1 to Picset 5) were created with 30 pictures in each set. A subsequent reanalysis of these picture sets by Snodgrass and Corwin (1988) with adults produced four revised sets (#6 to #9), each retaining 30 pictures.

Fragpix have been used with children as young as 3 years of age (Parkin & Streete, 1988), with adults (Snodgrass & Corwin, 1988), and with children diagnosed as

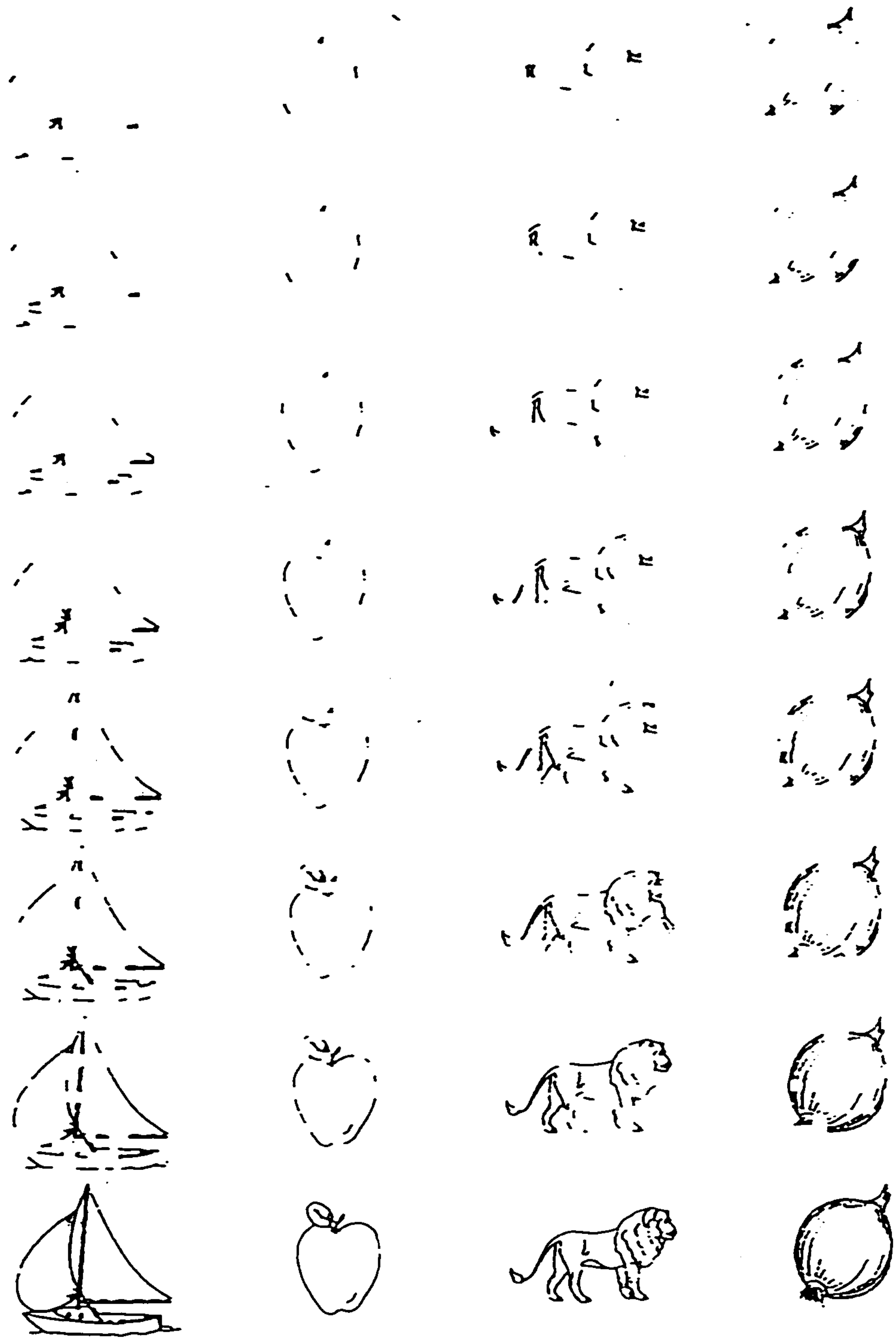

Figure 1. Examples of the fragmented pictures (Level 1 is at the top and Level 8 is at the bottom). From Snodgrass and Feenan (1990)

learning disabled (Lorsbach & Worman, 1989) without producing floor or ceiling effects. This suggests that fragpix are suitable stimuli for examining differential age-rated changes for priming. Equally advantageous is the likelihood that young subjects will find the opportunity to play games on a computer an appealing proposition. This factor, plus the use of age-normed pictures, promotes affective and motivational responses that further enhance cooperation and optimum performance (Franken, 1982). Most important, because one of the goals of this research project is to examine factors that influence the magnitude of priming, the availability of eight levels of fragmentation establishes fragpix as propitious stimuli for manipulation during exposure.

Although fragpix have primarily been employed in studies with adult subjects, a few researchers have used them with children. Lorsbach and Worman (1989) used fragpix with 8- and 12-year-olds, whereas Parkin and Streete (1988) used them with children aged 3 to 7 years, and Russo et al. (1995) included 4- and 6-year-old children. In the Lorsbach and Worman study, utilization of the stimuli underwent significant alterations, that is, only 4 of the 8 fragmented levels were used. Consequently, direct comparisons of mean thresholds of identification from the Lorsbach studies with the current or similar studies are not feasible. The procedure followed by Parkin and Streete most closely replicated the typical priming paradigm introduced by Snodgrass et al. (1987). The application to a preschool-aged population of the typical priming paradigm using the standard-sized picture set overlooks two potential difficulties.

The first concern relates to the limited attention span of younger children compared to adults, and the second to the ability of preschool-aged children to identify the pictures. It was noted that in several of the studies where fragpix are used with young children some aspect of the standard fragpix priming paradigm was altered, either in the stimulus materials themselves or the procedure. Lorsbach and Worman (1989) used only 4 of the 8 levels of fragmentation. Russo et al. (1995) retained all eight levels of fragmentation in their study but they reduced the size of the picture set from 30 fragpix to 24. In addition, the study stimulus was only the completed picture; presentation of fragpix by ascending levels of fragmentation occurred only at test. Parkin and Streete (1988) introduced a delay condition such that subjects were given either a one-hour or a two-week break between exposure and test.

It is conceivable that the one-hour recess was not simply a manipulation of a delay condition; the researchers likely recognized that the limited attention span of younger-aged subjects precluded completing the exposure and test phases in a single session. Reducing the number of fragpix in a picture set or limiting the number of levels of fragmentation shown also suggests some accommodation for the shorter and more variable attention span of young children. In addition, because fragpix have only been normed in terms of picture name agreement with 8-year-olds and adults (Berman et al., 1987), it is possible that not all of the pictures in a selected picture set are identifiable by a majority of preschool-aged children.

Experiment 1, therefore, was a pilot study with eight preschool-aged children in which exposure and test were completed in one sitting. Two of the original picture sets developed by Snodgrass et al. (1987) were used. In addition to recording the child's identification responses to the stimuli and the time each child took to complete the session, notations were made of compliance to task instructions and how long a child could attend to the task before needing significant encouragement to continue.

Experiment 1

Method

Participants. Eight children (4 girls) from a local day care in Victoria, B.C., participated with written parental permission. Their ages ranged from 44 to 67 months.

Materials. An Apple Macintosh micro-computer program consisting of 150 pictures that had been submitted to an algorithmic fragmentation process was purchased from Dr. Joan Snodgrass. The pictures were black and white line drawings representing 12 taxonomic categories of animals, birds, furniture, vehicles, toys, food, musical instruments, human body parts, tools, clothing, and kitchen utensils (Snodgrass & Vanderwart, 1980). Details of the fragmentation process are described in Snodgrass et al. (1987). The five picture sets created in the latter study were reorganized by Snodgrass and Corwin (1988) and one of the four sets of these revised fragpix (Picset 8) was utilized in the current study.

Three practice pictures plus the fragpix from Picset 8 were used as stimuli for all children (see Appendix A for list of pictures). Picset 8 consisted of 30 fragpix, 15 in subset A and 15 in subset B. The subsets were used alternately during exposure such that four children were exposed to subset A and four were exposed to subset B. Stimulus presentation was executed with an Apple Macintosh computer, which recorded the level at which a picture was named (Level 1 - 8) or not named (Level 9--complete picture shown but not named correctly). A stopwatch was used to time each phase of the experiment.

Procedure. All children were tested individually in a quiet room at their day-care, each session lasting from 50 to 60 minutes. After being greeted, an informal query was made of the child's familiarity with computers and willingness to play a game on the computer. The game was described as one in which the child would be asked to name a picture displayed on the computer monitor "...but the problem is that only part of the picture is shown; if you don't know what the picture is, you can ask the computer to give you 'more pieces,' and you can keep asking until you can name the picture."

Presentation of fragpix was the same for both the exposure and test phase. All fragpix were initially presented at Level 1--in their most fragmented form. The child was encouraged to make a guess and then to check with the experimenter to see if the response was correct. If the child correctly named the picture, the child was allowed to press the button on the mouse which triggered the "yes" box on the screen; the computer then produced an on-screen response of "yes, that is correct, it is a ___________". If the answer was incorrect, the computer displayed the next less-fragmented level of the picture. This continued, using an "ascending method of limits" until the child correctly identified the picture; the computer recorded the level of fragmentation at which correct identification was made. Once the picture was correctly named, the next fragpic was presented until all fragpix for the particular picset had been exposed. The order in which fragpix were presented was randomly determined by the computer program for both the exposure and test phase.

The entire experimental session encompassed three phases: exposure, distracter, and test. Instructions for the game were presented on the computer screen and were verbally paraphrased by the examiner. During the exposure phase, three practice pictures were presented using the ascending method of limits until the picture was identified. The child was informed that the practice session was over and the real game would now begin. Each of the 15 fragpix from the designated subset were presented one at a time until identification was made. The identification of fragpix in this phase was designated as the "Train" condition. When all 15 fragpix had been displayed, the computer signalled the end of that phase and a two-minute distracter phase ensued in which the examiner chatted informally with the child "while the computer gets the next game ready."

The test phase was introduced as "...another game just like the last one. You will see more pictures and be asked to tell me what they are." During this phase, all 30 of the fragpix from the picset were used, the 15 seen during the exposure phase ("Old" pictures) intermixed with 15 not-yet-seen pictures ("New" pictures). Fragpix were again presented using the ascending method of limits. When all 30 pictures had been displayed, the computer signalled the end of this phase. The examiner debriefed the child and thanked them for their participation and patience.

In all, each child viewed 48 fragpix--3 fragpix for practice, 15 fragpix at exposure and 30 at test. Notes were made of length of time taken to complete the session, time taken before the child's behaviour (either verbally or physically) indicated restlessness, and general behavior throughout the testing, for example, if the child left the chair during the session or verbally attempted to redirect the testing session.

Scoring. The level of fragmentation at which the child was able to correctly identify the fragpic, ranging from 1 to 9, was referred to as the threshold of perceptual identification. Threshold means were calculated for each subject across the repeated-measures factor of picture identification condition (Train, Old, New). Scores for the Train condition represented threshold means during the exposure phase, while scores for Old and New were both obtained during the test phase.

Results

Picture naming. Tabulations were made for the level at which each of the 30 pictures was identified by the child. Error-point totals were calculated for each picture as follows: the level at which each picture was identified was recorded and weighted (i.e., those misnamed at Level 9 were assigned 9 points, those correctly named at Level 8, 8 points, those correctly named at Level 7, 7 points, and so on) and listed in descending order of accumulated points. One picture (Ear) could not be identified by 7 of the 8 children although typically a child names a picture of an ear by 2 years of age (Snodgrass & Vanderwart, 1980). Five pictures (ear, tie, football, suitcase, rolling pin) could not be identified by at least half of the subjects. It is likely that the computer-generated images particular to this program are not easily identified by very young children.

Age and threshold level. Table 2 presents the age, gender and mean thresholds for each of the eight children across the repeated-measures factor of identification (Train, Old, and New). Age (in months) was correlated with scores (on a 1-9 fragmentation scale) in each identification condition; the resulting correlations were all strong and negative, Age and Train = -.84, Age and Old = -.83, and Age and New = -.70. This suggests that there are age-associated differences in children's ability to identify physically degraded pictures, with older children being able to identify pictures more readily than younger children.

This conclusion gained some further support when the average threshold levels in each identification condition for the four younger children (mean age = 45.8) were compared to those of the four older children (mean age = 58.8). Table 3 gives the means, standard deviations, and variances for the median split between the younger and older children as a function of the Train, Old, and New identification conditions.

Analysis of these data was complicated by the small

Table 2

Age (in months), Gender, and Mean Threshold for Picture Identification Condition for Children in Experiment 1

			Picture Identification Condition		
Child	Age	Gender	Train	Old	New
1	44.0	F	7.20	5.73	7.07
2	45.0	M	6.93	5.93	6.40
3	47.0	F	7.27	6.40	6.93
4	47.0	M	7.00	6.60	6.87
5	52.0	M	6.67	6.00	7.40
6	53.0	F	6.33	4.70	5.67
7	63.0	F	5.73	4.53	6.33
8	67.0	M	6.33	4.40	4.87

Table 3

Means, Standard Deviations, and Variances for Picture Identification Condition as a Function of the Median Split by Age for Children in Experiment 1

	Picture Identification Condition		
Age Group	Train	Old	New
Younger (N = 4)			
M	7.10	6.16	6.82
SD	0.16	0.40	0.29
s^2	0.03	0.16	0.08
Older (N = 4)			
M	6.26	4.91	6.07
SD	0.39	0.74	1.07
s^2	0.15	0.55	1.14

sample size (n = 4) and unequal variances, greater than a 4:1 ratio. Using a traditional ANOVA on the 2 X 3 mixed factorial design might potentially produce a biased outcome, therefore a nonparametric randomization test on the factorial design was carried out using the statistical package NPFACT (May, Hunter, & Masson, 1993). Table 4 presents the statistical test analyses for the mixed factorial design as a function of each type of analysis. Although the obtained probability values from the ANOVA were marginally more liberal than those from the randomization test, the interpretation of the data was not affected. There was a significant main effect for age and for identification condition; the two factors did not interact. Younger children required a less fragmented picture for identification than did older children; and, for each identification condition, the pattern of the means was in the same direction for both age groups.

Attention to task. Although no child had to leave the test prematurely, six of the younger subjects had difficulty sustaining their attention to the task throughout the test phase. Two boys literally completed the test while wandering around the room. Most 3- and 4-year-olds were able to attend to the task without prompting from the researcher for about 30-35 minutes, although the youngest child, a girl, attended diligently for 50 minutes before finally asking if the test was almost over. Curiously,

Table 4

Experiment 1: Results of Statistical Analyses on 2 (Age) X 3 (Identification Condition) Mixed Factorial Design using ANOVA and Randomization Tests

Statistical test	Test Statistic	Probability Value
ANOVA	*F* value	
Age main effect	$F(1, 6) = 7.75$	< 0.032
MSe = .695		
IC[a] main effect	$F(2, 12) = 16.09$	< 0.001
Interaction	$F(2, 12) = 0.81$	> 0.466
MSe = .182		
Randomization Test	Permutations	
Age main effect	65/2000	< 0.0325
PIC[a] main effect	1/2000	< 0.0005
Interaction	928/2000	> 0.4640

[a]IC is Identification Condition (Train, Old, New)

there did not appear to be a direct relationship between a child's ability to attend continuously to the task and the obtained mean threshold levels of identification. That is, the mean thresholds of identification for children who had difficulty attending (e.g., child # 2, 4, and 5) were the same as, or even lower than, those who completed the task with little prompting to attend.

Recommendations

It was concluded that when subjects are very young children, it might not be suitable to use fragpix as test stimuli in their original sets. The inability of young subjects to name some pictures even in their complete form, plus their difficulty in attending to the test session might obscure the findings. It was decided, therefore, to reduce the size of the picture set from 30 to 18 pictures. To facilitate its application to a later experiment, the number of pictures in a set was limited to a multiple of three. Error-point totals were calculated and the six pictures in each subset with the highest point-total were subsequently eliminated. The fragpix program was altered and a new picture set, Picset 10, was created which consisted of 18 pictures, 9 in subset 10A and 9 in subset 10B (see Appendix A for a list of the fragpix included in each picture set).

Six different preschool-aged children (four boys and two girls) participated in a practice run with the revised picture set. Test sessions could be completed in less than half an hour, a time span each child tolerated without difficulty, i.e., each child could attend to the task without needing a break. No new problems were apparent with the pictures retained for Picset 10. A similar process was followed with a second group of children (N = 8) to alter picture set 9 which produced Picset 11. The revised Picsets permitted test sessions to be completed within 20 to 25 minutes--under the 30-minute time-frame that appeared to be most efficient for this age. As a consequence, the later addition of three retention tests did not compromise a child's ability to attend to the new time-frame of the expanded experiment.

Experiment 2

No published studies have normed the use of fragpix with preschool-aged children. As a consequence, the threshold levels of identification obtained from the modified Picsets might be qualitatively unique to this age group, potentially limiting comparisons with other studies. Norms for picture name agreement have been established, however, for 8-year-olds (Berman et al., 1987). A second experiment was carried out with 8-year-olds in which responses from subjects tested with the revised Picsets (10 & 11) were compared against data obtained from subjects using the original picture sets (8 & 9). Although it was not anticipated that performance would be radically or seriously altered as a function of picture set, it was felt that the possibility should be addressed.

Method

Participants. Upon receipt of written parental permission, 40 students from public and independent schools in the Saanich School District in Saanichton, B.C., participated in this portion of the project, forming two gender-balanced groups of 20 students each. The original picture sets 8 and 9 were used with half the students (N = 20), who had a mean age of 105 months (8.8 years) and a standard deviation of 4.1 months, and range of 100 to 114 months. The remaining participants (N = 20) were exposed to the revised picture sets; the mean age for these students was 104 months (8.7 years) with a standard deviation of 4.0 months and an age range of 99 to 110 months.

Materials. Four picture sets were used, two from the original picture sets (Picsets 8 and 9) and the two picture sets (Picsets 10 and 11) that had been modified from picture sets 8 and 9. There were 30 pictures in the original picture sets, the A/B subsets containing 15 items each. Eighteen pictures made up each modified picset, the A/B subsets containing 9 items each. Use of subsets was alternated systematically within each age group. Stimulus presentation began with the three practice pictures and was by means of a Macintosh computer.

Procedure and Design. The procedure used for Experiment 2 was identical to that for Experiment 1 except that no formal account was kept of the students' attentional and behavioral responses. All children were randomly assigned to either the original or modified picture set condition; exposure to Picset 10 or 11 and to subset A or B within each picture set was counterbalanced. Children took between 20 and 35 minutes to complete the session.

The two factors of the design included the between-groups factor of Picset (original or modified) and the repeated-measures factor of Identification condition (Train, Old, New). The dependent measure was mean threshold level of picture identification with measures recorded for Train, Old, and New. A measure was also taken of the magnitude of the priming effect, the difference between the mean threshold of identification for Old and New items (New minus Old).

Results

Analyses focused primarily on whether modification of the picset differentially influenced performance on measures of threshold identification and whether the smaller picset influenced the magnitude of priming. Both groups of 8-year-olds were gender-balanced. All analyses initially included Gender as one of the factors. Gender never figured in any of the interactions, nor was it reliable as a main effect, all ps > .85, so it was dropped from subsequent analyses.

Effect of Picset. The data were submitted to a 2 (Picset: Original or modified) by 3 (Identification

Condition) mixed factorial ANOVA to examine the influence of picture set modification on three measures of fragpix identification (Train, Old, New). Table 5 presents the means and standard deviations for this analysis. There was no main effect for the picture modification condition, nor did the two factors interact, MSe = .490, both ps > .25. As expected, there was a main effect across the identification conditions, F (2, 76) = 246.92, MSe = .146, $p < .001$, η^2 = .87, but, as Table 5 illustrates, the pattern of means was the same across both the original and the modified versions of the Picsets. Modification of the size of the picture sets did not appear to appreciably influence performance for these 8-year-olds.

Because the above analysis represented performance averaged across both pictures sets, that is, the means for Picset 8 and 9 were compared against the means for Picset 10 and 11, a further analysis was carried out to compare performance of each Picset with each group of subjects. A mixed factorial ANOVA applied to a 2 (Picset) x 2 (Original versus Modified Set) x 3 (Identification Condition) design examined the effect on picture identification for Picset 8 and 9 of the original sets and Picset 10 and 11 from the modified picture sets. The repeated-measures factor was Identification Condition (Train, Old, New). Table 6 presents the means and standard deviations for this analysis. The main effect for Identification Condition was,

Table 5

Means and Standard Deviations for the Original and Modified Picture Sets (Picset) as a Function of Picture Identification Condition (Train, Old, New) and Priming (New minus Old)

	Picture Identification Condition			
Picset	Train	Old	New	Priming
Original Set (30 pictures)				
M	5.30	3.53	5.13	1.60
SD	0.42	0.58	0.36	0.46
Modified Set (18 pictures)				
M	5.10	3.43	4.94	1.51
SD	0.57	0.77	0.49	0.79

as expected, reliable $F(2, 72) = 236.83$, $MSe = .149$, $p < .001$. As Table 6 illustrates, the pattern of mean identification thresholds remained consistent with previous findings, i.e., higher mean values for the original picture sets, and, within each Picset the Train identification condition had the highest mean value and the Old condition the lowest. An unexpected finding was a reliable main effect for Picset, $F(1, 36) = 9.85$, $MSe = .490$, $p < .01$, accounting for 20% of the variability. The fragpix in both Picset 8 and its modified version, Picset 10, could be identified at lower mean levels of fragmentation than fragpix in either Picset 9 and its modified version, Picset 11. The presence of this Picset effect reinforces the importance of counterbalancing the use of picture sets in future experiments.

Magnitude of Priming. The final analysis examined the size of the priming effect, the difference between studied and non-studied test pictures. An independent-samples t-test was carried out between the two groups of 8-year-olds across the averaged Picsets. The mean measures for magnitude of priming were similar (1.60 and 1.51, respectively) and were not statistically different from each other, $p > .60$. To explore whether the Picset effect noted above influenced priming, a 2 (Picset) by 2 (Subjects) between-groups ANOVA was carried out on the mean magnitude of priming measure. There were no reliable main effects,

Table 6

Means and Standard Deviations for the Original Picture Sets (Picsets 8 and 9) and Modified Picture Sets (Picsets 10 and 11) as a Function of Picture Identification Condition (Train, Old, New) and Priming

	Picture Identification Condition			
Picset	Train	Old	New	Priming
	Original Picture Sets (30 pictures)			
Picset 8				
M	5.18	3.36	5.07	1.70
SD	0.50	0.68	0.31	0.53
Picset 9				
M	5.46	3.73	5.20	1.47
SD	0.25	0.39	0.42	0.34
	Modified Picture Sets (18 pictures)			
Picset 10				
M	4.83	3.13	4.78	1.64
SD	0.51	0.69	0.41	0.62
Picset 11				
M	5.43	3.80	5.15	1.34
SD	0.47	0.72	0.52	0.98

nor did the two factors interact, MSe = .425, all ps > .20. These analyses provided further support for no qualitative differences between averaged versions of the original and modified Picset.

Conclusions and Recommendations

The manipulation of picture set size produced mean threshold values in the same direction for all three measures of the fragpix identification conditions and further analyses revealed no differential influence on performance as a function of modification of the size of the picture sets. Because use of the modified picture set facilitates testing with young children, picture sets 10 and 11 were retained for the remainder of the research project. The finding of a between-sets picture set effect stressed the importance of counterbalancing subjects' exposure to Picsets 10 and 11.

Chapter II

Age, Gender, and Closure:

A Manipulation of the Priming Stimulus

Having determined that the abbreviated picture sets were suitable as stimulus materials for this project, Experiment 3 explored the association of age and gender with prior exposure on direct and indirect measures of cognitive processing. The experience of prior exposure was not limited solely to a study of the priming effect, but was extended to incorporate two measures of learning, priming and transfer of learning. In addition, a manipulation of the priming stimulus to test the closure hypothesis, which is described below, was introduced in which, following correct identification of the fragmented picture, half of the subjects were shown the completed picture.

Age, Gender, and Priming

As revealed in Experiment 1, there was a strong inverse correlation between age and mean threshold of identification for each fragpix identification condition (Train, Old, New). This suggests there may be reliable developmental change in the ability to identify very fragmented pictures. Parkin and Streete (1988) used fragpix with young children and found age differences in the level at which fragpix were identified across four age groups (3, 5, 7 years, and adults). It is not untenable that one might observe age-associated changes in threshold identification while the magnitude of priming remains developmentally stable. Because priming compares performance between thresholds of identification for Old and New fragpix, within each age group there may be different baseline thresholds for Old pictures, while the mean difference between Old and New, a measure of the magnitude of the priming effect, remains developmentally invariant.

Snodgrass (1989b) and Snodgrass and Feenan (1990) reported comparable levels of priming across a variety of manipulations of the priming stimulus, but differential thresholds of identification that varied as a function of these same conditions. Experiment 3 in this dissertation, therefore, examined the trait variable of age for both the mean threshold of fragpix identification and the magnitude of priming.

A second trait variable examined in Experiment 3 was gender. Because few priming studies carried out with children and/or adults included gender in their analysis, no strong theoretical or empirical position exists to support the inclusion--or exclusion--of this variable. An exception was a study by Naito (1990). Using a word fragment completion test with elementary school-aged children, Naito included gender as an variable in her analysis; no main effects or interactions involving gender were found. Regardless, it is reasonable to consider that the superior attention-to-task behaviour typically attributed to little girls, compared to later-maturing boys (Jacklin & Maccoby, (1983), might facilitate performance for fragpix identification or impact on the priming effect. Although the failure of previous studies to find a differential association between gender and the effect of prior exposure precludes a specific prediction for the present study, this factor was retained for the experiment. The third variable explored in Experiment 3 was a manipulation of the priming stimulus.

Closure: A Manipulation of the Prime

Perceptual closure, or "the perceptual phenomenon of filling in the gaps and 'seeing' the incomplete objects" (p. 278) was proposed by Snodgrass and Feenan (1990) as an explanatory mechanism for perceptual learning. A review of the concept of closure reveals a six decade attempt to disentangle the influence of perceptual and conceptual factors on learning--a debate that in its contemporary form is reflected in discussions of priming vis-a-vis, for example, implicit versus explicit memory, data-driven versus conceptually driven processes, and age-invariance versus age-associated changes in the magnitude of priming. A brief review of the relationship between perceptual closure and fragmented pictures illustrates this point.

Braly (1933), who studied the effect of prior experience on visual perception, and Leeper (1935), in his learning-based theory of sensory organization, cited the

Gestalt school of psychology as the origin of closure. The law of closure--and related laws of proximity, similarity, and continuity--were thought to be factors that determined or directed perceptual organization. Simple, incomplete geometric forms or patterns were used in early demonstrations of closure, and as a consequence incomplete pictorial stimuli became closely associated with procedures examining the concept of perceptual closure.

Figure 2 illustrates three variations of incomplete pictures utilized by theorists in the first half of this century. Street (1931) developed the first series of incomplete pictures, using them as part of an intelligence test to determine if there was a correlation between the ability to complete fragmented visual figures and mental competency in verbal completion tests. The correlation proved to be negligible: Verbal ability increased with age for children in grades 3, 6 and 9, while all achieved about the same mean score for accuracy in identification. Leeper (1935) revised Street's materials and examined the premise that complex learning could be interpreted as function of perceptual organization, concluding that "...sensory organization is facilitated by verbally aroused redintegration to some extent, and by preliminary perceptual preparation to an even greater extent" (p. 72).

In 1946, Verville and Cameron revised Street's original figures and studied the relationship between individual

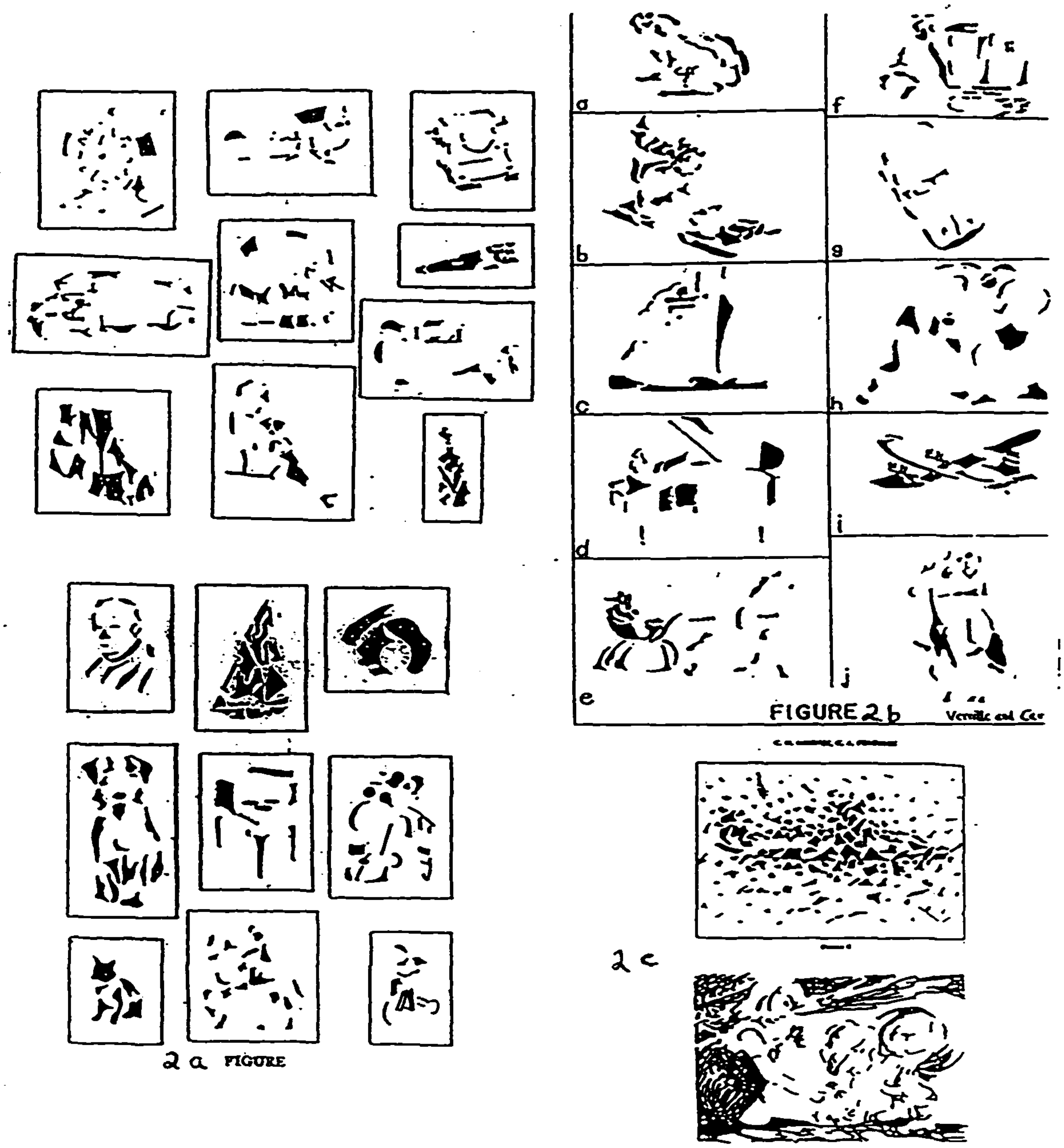

Figure 2. Early examples of incomplete pictures.

2a. Street (1933). 2b. Verville & Cameron (1946).

2c. Mooney Closure Test (1951)

differences such as age and gender on reaction time for picture identification. Associations for both age and gender were revealed. Younger adults identified pictures more rapidly than older adults, and although there were no gender differences for younger adults, older males identified pictures more readily than older females. In addition, Verville and Cameron replicated Leeper's findings that verbal prompting aided identification. More recent studies with sequentially degraded pictures replicated the findings for age difference in picture identification (e.g., Danziger & Salthouse, 1978; Salthouse & Prill, 1988; Whitfield & Elias, 1992). The gender difference reported by Verville and Cameron was almost replicated by Salthouse and Prill ($p < .10$ on the Gestalt Completion Test) but a related study by Whitfield and Elias (1992) found no gender-specific differences on perceptual closure tasks.

In the 1950s, Mooney, a Canadian psychologist from McGill, modified Street's figures "to facilitate subsequent investigation on the nature of the closure phenomenon" (Mooney & Ferguson, 1951, p. 129). Mooney (1954) redefined psychological closure as "the moment of perceptual resolution: as the terminal phase of an act of perceptual contemplation; as the tension-relieving instant when meaning is ascribed to or is recognized as emerging from a compelling constellation of objects or events" (pp. 51-52). He suggested a kinship between insight and closure, with the moment of the "aha" experience being the instance of closure.[1]

Mooney also conducted a factor analysis of 15 mental and perceptual tests to analyze the separate contributions of cognition and perception to learning. Of these 15 tests, 9 examined mental ability and 6 (e.g., incomplete pictures, mutilated sentences, mutilated words, hidden words) assessed closure. Five factors emerged from this analysis with closure tests loading most heavily on the perceptual closure factor and secondarily on a cognitive rigidity factor, this latter factor reflecting measures of "puzzle-solving" (Mooney, 1954). Mooney's closure test was not represented on any other cognitive factor. Mooney concluded that perception of (his) stimuli did not require any conceptual restructuring of the given materials; rather, an act of completion was required in which the enveloping whole was directly perceived. He concluded that his closure test was an effective measure of perceptual closure.

In the 1960s, Gollin dramatically altered the concept of incomplete pictures by borrowing from the earlier work of Heilbronner (1905, cited in Gollin, 1960) who, as part of his psychiatric examination of children, had used line drawings of objects from which finer interior details had been omitted. As illustrated in Figure 3, Gollin created a 5-level fragmented series of line drawings to examine the influence of different exposure conditions and subject

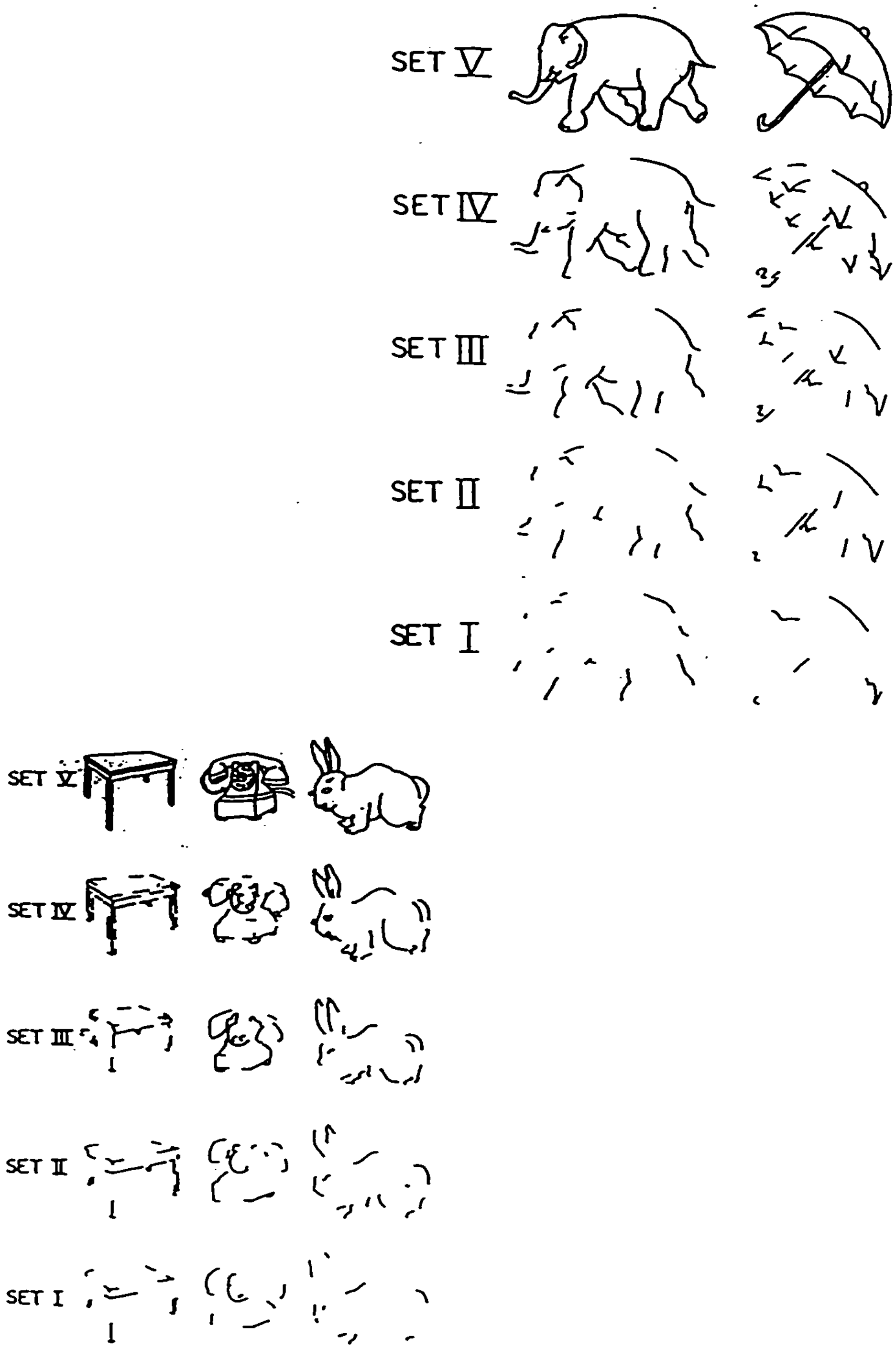

Figure 3. Five-level degraded stimuli (Gollin, 1960)

traits on visual recognition of incomplete objects. Gollin (1965, 1966) eventually referred to the perception of incomplete visual forms as a <u>recognition response (Re)</u> rather than closure and interpreted his findings in behavioral/learning theory terminology, proposing that the experience of closure represented generalization, while failure to achieve closure reflected the effect of reactive inhibition.

In the 1980s, Snodgrass and her colleagues extended Gollin's picture series from five arbitrary levels of fragmentation to eight systematically degraded pictures and nicknamed them fragpix. As noted in Chapter 1, the pictures were adapted for computer identification and norms for threshold of identification were determined. The current method of a computer-generated presentation is a marked contrast to the original procedure used by Street in which he held each picture up in front of his group of subjects and, to facilitate the identification process, moved forward or backward in accordance with their instructions.

Regardless of which method of presentation is used, the experience of perceptual learning through the mechanism of perceptual closure is said to be the consequence of a three-stage process: first, recognition of the stimulus during the study phase by either visual identification or from verbal prompting; second, presentation of the stimulus at test at an unrecognizable level of fragmentation; and finally, sequential presentations of the fragmented stimulus, gradually adding more pictorial information, until identification occurs (Snodgrass & Feenan, 1990). The major premise for perceptual closure is that identification of the stimulus occurs without seeing the complete picture. A potential technique to probe this phenomenon would be, during exposure, to show half the subjects the complete picture after they had correctly named the fragmented stimulus. If perceptual resolution at some level of fragmentation was truly completed at study, then at test, subjects should perform similarly regardless of whether or not they had seen the complete picture at study.

Results from past studies are unclear on this point. Gollin (1960, 1961, 1962) manipulated his exposure condition such that subjects were trained to identify either a set of moderately fragmented pictures (Set III) or a set of non-fragmented pictures (Set V). He reported that, at test, subjects trained with the fragmented pictures identified very fragmented pictures (Set I) more readily than those trained with the complete picture. In the study by Parkin and Streete (1988), following identification of each fragmented picture, all subjects were shown the complete picture. No manipulation of a complete versus incomplete picture occurred during exposure in the Parkin and Streete study, and no published studies could be located that examined this manipulation. A study with adults employing a

Show/No Show manipulation found no differential influence of this condition on measures of picture identification, free recall or picture recognition Gonzales (1997). The current study manipulates the closure condition such that half the subjects in each age group are shown the full picture after they have correctly named it.

Prior Exposure on Measures of Learning: Priming and Transfer

The successful identification of fragpix involves the combined elements of skill learning and perceptual learning (Snodgrass & Corwin, 1988a), which, in turn, produces two measures of learning, transfer and priming, each of which can be calculated from the identification threshold measures. These measures have been considered, both separately and in combination, as unique measures of implicit memory (e.g., Parkin, 1993; Parkin & Street, 1988; Snodgrass & Feenan, 1990). Because a lack of consistency exists across studies in the language used to define these two measures of learning, a definition of each term relative to its use in the current study follows.

Priming. Priming reflects perceptual learning, and perceptual learning represents item-specific learning. Appertaining to fragpix, when subjects identify the fragmented picture they require less pictorial information than they would have without the priming experience. It is said that the subject is able to point to a location of an invisible part and "see" the missing part (Snodgrass &

Feenan, 1990). The effect of priming is examined on responses given at test; that is, mean thresholds of identification for previously seen (Old) fragpix are compared to mean thresholds for New fragpix. Priming has been reported to be a robust phenomenon across all studies using fragpix as the priming stimulus.

The usual measure for the magnitude of priming is the mean threshold <u>difference</u> between Old and New pictures. This measure is particularly effective in examining the developmental stability of the priming effect. As reviewed in Chapter I of this dissertation, priming has been reported to be developmentally stable from preschool age to adulthood, although Parkin (1993) reported age-related increases in the magnitude of priming in a reanalysis of the Parkin and Streete (1988) data.

<u>Transfer of learning.</u> Transfer is also referred to as skill learning, learning that is specific to the task but independent of the items used (Snodgrass et al., 1987). A subject gains a skill that facilitates identification of fragmented pictures as a <u>task</u>--not simply item-specific identification. Transfer of learning occurs when experience or performance on one task influences performance on a related but not identical condition (Ellis, 1965). The higher the similarity between the original and transfer task the greater the degree of transfer. In the Train condition of a typical fragpix experiment, novel items are presented

in a novel task. During the test phase, scores in the New condition come from performance on novel items presented in a not-so-new task. Reliable improvement in fragpix identification between the New and Train conditions has been reported with adults (Snodgrass et al., 1987; Snodgrass & Corwin, 1988a). To date, no published studies that used fragpix as the priming stimuli with children specifically examined this measure of learning. In Parkin and Streete (1988), the values reported for mean thresholds in the Train and New conditions, although not statistically analyzed, were nearly identical for all four age groups, suggesting no influence of skill learning on fragpix identification for young children or adults.

A measure of transfer of learning (or skill learning), then, compares the mean threshold of identification for the Train condition with that of the New condition. The measure of improvement between novel pictures at study and test (the difference score between Train and New) reflects the magnitude of transfer. The lack of transfer reported in the Parkin and Streete study suggested that this measure of learning demonstrated no developmentally based differences for 3-, 5-, 7-year-olds, and adults.

Indirect and Direct Measures of Memory

A typical empirical paradigm for exploring the effect of prior exposure is the inclusion of both direct and indirect tests of memory. Although one focus of Experiment

3 (and the primary focus of Experiment 4) was to examine the impact of manipulations of the priming stimulus on picture identification (an indirect measure of memory), there was also a secondary interest in exploring these effects on other forms of memory. Consequently, as well as a fragpix identification test, three direct measures of memory--free recall, cued recall, and picture recognition--were incorporated into the test phase.

Free and cued recall tests, as measures of explicit memory, are conceptually driven tasks that draw on cognitive processes for optimum performance (Jacoby, 1983; Srinivas & Roediger, 1990). The age differences exhibited in performance are predicable and well-documented. In contrast, picture recognition tasks are believed to draw on both data-driven and conceptually driven processes, and thus benefit from both implicit and explicit cuing (Jacoby & Dallas, 1981; Johnston et al., 1991). As noted earlier, in Chapter 1, depending on the nature of the task and age of the subjects, age-associated differences are typically smaller for picture recognition than for free recall--or they may be absent altogether.

Typically, the rationale for including both types of memory tests is to test for a dissociation between implicit and explicit memorial processes or to demonstrate the differential influence on memory of data-driven versus conceptually driven tasks. As noted in Chapter 1, these explanatory mechanisms have been inadequate in providing a theoretical explanation for the effect of prior experience on performance. The inclusion of both forms of memory tests in the current project (Experiments 3 and 4) was not to attempt to confirm or disconfirm a dissociation among types of memory tests, but rather to have greater flexibility in considering alternative theoretical perspectives as explanatory mechanisms for subjects' performance (Bruner & Potter, 1964; Greenwald, Pratkanis, Leippe, & Baumgardner, 1988).

To summarize, Experiment 3 examined the influence of prior exposure and perceptual closure on picture identification as a function of age and gender. The primary focus of this experiment was as a scaling study to determine whether there were age-associated changes in threshold of identification for young children. Three successive age groups consisting of 3-, 4-, and 5-year-olds, and a group of 8-year-olds were tested. To minimize the age similarity of successive age groups, a four-month gap between ages was defined. For example, the oldest 3 year old was 46 months and the youngest 4 year old was 51 months.

Of secondary, and more exploratory interest, the prior exposure effects on two measures of learning (priming and transfer of learning) on fragpix identification were considered. Based on outcomes from previous studies, it was expected that both priming would be observed across all age groups. In contrast, transfer of learning, a more conceptually based process, might be facilitative only for older children. Given the perceptual nature of the stimulus, age differences in the threshold of fragpix identification were expected while the magnitude of the effect of prior experience was expected to remain developmentally stable. Delineation of distinctive age groups facilitates the examination of the developmental nature of these effects.

In addition, the influence of a specific manipulation of the priming stimulus, the Show/No Show condition, on these learning measures was examined. If perceptual closure is concurrent with identification of the fragmented stimulus, then perception of the completed picture should have no differential influence on identification of that same picture at test.

Following completion of the picture identification test, each subject was given, in order, three retention tests--free recall, cued recall, and picture recognition. Mean correct responses were recorded on each of these memory tasks, although only the measure of prior exposure on free recall was analyzed. Following the meta-analysis by Mitchell (1993) and a review of the literature by Parkin (1993) and by Naito and Komatsu (1993) on developmental considerations in implicit and explicit memory processing, age-associated increases in correct responses were anticipated for the two recall measures, while, on the picture recognition task, developmental differences were expected to be attenuated or absent.

The inclusion of the direct and indirect tests of memory might also help disentangle the controversy regarding differential influences of data-driven and conceptually driven processes on a task that is widely accepted as being primarily perceptually based. In addition, regardless of whether the oft-reported dissociation between indirect and direct tests of memory is sustained, the results permit further ruminations on the explanatory mechanisms for cognitive and perceptual processing in young children

EXPERIMENT 3

Method

Participants

A total of 120 children were recruited from day care centres and elementary schools in the Victoria and Saanich regions. Written parental permission was required for participation. Data from 96 of the 120 children were included in the study; reasons for subject exclusion (e.g., limited language abilities) are detailed in Appendix B.

The children were representative of a broad cross-section of the socio-economic and racial groups of this moderately sized, metropolitan and suburban city, e.g., about 10% of the children were of racial backgrounds other than Caucasian. Forty-eight girls and 48 boys formed four gender-balanced age groups; there were 24 children in each age-specific group of 3-year-olds, 4-year-olds, 5-year-olds, and 8-year-olds. Table 7 presents the means, standard deviations, and ranges of each age group as a function of gender. Within each group, there were no reliable differences in age as a function of gender, all ps > .50.

Materials

Picsets 10 and 11, as described in Experiment 2, were used. Hard-copy picture templates were developed from each picset for use with the picture recognition task. See Appendix C for a sample of templates used in Experiment 3. Each template consisted of five rows of six pictures for a total of 30 pictures--18 from the relevant picset, three practice pictures, and nine new pictures that were distracters. The distracters were taken from the larger pool of age-normed pictures (Snodgrass & Corwin, 1988a) and were comprised of items that were either functionally or taxonomically or physically related to the pictures used in Picset 10 or 11, e.g., comb/brush, tiger/lion, or pot/frying pan, respectively (distracter items are underlined). The arrangement of rows was systematically rotated between subjects, producing five template variations for each picset.

Test-response sheets were developed for each Picset, samples of which are included in Appendix D. Subjects' verbal responses on the free recall and cued recall tasks

Table 7

Means, Standard Deviations, and Ranges of Age (in months) as a function of Gender for the Four Age Groups in Experiment 3

Age	Range	Mean	SD[a]
3-years			
Girls	37 - 46	42.0	3.0
Boys	34 - 46	42.6	3.7
4-years			
Girls	51 - 58	54.0	2.4
Boys	52 - 58	54.7	1.6
5-years			
Girls	63 - 72	68.2	3.3
Boys	63 - 72	66.1	2.9
8-years			
Girls	100 - 113	105.1	4.1
Boys	97 - 113	104.8	5.1

[a]SD = Standard deviation

were recorded on these response sheets. Responses from the computer-controlled fragmentation task and the non-fragmented picture-recognition task were summarized and transferred to the test-response sheet. A stopwatch was used to time the distracter phase.

Procedure

All subjects were tested individually in a quiet room at their school or day-care, each session lasting from 20 to 40 minutes. The procedure use for presentation of fragpix was identical to the one used in Experiment 2 with the addition (in Experiment 3) of a between-subjects manipulation of the factor Closure. During the exposure phase, after each fragpic had been correctly identified, children in the Show condition were first informed verbally that their response was correct and then were shown the complete picture. The monitor displayed the complete picture under which were the words "Yes, that is correct, it is a _____". In the "No-Show" condition the computer monitor presented a blank space where the picture had been, under which were the words "Yes, that is correct, it is a ______". When all nine fragpix had been presented, the child was engaged in conversation for about 2 minutes before beginning the test phase of the experiment. This constituted the distracter phase.

The 18-item Test phase was introduced as "...another game just like the last one." Children in the Show condition were told that this time when they responded correctly, they would not see the complete picture. Fragpix were again presented using the ascending method of limits. Once all 18 pictures had been identified, the computer signalled the end of this phase and, for the distracter phase, the examiner engaged the child in informal conversation for 1 to 2 minutes before beginning the direct memory tests.

Three retention tasks were administered--free recall, cued recall, and picture recognition, in that order. For the free recall task, the child was asked to recall the names of pictures seen on the computer. The child's responses were recorded by the researcher on the test-response sheet. When it appeared that no more pictures could be recalled, the examiner then cued recall of the pictures by using the category names as designated by Snodgrass and Vanderwart (1980), for example, "...did you see any tools? any other animals?", recording each response on the test-response sheet. When all categorical cues had been exhausted, the examiner then introduced the picture recognition task. The child was asked to draw a circle or an "X" on all of the pictures that had been shown on the computer. The examiner then reviewed each response on this task with the child; for example, in the presence of a circled fish and giraffe and unmarked lion "...you saw a giraffe, you saw a fish, but you didn't see a lion...". The child was then debriefed and thanked.

Design

Subjects were randomly assigned, with restriction for age and gender, to the Show/No Show condition. Exposure to the four Picset and subset conditions (10A, 10B, 11A, 11B) was counter-balanced within each Show/No Show condition. The study examined three independent factors, Age, Gender, and Closure, on the repeated measure factor of fragpix Identification Condition (Train, Old, New) in a factorial design. The dependent variable was mean threshold for fragpix identification (the average level of fragmentation at which picture identification occurred), with mean thresholds recorded for fragpix identified in the Train, Old, and New conditions.

A comparison made between pairs of identification conditions produced two separate measures of learning: (a) priming (New versus Old) and (b) transfer of learning (Train versus New). In addition, the magnitude of each learning effect was examined by computing a difference score for each measure of learning (a) magnitude of priming effect (New minus Old) and (b) magnitude of transfer effect (Train minus New).

Data from the three tests of direct memory were also recorded for each child. Memorial responses in terms of number correct for Old and New picture stimuli from free recall, cued recall, and picture recognition tasks were tabulated. If any of the three practice items was recalled, this was noted, but not scored. The maximum correct score on each of the retention tests was 9 for Old items and 9 for New items. As well, for the picture recognition test, maximum correct rejection of distracter items (i.e., the child correctly did not circle the item as having been seen) was 9. Mean threshold levels for picture identification, as recorded by the computer, and responses from the memory tests were transferred by the researcher to each child's test sheet.

Because the initial intent of Experiment 3 was to serve as a scaling study, data collection began before the addition of the direct tests of memory and only 80 of the 96 subjects participated in this portion of the testing. The number of children from each age group who contributed information to the recall and recognition tests is detailed in the relevant portion of the results section.

Results

Data analyses were carried out in three stages. The first stage examined children's fragpix identification (Train, Old, New) within each age group and across age as a function of Gender and Closure. The second stage explored the same factors for the learning measures of priming and transfer, and the third stage of the analysis examined subjects' responses on the free recall and picture recognition tests of memory. At each stage the factors of

Age, Gender, and Closure were examined on the dependent variables of interest by a factorial ANOVA. Any reliable interaction involving Age was probed by a trend analysis of developmental change. Trend analyses were carried out using adjusted contrast weights[2] to compensate for the unequal intervals among the four age groups (Howell, 1992; Keppel, 1973). Although the a priori criterion for $p(\alpha)$ was flexible, it never exceeded 0.06 (Neyman & Pearson, 1928).

A probes of reliable interactions were carried out using multiple comparisons. Application of these procedures was guided by the following criteria: Howell (1992) advised that if the number of planned comparisons exceeds two, Tukey's or Newman-Keuls tests for multiple comparisons are preferred to Dunn's to provide a more reasonable protection against the probability of a Type I error. When comparisons involved a repeated measures factor, such as an exploration for whether the difference between two identification conditions was reliable within an age group, then an adaptation of Tukey's HSD formula was used (May et al., 1990). The Mean Square error (MSe) value was computed separately for each comparison so that each pairwise comparison incorporated only the variability for the two groups involved in that comparison; the df for the critical value was calculated as n - 1 rather than using df from the MSe term. Application of this formula for Tukey's test involved a separate computation for each critical value of

HSD; a significant difference was observed when the mean difference for the pairwise comparison exceeded this critical value. The mean difference is easily computed from the tables that accompany each analysis; the computation of HSD is less accessible and therefore, in reporting post-hoc outcomes involving Tukey's test, the critical value for HSD is given.

Identification thresholds

To examine the association between gender, developmental change, and perceptual closure on each fragpix identification condition, data were submitted to a 4 (Age) X 2 (Gender) X 2 (Closure) X 3 (Identification Condition) mixed factorial ANOVA with Identification Condition (Train, Old, New) as the repeated measures factor. There were no reliable main effects or interactions involving the variables Gender or Closure, all Fs < 1. Exposure to the complete picture during study had no differential influence on performance, neither was the gender of the child differentially associated with performance, therefore the factors of Gender and Closure were dropped from further analyses.

Table 8 presents the mean threshold and standard deviation for level of fragpix identification as a function of Age and Identification Condition. As depicted in Table 8, threshold means for each identification condition showed the expected age-associated decrease; older children were

Table 8

Mean Threshold Levels (Range 0 - 9) and Standard Deviations of Fragpix as a Function of Fragpix Identification Condition (Train, New, Old) and Age

	Fragpix Identification Condition		
Age[a]	Train	New	Old
3-years			
M	7.07	6.82	5.93
SD	0.44	0.38	0.50
4-years			
M	6.37	6.24	4.85
SD	0.35	0.37	0.73
5-years			
M	5.86	5.42	4.22
SD	0.43	0.46	0.65
8-years			
M	5.07	4.92	3.44
SD	0.57	0.52	0.74

[a]N = 24 for each age group.

able to identify pictures at a more fragmented state than younger children.

Trend analyses across the age variable were carried out individually on the repeated measures conditions of Train, New, and Old. All three analyses revealed that, for each identification condition, the majority of the explained variability (more than 70%) was represented by a linear function: Train $F(1, 92) = 224.72$, MSe = .206, $\eta^2 = .71$; New $F(1, 92) = 245.42$, MSe = .189, $\eta^2 = .73$; Old $F(1, 92) = 175.53$, MSe = .439, $\eta^2 = .88$, all $ps < .001$.

In addition to determining the direction of developmental change, it was also important, in terms of the scaling component of this study, to know whether the threshold at which a child identified fragpix changed reliably from one age level to the next. Post-hoc probes of each dependent measure were carried out to examine change across successive age groups; for example, for the Train condition, probes were carried out between 3- and 4-year-olds, 4- and 5-year-olds, 5- and 8-year-olds. All between-group differences were reliable for each dependent measure of Train, Old, and New, all $ps < .01$, Tukey's test. It appeared that children's ability to identify novel and previously seen fragmented pictures improved reliably, rapidly, and rather consistently during the preschool and early elementary school years.

Because a picture set effect was found in Experiment 2 for the 8-year-olds, the data in Experiment 3 were also analyzed to determine whether Picset 10 was easier for all four age groups. Figure 4 presents the means for Picset 10 and 11 as a function of identification condition. The ANOVA carried out on the 4 (Age) X 2 (Picset) X 3 (Identification Condition) revealed a main effect of Picset, $F(1, 88) = 19.41$, $MSe = .465$, $p < .001$, 4% of the variation accounted for. The Picset factor did not interact with age, nor did it interact with the Identification Condition, both $ps > .50$. For all age groups, the fragpix in Picset 10 were identified more readily than those in Picset 11, although the amount of explained variability contributed by this difference was quite small. The counterbalancing exposure to Picsets and Subsets within each age and Show/No-Show condition avoided a confound for picture set effect.

Measures of Learning: Priming and transfer

Table 8 presents the means and standard deviations for each identification condition used to derive each learning measure as a function of age. A 4 X 2 X 2 between subjects ANOVA (Age X Gender X Closure) was carried out individually on each measure of learning. There were no reliable main effects of Gender or Closure in any of the analyses nor did these factors contribute to any interactions, all $ps > .25$. The factor of Age was significant for each measure of learning, ps ranging from .001 to .06; specific outcomes are discussed below.

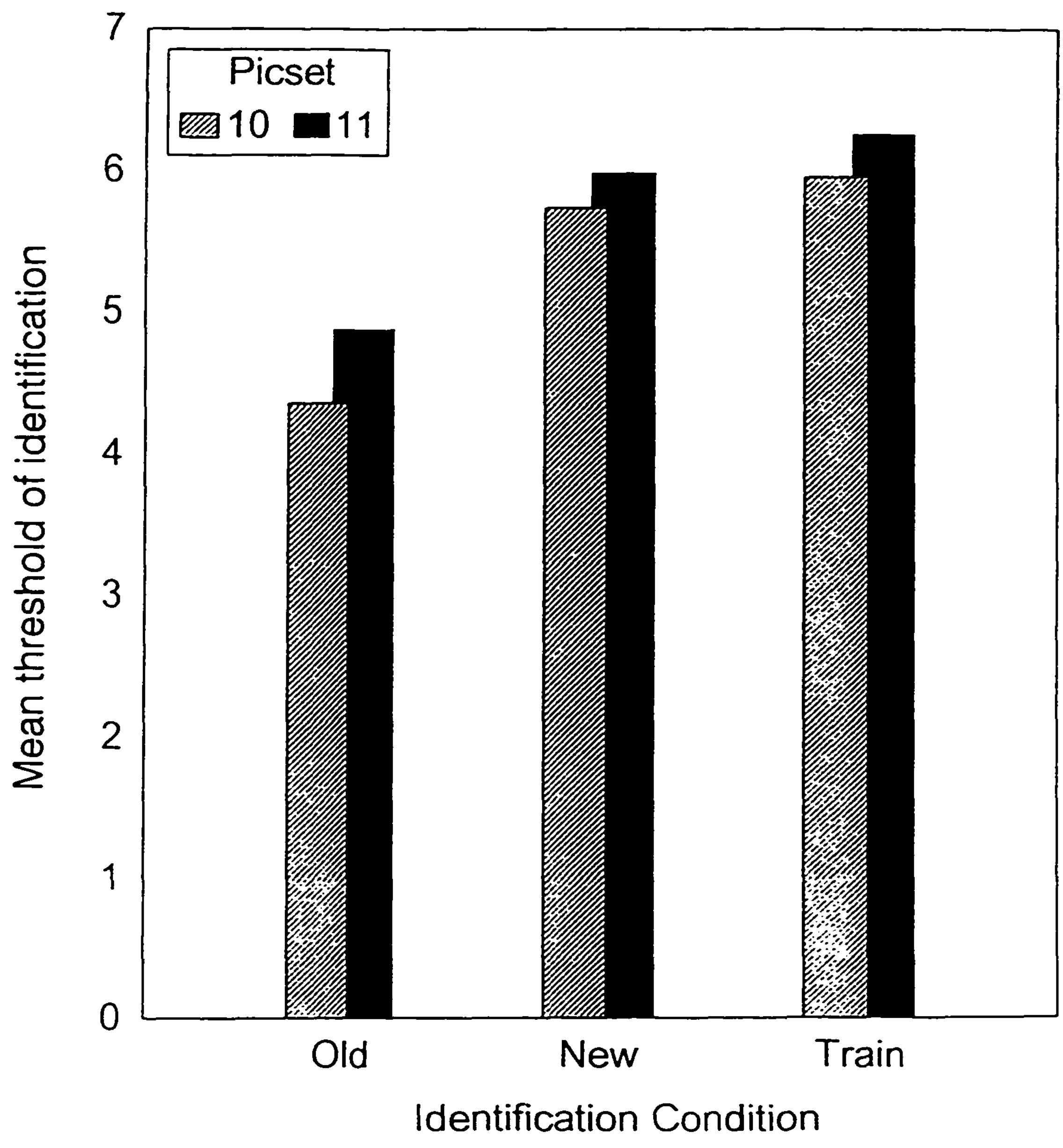

Figure 4. Mean threshold level of identification for Old, New and Train conditions for Picset 10 and Picset 11.

The data were reexamined without the factors of Gender and Closure by exploring each learning measure separately. Table 9 gives the means and standard deviations for the mean magnitude of each learning measure as a function of age. A 4 (Age) X 2 (Learning Measure) mixed factorial was carried out on the identification conditions relevant to the learning measure of interest. The interaction was probed by pairwise comparisons at each age level to ascertain, for example, if the difference between New and Train was reliable for the 3-year-olds, for the 4-year-olds, and so on. Trend analyses then followed to examine the developmental trend of the magnitude for each learning measure using weighted contrasts.

<u>Priming.</u> The comparison in children's performance during the test phase for identification of New and Old fragpix provided a measure of priming, which is said to reflect perceptual learning. The mixed factorial ANOVA applied to 4 (Age) X 2 (Identification Condition: New, Old) revealed a main effect for Age, $F(3, 92) = 98.61$, $MSe = .436$, $p < .001, \eta^2 = .76$, and a main effect for Identification Condition [$F(1, 92) = 387.18$, $MSe = .191$, $p < .001$, $\eta^2 = .81$. Figure 5 presents the means for the interaction between these two factors, $F(3, 92) = 4.38$, $p < .01$, $\eta^2 = .12$.

Probes of the interaction demonstrated that the phenomenon of priming was established at least by 3 years of

Table 9

Means and Standard Deviations for Calculations of Magnitude of Priming and Transfer of Learning as a Function of Age

	Learning Measures	
Age	Priming (New - Old)	Transfer (Train - New)
3-years		
M	0.89	0.25
SD	0.32	0.32
4-years		
M	1.40	0.13
SD	0.62	0.38
5-years		
M	1.20	0.44
SD	0.66	0.50
8-years		
M	1.48	0.15
SD	0.77	0.53

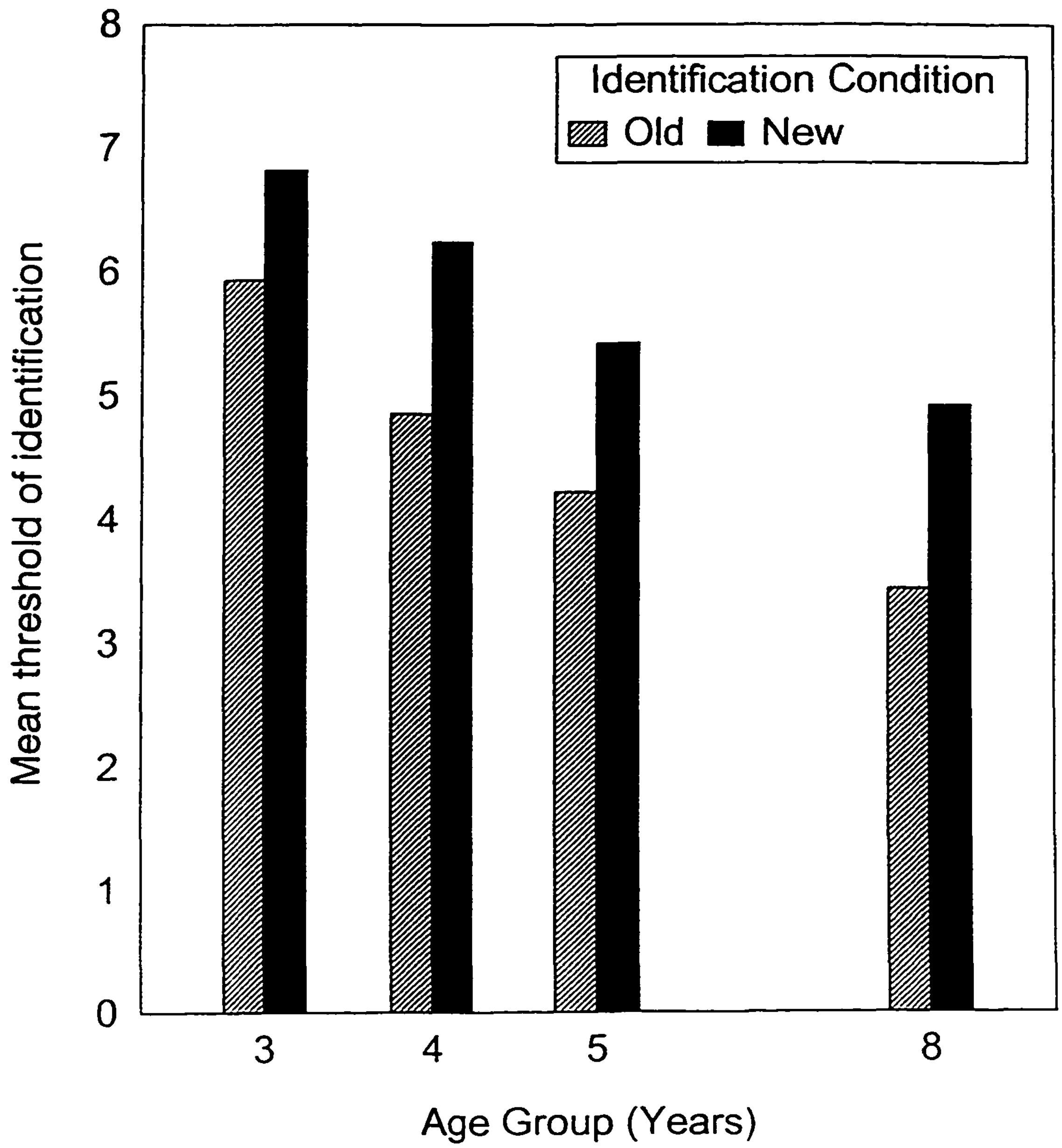

Figure 5. Mean threshold level of identification for Old and New Identification conditions as a function of Age.

age, and that it was facilitative for all four age groups. There was a reliable difference, for each age level, between the mean thresholds at which New and Old fragpix were identified; the critical values for Tukey's test, HSD = .231, .441, 469, and .548, were less than the obtained mean threshold differences for 3-, 4-, 5-, and 8-year-olds, respectively, all $ps < .01$. The Age main effect on threshold means averaged across New and Old supports the outcome reported above for age-related differences in the level of fragmentation needed to identify fragpix.

The developmental nature of the magnitude of priming was examined next. Trend analyses on Age revealed both a reliable linear and cubic function although the linear function accounted for more of the total variability, $F(1, 92) = 7.29$, $MSe = .382$, $p < .01$, $\eta^2 = .07$. The occurrence of a smaller effect of priming for 5-year-olds relative to 4- and 8-year-olds likely contributed to the reliable finding for a cubic function, $F(1, 92) = 4.57$, $p < .05$, $\eta^2 = .04$. In these data, priming was not developmentally stable over time. Age-related changes were found, although the magnitude of improvement appeared to be variable and the proportion of variability accounted for by age was only moderate. A contributing factor to the weakness of this outcome might be the wide variation in threshold of identification that occurred within age groups. For example, some 4-year-olds performed as well as some 5-year-olds and even as well as some 8-year-olds.

Snodgrass (1989a) recommended that, when comparing difference scores across subjects who have different baseline scores, data should be analyzed as a proportion of learning. For example, proportion of perceptual learning would be calculated as (New minus Old) ÷ (New minus 1). The re-analysis of the data from Parkin and Streete (1988) using this transformation revealed age-associated changes in priming (Parkin, 1993).

Table 10 presents the means and standard deviations of this transformation on the data for the three learning measures. Trend analysis on the transformed data for priming, using weighted contrasts, revealed a reliable linear function, $F(1, 92) = 28.18$, $MSe = .019$, $p < .001$, and an increase in the proportion of variation accounted for relative to the non-transformed data, $\eta^2 = .23$. In general, there were age-associated increases in the magnitude of priming from age 3 to 8 years, $HSD = .104$, $p < .05$, with the exception of the 4- and 5-year-olds who performed similarly, $p > .05$, Tukey's test. This outcome replicates Parkin's (1993) reanalysis of data with 3-, 5-, and 7-year-olds.

To summarize, when young children had prior experience in identifying a set of fragpix, they identified the same fragpix more readily at test than they did a novel set; the amount of pictorial information needed for identification was less for Old fragpix than for New fragpix. The size of

Table 10

Transformed Data for Learning Measures: Mean Proportions and Standard Deviations for the Magnitude of Priming and Transfer of Learning as a Function of Age

	Learning Measures	
Age	Priming	Transfer
3-years		
M	0.15	0.04
SD	0.06	0.06
4-years		
M	0.27	0.03
SD	0.12	0.08
5-years		
M	0.27	0.11
SD	0.15	0.13
8-years		
M	0.38	0.05
SD	0.19	0.15

this difference varied as a function of age, but in general, when computed as a proportion of learning, the relationship between age and magnitude of the priming effect was monotonic: the older the child, the larger the effect of priming.

Transfer of learning. Transfer of learning, labelled skill learning, represents the application of previously learned skills to a similar but not identical situation at test. Table 9 provides the means for transfer, derived as a comparison between mean thresholds of identification for Train and New from Table 8.

The ANOVA applied to the 4 (Age) X 2 (Identification Condition: New, Train) mixed factorial revealed a main effect for the Identification Condition; novel fragpix were identified during the test phase at a lower mean threshold of fragmentation than the fragpix seen during exposure, $F(1, 92) = 29.22$, $MSe = .098$, $p < .001$, $\eta^2 = .24$. There was also a main effect for Age, $F(3, 92) = 114.09$, $MSe = .297$, $p < .001$, $\eta^2 = .79$, which was examined by trend analysis and is reported below. Age and Identification Condition did not interact, $F(3, 92) = 2.50$, $p > .05$, $\eta^2 = .08$.

Table 9 provides the means for the magnitude of transfer of learning, the mean difference between Train and New, as a function of Age. Trend analysis on mean magnitude of this difference revealed that transfer of learning was not developmentally stable. Although, for each age, the threshold means for identification of New fragpix were lower than means for the Train condition, a reliable cubic function suggested that the magnitude of the difference was inconsistent across age, $F(1, 92) = 5.02$, $MSe = .195$, $p < .05$, $\eta^2 = .05$. Probes at each level of age revealed that the 3-, 4-, and 8-year-olds performed similarly, that is, had the same magnitude of transfer, while 5-year-olds demonstrated a larger effect than any other age group.

Table 10 illustrates the proportion of transfer for each age group. Conversion of scores to proportion of skill learning (Train minus New) ÷ (New minus 1) did not alter the findings noted above for a cubic function for transfer, $F(1, 92) = 4.42$, $MSe = .012$, $p < .05$, $\eta^2 = .05$.

Direct Tests of Memory

The direct tests of memory were added to the study partway through data collection. Consequently data were available for only 80 of the 96 subjects--22 three-year-olds, 13 four-year-olds, 21 five-year-olds, and 24 eight-year-olds. Table 11 presents means and standard deviations for number of Old and New pictures recalled as a function of Age and type of recall (free or cued) test. The number of items correctly recalled for Old and New items was tabulated as the dependent measure (scores ranged from 0 to 9).

Data analysis took place in two stages. The first stage explored responses to the free recall test. Free recall of Old and New fragpix was examined first as a

Table 11

Mean Number of Pictures Correctly Recalled (Range 0 - 9) and Standard Deviations as a Function of Type of Recall Memory Test, Age, and Identification Condition

	Memory Test				
	Free Recall			Cued Recall	
	Identification Condition				
Age	Old	New	(Old-New)	Old	New
3-years (N = 22)					
M	0.98	0.73	0.25	0.35	0.19
SD	0.31	0.27		0.22	0.15
4-years (N = 13)					
M	2.46	0.88	1.58	1.11	0.69
SD	0.43	0.37		0.30	0.21
5-years (N = 21)					
M	2.84	1.68	1.16	1.20	1.00
SD	0.32	0.28		0.46	0.34
8-years (N = 24)					
M	5.29	2.38	2.91	1.25	1.33
SD	0.30	0.26		0.26	0.19

[a]Represents mean difference between Old and New on free recall test and are the means for magnitude of priming.

function of Age, Gender, and Closure by a series of mixed factorial ANOVAs. This was followed by an exploration of developmental change on the magnitude of priming using trend analyses. The second stage of the analysis examined responses to the picture recognition task using signal detection theory. Correct raw score responses were converted to three measures as recommended by Snodgrass and Corwin (1988b): Probability of hits (or false alarms), an index of discrimination, and an index of response bias. The formulas used, and the rationale for their selection is presented just prior to the report of the analyses.

A priori and a posteriori probes were employed for all analyses as appropriate following the criteria outlined above for the analysis of fragpix identification. Because of the unequal number of children in each age group, probes were carried out using the Games and Howell adjustment of Tukey's HSD formula (Howell, 1992).

The analysis on data from the cued recall test contributed little additional worthwhile information. It is likely that the weakness of this particular measure as a test of memory limited its usefulness. Because of this experimenter's concern about the validity of this test as a measure of memory and subjective bias in the collection of responses, the results of the analysis are not reported. Means and standard deviations are included in Table 11 as a summary of children's raw score responses.

Free recall. As illustrated in Table 11, for each age, the majority of the items recalled were reported during the free recall rather than the cued recall test, with the mean number of Old and New items remembered increasing as a function of age. Responses to the free recall test were examined first. A 4 (Age) X 2 (Gender) X 2 (Closure) X 2 (Identification Condition: Old, New) mixed factorial ANOVA revealed a 3-way interaction between Closure, Gender and Identification Condition, $F(1, 64) = 4.01$, $MSe = 2.080$, $p = .05$, $\eta^2 = .06$.

Figure 6 illustrates this interaction. Probes of the Identification Condition (Old, New) as a function of Gender and Closure revealed that reliably more Old than New fragpix were recalled across all conditions (all $ps < .05$) except for males in the Show condition, $p > .05$, Tukey's test. This implied that showing boys the completed picture during the exposure phase reduced their ability to recall Old fragpix and facilitated free recall of New fragpix at test, a rather dubious conclusion. A more likely explanation, given the borderline probability value and minimal variability accounted for, is that this finding was a Type 1 error.

Of more interest was the 2-way interaction between Age and Identification Condition, $F(3, 64) = 8.75$, $p < .001$, $\eta^2 = .29$. Probes of this interaction revealed that, although more Old than New fragpix were recalled by each age group,

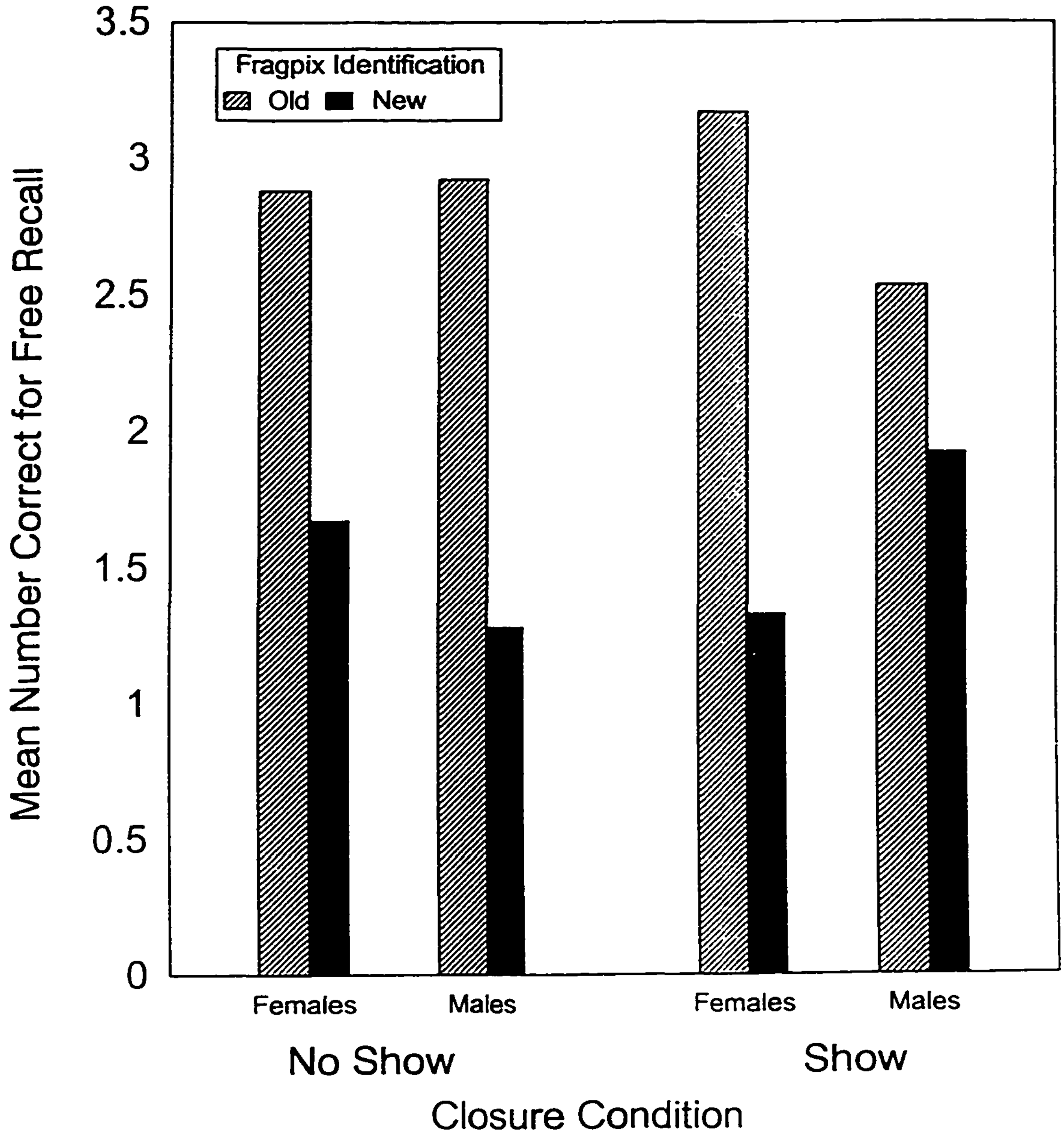

Figure 6. Gender X Closure interaction: Mean number correct responses for Old and New items on free recall tests.

the rate of increase across age was greater for Old fragpix than for New ones. This interaction is explored in more detail below, under the subheading for developmental change in priming. The mixed factorial analysis also revealed a main effect for Age, $\underline{F}(3, 64) = 33.20$, $\underline{\eta}^2 = .58$, and a main effect for Old versus New, $\underline{F}(1, 64) = 39.16$, $\underline{MSe} = 1.657$, $\underline{\eta}^2 = .38$, both $\underline{p}$s < .001.

Developmental change in priming. Two hypotheses were examined: First, whether priming occurred within each age group, and second, if there was a developmental change in the size of the priming effect. To explore whether there was a reliable effect of priming at each age, repeated measures probes of free recall responses between Old and New items in the Age by Identification Condition were carried out. Only the mean difference for the 8-year-olds (2.92) was reliable, $\underline{HSD} = 1.37$, $\underline{p} < .01$, Tukey's test. Although all children recalled more twice-seen pictures than once-seen pictures, the experience of prior exposure was statistically facilitative only for the oldest age group.

A probe of the magnitude of priming across age for free recall was examined by trend analyses using weighted contrasts. A reliable linear function for free recall was revealed, $\underline{F}(1, 76) = 25.42$, $\underline{MSe} = 3.166$, $\underline{p} < .001$, $\underline{\eta}^2 = .25$. The influence of prior experience on a child's ability to recall fragpix demonstrated age-associated improvement in number of correct responses for free recall.

In summary, age-associated changes occurred on all measures of free recall, a predictable outcome. Old fragpix were freely recalled more easily than New fragpix, although, within each age group, the degree of difference between these two conditions (priming) reached significance only for 8-year-olds. The size of the priming effect increased linearly with age.

Picture recognition. Children were requested to circle all the pictures they recalled seeing on the computer. Table 12 presents the means and standard deviations for correct responses on Old, New and Distracter pictures for each age group. Data from six children (five 3-year-olds and one 4-year-old) were not included because of indiscriminate circling--they circled all 30 pictures on the response sheet. When queried if they had seen each picture, they responded in the affirmative. Table 12, therefore, gives the responses for the remaining 74 children.

Conversion of raw scores to values that can be analyzed by signal detection theory (SDT) allowed the experimenter to retain the picture recognition data for all 80 children. The use of signal detection theory for analysis of responses to yes/no discrimination tests is a common method for measuring picture recognition (e.g., Snodgrass, Hirshman, & Fan, 1996). The choice of indices, however, is more controversial. For the current study on normal memory processes, calculations were made first of the probability

Table 12

Mean Number and Standard Deviations for Pictures Correctly Recognized (Range 0 - 9) as a Function of Age and Identification Condition

	Identification Condition			
Age	Old	New	(Old-New)	Distracter
3-years (N = 17)				
M	8.71	8.59	0.12	6.12
SD	0.77	0.62		2.15
4-years (N = 12)				
M	9.00	8.50	0.50	7.58
SD	0.00	0.52		1.83
5-years (N = 21)				
M	8.86	8.24	0.62	7.67
SD	0.36	1.30		1.80
8-years (N = 24)				
M	9.00	8.62	0.38	8.71
SD	0.00	0.50		0.46

of correct responses to previously seen items, that is, p(hits) for Old items and for New items, and the probability of circling distracter or never-seen items [p(false alarms)].

The formula[3] used for the index of discrimination is the nonparametric measure of A" proposed by Smith (1995) as an adjustment to the formula for A'. This approach tot he analysis avoids the restrictive assumptions required when using parametric methods for SDT to estimate the area (A_U) under the ROC. Two corrections are made for the probability values of 0.00 and 1.00. Under the rationale presented by Smith that a probability value of 0.00 does not really occur, when p = 0.00, the following calculation was made to replace zero: 1 ÷ 2N, where N = number of trials, either 3 or 9. When the value for p = 1.00, then that value was replaced by the value from this formula: 1 - (1 ÷ 2N). The formula[4] used to calculate response bias was the nonparametric index B''_D described by Donaldson (1992).

Analysis was carried out first on the probability of hits (p/H) and false alarms (p/FA), then on the sensitivity measure A", and finally on a measure of response bias (B''_D). For each measure, responses were examined as a function of Age, Gender, and Closure.

Picture recognition: P(hits) and p(FA). An ANOVA was applied to the probability values of correct responses to previously seen pictures (p/H) from the mixed factorial design of 4 (Age) X 2 (Gender) X 2 (Closure) X 2 (Identification Condition) with Identification Condition (p/H-Old, p/H-New) being the repeated measures factor. Table 13 presents the mean proportions of hits for Old and New pictures as well as proportions for the mean number of false alarms as a function of Age.

The only reliable finding was a main effect for the Identification Condition; the probability of distinguishing between the distracter and Old pictures (M = 0.94) was statistically greater than between distracter and New pictures (M = 0.91), $F(1, 64) = 9.73$, $MSe = .002$, $p < .01$, $\eta^2 = .13$. Despite the near-ceiling performance for both once-seen and twice-seen pictures, prior exposure to fragpix facilitated accuracy in recognition responses. The ceiling effect likely obscured findings for age-related differences in performance. Parkin and Streete (1988) reported a similar null effect in proportion of correct responses for age-related differences in a same-day picture recognition test for 3-, 5-, 7-year-olds and adults.

A 4 (Age) X 2 (Gender) X 2 (Closure) between groups ANOVA was applied to the data for proportion of false alarms, (p/FA), the likelihood of incorrectly circling pictures never seen. Table 13 gives the means for the only reliable finding, a main effect for Age, $F(3, 64) = 9.03$, $MSe = .054$, $p < .001$, $\eta^2 = .30$. Trend analysis using weighted contrasts revealed a linear function, $F(1, 64)$ =

Table 13

Means and Standard Deviations for Probability of Hits for Old [P(H/Old)] and New [P(H/New)] Pictures and Probability of False Alarms [P(FA)] for Picture Recognition Test as a Function of Age

	Fragpix Identification Condition		
Age[a]	P(H/Old)	P(H/New)	P(FA)
3-years (N = 22)			
M	0.93	0.92	0.42
SD	0.06	0.04	0.33
4-years (N = 13)			
M	0.94	0.92	0.24
SD	0.00	0.03	0.28
5-years (N = 21)			
M	0.94	0.88	0.18
SD	0.02	0.12	0.18
8-years (N = 24)			
M	0.94	0.92	0.07
SD	0.00	0.03	0.03

21.53, $p < .001$, which accounted for 25% of the variability in performance. In contrast to the false-alarm rate reported by Parkin and Street (1988), a ceiling effect was not present in this analysis; children demonstrated an age-related improvement in their ability to correctly reject (i.e., not circle) pictures they had never seen.

Picture recognition: Discrimination index (A"). Table 14 provides the means and standard deviations for values of the discrimination index for both Old and New pictures as a function of Age. The value for A"-Old represents the child's ability to discriminate between twice-seen (at exposure and test) and never-seen (i.e., distracter) pictures. The value for A"-New represents the child's ability to discriminate between once-seen (at test only) and never-seen pictures.

The ANOVA applied to the 4 (Age) X 2 (Gender) X 2 (Closure) X 2 (Identification Condition) mixed factorial design on the discrimination indices of A"-Old and A"-New revealed a between-groups main effect for Age, $F(3, 64) = 7.24$, $MSe = .023$, $p < .001$, $\eta^2 = .23$. This factor was examined further at each level of the Identification Condition rather than on the averaged values for Old and New. Trend analysis using weighted contrasts revealed a linear function for the measure on Old, $F(1, 64) = 17.51$, $p < .001$, $R^2 = .22$, and for New, $F(1, 64) = 15.90$, $p < .001$, $R^2 = .20$. A quadratic trend was also revealed for

Table 14

Means and Standard Deviations of Values for Discrimination Index (A") and Response Bias ($B"_D$) for Old and New Fragpix Correctly Recognized on Picture Recognition Test as a Function of Age

	Discrimination		Response Bias	
Age	A"(Old)	A"(New)	$B"_D$(Old)	$B"_D$(New)
3-years (N = 22)				
M	0.81	0.80	-0.60	-0.59
SD	0.16	0.16	0.45	0.42
4-years (N = 13)				
M	0.89	0.88	-0.40	-0.28
SD	0.13	0.13	0.39	0.42
5-years (N = 21)				
M	0.92	0.90	-0.27	-0.10
SD	0.05	0.07	0.40	0.54
8-years (N = 24)				
M	0.95	0.94	-0.10	+0.03
SD	0.01	0.02	0.17	0.21

discrimination responses on the Old measure, $p < .05$, but it only accounted for 5% of the total variability. Age-related improvement in the ability to discriminate between previously seen and never-seen pictures was found, with the largest improvement occurring between age 3 and 4 years.

The within-subjects portion of the analysis revealed a main effect for priming, $F(1, 64) = 11.90$, $MSe = 0.0004$, $p < .001$, $R^2 = .16$, with the ability to discriminate twice-seen pictures ($M = 0.89$) being better than that for once-seen pictures ($M = 0.88$). There was also an interaction between Gender, Age, and Identification Condition that just surpassed conventional values for significance. Figure 7 gives the means for this 3-way interaction, $F(3, 64) = 2.64$, $p = .057$, $R^2 = .10$.

Post-hoc probes of this interaction with Neuman-Keuls test at each level of the Gender factor revealed that, while age-related improvement in ability to distinguish between never-seen and previously seen pictures was found at each successive increment for age, there were also gender-related differences in the rate of improvement. Girls made the largest statistically significant improvement between ages 3 and 4 years on both Old ($M_{dif} = 0.12$) and New ($M_{dif} = 0.10$) pictures, Q_{crit} (64) = 0.029, both ps < .01. Boys improved at a more gradual rate but made the greatest improvement between ages 4- and 5-years ($M_{dif} = 0.07$ for both Old and New pictures), Q_{crit} (64) = 0.028, both ps < .01.

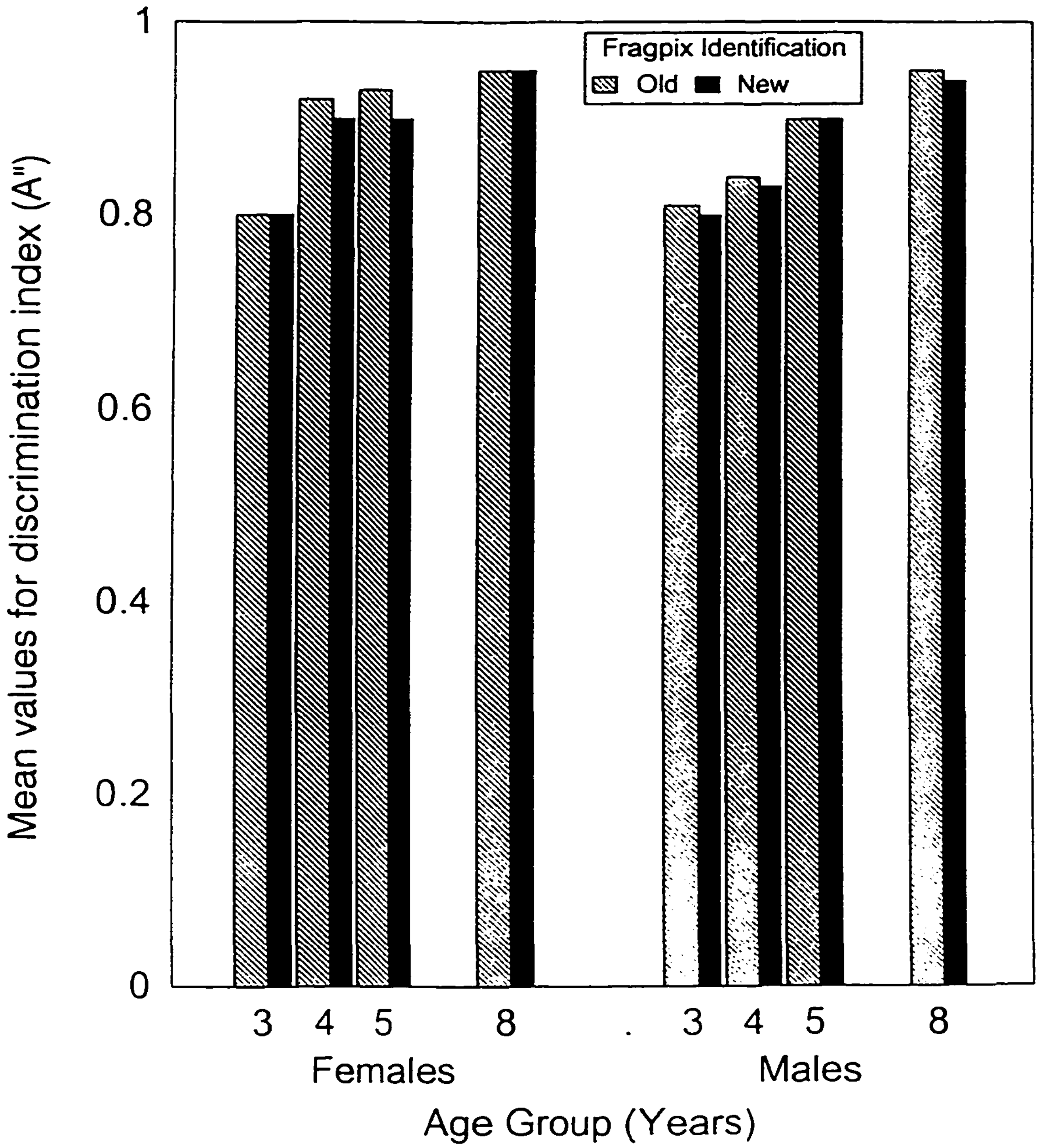

Figure 7. Mean values of discrimination index (A") for Interaction between Age and Gender for priming (Old vs New) on picture recognition tests.

Picture recognition: Response bias index (B''_D). This measure, a bias index, examined young children's likelihood of responding conservatively (i.e., nay-saying) or positively (i.e., yah-saying) without necessarily being sure of the accuracy of their response. Values that are towards zero represent a neutral bias; a liberal bias moves in a negative direction away from zero, while conservative responses are reflected in values that move away from zero in a positive direction. It would be expected that less exposure to pictures would result in a more conservative response, a greater likelihood of not circling the picture.

Table 14 gives the means for the ANOVA applied to the response bias measure for Old and New pictures in the 4 X 2 X 2 X 2 mixed factorial. As children got older, they tended to make fewer "yes" responses and to demonstrate neither a liberal or conservative bias in their response. This was confirmed through the reliable Age main effect in the between-groups portion of the analysis, $F(3, 64) = 9.42$, $MSe = .262$, $p < .001$, $\eta^2 = .26$. Trend analysis at each level of Identification Condition using weighted contrasts revealed a linear function for the response to Old, $F(1, 64) = 19.41$, $R^2 = .23$, and to New pictures, $F(1, 64) = 23.96$, $R^2 = .27$, both ps $< .001$.

As expected, seeing the picture at both exposure and test ($M = -0.33$ for Old pictures) significantly increased the bias toward making a liberal response compared to responses to pictures seen only at test (M = -0.22), with the difference being statistically significant, $F(1, 64) = 20.03$, $MSe = .021$, $p < .001$, $\eta^2 = .24$. Prior exposure to pictures influenced responses while no other effects or interactions were reliable.

To summarize the data for picture recognition, prior exposure to pictures (i.e., at study and test) facilitated the ability of children to correctly recognize these same pictures at test, relative to once seen pictures, on measures of correct responses (p/H) and discrimination. In addition, prior exposure reduced children's tendency to say yes indiscriminately. Analysis of values for correct responses on the measure of probability of hits, obscured by near-ceiling performance, revealed no age-related changes. In contrast, conversion of scores to indices of discrimination and response bias yielded age-related improvements, with only 8-year-olds achieving near-ceiling performance in discrimination and no response-bias. Finally, for measures of incorrect circling of distracter pictures, the only effect of interest was age-related improvement in the correct rejection of never-seen pictures.

Discussion and Conclusion

Experiment 3 was designed both as a scaling study to delineate age-associated identification thresholds for fragmented pictures, and to examine hypotheses regarding the effect of prior exposure and perceptual closure on indirect and direct tests of memory as a function of age and gender. The findings complement and challenge previous research regarding the performance of young children on perceptual and memorial tasks. A review of the results and a discussion of their implications follows.

A Scaling Study with Fragpix as Stimuli

At each successive age, 3-, 4-, 5-, and 8-year-old children required less pictorial information to name fragmented pictures than their younger counterparts, regardless of whether fragpix were novel (Train, New) or previously studied (Old). Statistical support for this outcome was reflected in the significant linear trend for each fragpix identification condition (Train, Old, New), and reinforced by the large proportion of variability accounted for in each condition. Although typically not a primary focus of their studies, age-related differences in picture identification responses (orthogonal to the priming effect) are consistently reported by other researchers who study young children's performance with pictorial stimuli (Bullock-Drummey & Newcombe, 1995; DiGuilio et al., 1994; Parkin & Street, 1988; Russo et al., 1995).

In contrast, Gender, the other measured variable examined in this experiment, had no differential association with any direct or indirect measure of cognitive processing. This supports the results reported by Naito (1990) and Verville and Cameron (1946).

Fragmented Pictures: Prior Exposure, Perceptual Closure, Age

In examining the effect of prior exposure to fragpix on picture identification at test, all 96 children identified previously seen (Old) fragpix at a lower mean threshold than the mean threshold for novel (New) fragpix. The large proportion of variation accounted for on the indirect measure of memory (0.81) supports the robust nature of this phenomenon. In addition, priming was reliable at each level of the age variable. This supports findings by Bullock-Drummey and Newcombe (1995), Greenbaum and Graf (1989), and Parkin and Street (1988), and others, and the conclusion drawn by Graf (1990) that priming, as measured by the comparison of performance between previously seen and novel pictorial stimuli, is functional at least as early as 3 years of age.

Alternately, when prior exposure is examined as the magnitude of priming, developmental invariance is typically reported suggesting that priming is established early, and then has a relatively constant influence on performance over time. Even re-computing the magnitude of priming as a proportion of perceptual learning did not amend the claim of age-invariance for this effect for Russo et al. (1995).
A challenge to this claim for developmental stability in priming is tendered by the significant linear trend and moderate effect size reported both in Experiment 3 of this dissertation and in Parkin's (1993) reanalysis of the Parkin

and Streete (1988) data. This discrepancy between these findings and the conclusions drawn from the Russo study might be explained through their choice of age groups.

Russo and his associates reported a stable priming effect between adults and a combined children's group of 4- and 6-year-olds. They commented, however, that the large amount of variability in the scores for the children's groups might have obscured a reliable difference in performance. They explored this possibility by collapsing the data for proportion of priming across their two experiments to gain statistical power, and subsequently reported "a significant difference in priming due to development" (p. 574). In the Russo study, they had combined the two children's groups together because, individually, the means and standard error for 4- and 6-year-olds were not reliably different.

It is possible that unique developmentally based differences exist between 3- and 5-year-olds that are not so apparent between the 4- and 6-year-olds. In Experiment 3 of this dissertation, post-hoc probes of the linear trend for magnitude of priming found reliable differences among 3-, 5-, and 8-year-olds, but no difference between 4- and 5-year-olds; this held for both the fragpix identification task and for free recall. The neuro-developmental status of the 4-year-old is unique from the 3-year-old in that the myelination process of the nervous system is nearly completed for the older child. The neurological changes and differences in cognitive abilities between 4- and 5-year-olds, and perhaps even between 5 and 6 year olds, may not as dramatic as between 3- and 5-years of age. This possibility lends further justification for the judicious selection of age groups when examining developmental change in young children's behaviour.

When age-related differences for priming are detected, as they were in Experiment 3 of this dissertation, the supposition of some critics is that they are spurious and likely reflect contamination by explicit influences of memory (Parkin, 1993; Russo & Parkin, 1993; Russo et al., 1995). Recollection, at test, of pictures previously seen during the Train phase might provide useful cues for identification of these pictures. In the current study, it was observed that during the test phase, when children recognized some fragpix as having been previously viewed, they often attempted to draw on their experience from the study phase to assist them in identifying the fragpic. To illustrate, if they perceived the still-fragmented picture as an animal, they would attempt to recall any animal or bird picture seen during the exposure phase. Older children are reported to be more efficient in explicit strategy use than younger children (Schneider & Pressley, 1989). It is conceivable that the superior performance of the older-aged children might reflect greater efficiency in the strategic use of memorial resources.

It is naive to assume, however, that such recollections have only a facilitative effect. As demonstrated by Snodgrass and Hirshman (1991) in their test of the Bruner-Potter effect (1964) with fragpix, such intentional recollections can also serve to delay correct identification of the stimulus. "Specifically, subjects generate an erroneous hypothesis about the identity of the target item during the ascending series which interferes with the correct hypothesis" (Snodgrass & Hirshman, 1991, p. 276). Advantages gained by explicit remembering may be offset by those lost through interference.

Recent attempts to minimize the use of intentional recall on indirect memory tests have not had a significant impact on performance. Russo et al. (1995) attempted to minimize the effect of explicit remembering by only showing the completed fragpic at study. Ascending levels of fragmentation were then presented at test, the intent being to eliminate subjects' use of memory for specific fragments as guides to identification. Regardless, as noted above, age differences in the magnitude of priming were found between children and adults. In an earlier study with adults, Russo and Parkin (1993) used a divided attention task at study to minimize the effect of explicit input on cognitive processing, and found no difference in performance on the data-driven task between the control and divided attention conditions. Brown, Neblett, Jones, and Mitchell (Experiment 4, 1991) also reported that when adults were given explicit information regarding which pictorial items had been studied and which were new, there was no differential influence of this manipulation on the magnitude of priming. No other reported studies with young children have directly attempted to manipulate the impact of explicit remembering on indirect tests of memory. However, if the use of intentional recall is not strongly and consistently facilitative for adults, it is even less likely to be facilitative for young children.

This is not to say that the fragpix identification task, or any task, is process-pure. Some of the age-related differences in the magnitude of priming likely reflect some components of conceptually based processing. It is suggested, however, that the greater proportion of these developmental differences embody perceptually based responses to the task. This proposition is examined further in terms of attributes of the stimulus and the task in the context of other findings from Experiment 3.

Fragmented pictures are data-driven stimuli and the task of identifying them in their incomplete state evokes the perceptually based mechanism of perceptual closure. Prior exposure to fragmented pictures facilitates the efficiency of the closure mechanism. As demonstrated in Experiment 3, attempts to further reinforce closure by showing the completed picture following correct identification had no discernible impact on later picture identification or free recall at any age level. This supports the closure hypothesis proposed by Gestalt theorists and tested by Mooney (1954); because perceptual closure had already occurred at the time the fragpic was initially identified, explicit presentation of the completed picture provided no additional memorial advantage.

Examining the findings for the other measure of prior experience, transfer of learning, lends further support to the potent perceptually based influence of this task on performance. Age-associated improvements were found for the magnitude of priming, while, with the exception of 5-year-olds, the magnitude of transfer was negligible.

The inability of 3-, 4-, and 8-year-olds to benefit from transfer, a more conceptually based form of learning than priming, suggests that cognitive influences played a minimal role in the processing of these stimuli. The resulting cubic trend for transfer accounted for only 5% of the total variability. If conceptually based processes made a larger contribution to performance, then it would be expected that a similar effect would have been exhibited by the 8-year-olds. These results nearly mirrored those of Parkin and Streete (1988); in their study, the magnitude of transfer was negligible for each age level.

In summary, there is strong support for identification of fragmented pictures being primarily a perceptually based task. Explicit cues such as showing the completed picture did not enhance performance. The perceptually influenced measure of the effect of prior experience, priming, was statistically more substantial than transfer, the learning measure derived primarily from skill improvement.

Direct Measures of Memory

Performance, measured by mean number correct, on direct measures of memory replicated some well-documented findings, but conflicted with others. The relationship between age and free recall responses was monotonic, as was the relationship between age and picture recognition on indices of discrimination and response bias, and on correct rejection of never-seen (distracter) pictures.

Prior exposure to fragpix facilitated memorial performance on picture recognition for all ages, but only improved performance on free recall for the 8-year-olds. The magnitude of the priming effect remained developmentally stable for picture recognition, but was expressed as a linear function for free recall.

Theoretical Considerations

Contrary to the majority of studies examining data-driven and conceptually driven influences on memory, this study did not find dissociations in performance between the indirect and direct tests. Age-associated improvements were recorded for fragpix identification, free recall, and picture recognition. Priming was not developmentally invariant for either test, nor did conversion of scores to proportionate magnitude of priming result in developmental stability. For the moment, at least, theoretical explanations of transfer appropriate processing and of perceptual fluency/stimulus similarity can account for some, but not all, of the findings. These explanatory mechanisms will be revisited in the discussion following Experiment 4.

Recommendations

Three major considerations emerged from Experiment 3 of this dissertation. First, priming is established by 3 years of age. When examining the effect of prior exposure on young children, it is acceptable to include children at least as young as age 3 years.

Second, in its function as a scaling study, one implication of the results was the importance, when studying developmental processes with very young children, of considering each age group as an independent entity. Performance on data-driven tasks, such as identification of fragmented pictures, and conceptually driven tasks, such as free recall, and picture recognition which is both data- and conceptually driven, reflected rapid, age-associated changes. Developmental changes were also displayed on measures of priming. It is possible that collapsing across ages when examining behaviours of young children might obscure the unique differences associated with individual age levels. It is therefore recommended to either keep age groups distinct or, alternately, let age vary continuously and apply a regression analysis to the data.

Finally, regardless of the implication that age-associated improvements in the fragpix identification task suggests there are some conceptually based influence on performance, the stimulus materials and the task itself appeared to primarily involve data-driven processes. To further explore the effect of prior experience on performance, and most particularly to manipulate factors that might facilitate the priming effect, it is reasonable to focus on the perceptual components of the stimulus materials and to manipulate the manner in which they are presented during exposure. This was the primary objective of Experiment 4, which follows.

Chapter III

Perceptual Closure and Stimulus Complexity: Four Manipulations of the Priming Stimulus

The fourth experiment for this research project manipulated four components of the priming stimulus to examine their impact on children's ability to identify fragmented pictures. Three manipulations originated from studies on stimulus complexity (e.g., Berlyne, 1960; May & MacPherson, 1971) and explored the influence of temporal contrast, or stimulus change, on picture identification. A fourth manipulation, following from Snodgrass and Feenan (1990), fixed the levels of fragmentation presented for study. The central premise underlying this last manipulation was that exposure to a moderate level of fragmentation is optimal for learning, that is, promotes more efficient performance at test.

An Optimal Level of Fragmentation

Both Gollin (1960, Experiment 4; 1961, 1962) and Snodgrass and Feenan (1990) used sequentially fragmented pictures to examine the supposition that presenting pictures at a moderate level of fragmentation during training enabled subjects to identify these same pictures more readily at test. Although there were procedural differences between their respective methodologies, both Gollin and Snodgrass found support for the concept that there exists an optimal level of fragmentation that enhances the learning process.

Gollin (1960, Experiment 4; 1961, 1962), drawing from a 5-level sequence of degraded pictures, trained half his subjects on pictures at an intermediate level of fragmentation (Level III) while the remainder used a complete picture (Level V). All subjects were tested by identifying pictures presented _only_ at their most fragmented level (Level I). Gollin reported that training with the intermediate level facilitated subjects' ability to identify the Level I pictures more so than training with the complete picture. Gollin hypothesized that identification occurred as a result of generalization: The Level III fragmented picture was psychologically more similar to the Level I test picture than was the complete picture (Level V).

Snodgrass and Feenan (1990) proposed an alternative explanation for this phenomenon in what they called the perceptual closure hypothesis. They theorized that the most facilitative priming experience is provided by the stimulus closest to the threshold of identification, allowing the subject to fill in or close up gaps for a particular stimulus during the course of the identification process. This experience of closure provides a durable perceptual learning experience that transfers to the new task of identifying the same stimulus when it is presented at its most fragmented level during a later perceptual identification task (Snodgrass & Hirshman, 1994). Two components of this hypothesis are important to note. First, as noted in Chapter 2, the experience of closure at study is generated by a three-stage process (i.e., identification of the stimulus during exposure, then, at test, presentation of the same stimulus at an unrecognizable level, and followed, finally, by sequential presentation until identification of the stimulus occurs). Second, there is an optimal priming, or prior exposure, experience that facilitates the closure experience for a given stimulus. Conceptually this optimum level is the level that contains the minimum amount of information necessary to support closure. Operationally, this optimum level is determined from the mean threshold at which identification of the fragmented pictures occurs.

For Gollin, an optimum level of fragmentation was the <u>physical</u> mid-point, or Level III, in his 5-level sequence. In contrast, Snodgrass and Corwin (1988a), rather than focusing on a physical mid-point, used the ascending method of limits and the 8-level sequence of fragpix to calculate subjects' <u>psychological</u> mid-point. The mean threshold of identification for adults fell between Level 4 and Level 5. Snodgrass (1989a, Experiment 1) initially tested the closure hypothesis with fragpix presented at Levels 3, 5, and 8 which she believed paralleled Gollin's respective levels of I, III, and V. The perceptual closure hypothesis predicted Level 5 as the optimum level, however, the initial studies using Level 5 were inconclusive. Snodgrass subsequently utilised Levels 1, 4, and 7, and found support for the perceptual closure hypothesis (Experiments 2-6, 1989a; Snodgrass & Feenan, 1990, Snodgrass & Hirshman, 1994). For adults, Level 4 rather than Level 5, appeared to represent a psychologically optimal level of fragmentation.

The methodology used by Snodgrass to probe this hypothesis involved exposing all subjects to a random ordering of 15 fragpix with five stimuli presented at the most fragmented level (Level 1), five at Level 4, and five at Level 7. At test, 30 pictures were presented using the ascending method of limits. Four identification threshold means were calculated, one for the 15 New pictures and one for each subset of pictures previously seen at a given exposure level (Levels 1, 4, 7).

The perceptual closure hypothesis predicts a U-shaped function between priming level and identification at test, with Level 4 providing optimum priming; pictures first seen at Level 4 would be identified at test more readily, that is at a lower level of fragmentation, than those presented at Level 1 or Level 7. Support for Snodgrass' perceptual closure hypothesis would be demonstrated only by a differential effect of priming favouring Level 4.

In a review of the experiments carried out by both Gollin and by Snodgrass and her colleagues, and acknowledging differences in methodology across studies, outcomes that lent support for an optimal level of fragmentation enhancing learning are summarized below:

1. Following training (or priming) with a moderately fragmented picture, fragmented pictures were identified more readily at test than training with a complete picture. This was true for both children (Gollin, 1960, Experiment 4) and adults (Snodgrass & Feenan, 1990, Experiment 1; Snodgrass & Hirshman, 1994, Experiment 5).

2. Over retention intervals ranging from 1 minute to 4 days, priming with a moderate level of fragmentation facilitated recognition of pictures for several age groups (preschoolers, 6.5 years, 8.5 years, and adults) better than priming with a full picture (Gollin, 1961, 1962).

3. Informing subjects at test that they had seen a particular fragpic at study further enhanced the effect of Level 4 as the optimum level for a priming stimulus (Snodgrass & Feenan, 1990, Experiment 1). This suggests that priming can be enhanced by explicit as well as implicit manipulations.

4. Following the initial identification of each fragpic, subjects were shown a portion of the fragpic again (either a fragment that they had seen or a complementary fragment). Showing pieces of the fragpic promoted closure for Level 4 pictures, but not for Level 1 or Level 7 pictures (Snodgrass & Feenan, 1990, Experiment 4). Although the effect was stronger when the <u>same</u> fragment was shown each time than when a different piece of the fragpic was seen, support for the closure hypothesis was sustained,

nonetheless.

5. Increasing the duration of the prime during exposure increased the probability of closure (Snodgrass & Feenan, 1990, Experiment 5).

In summary, in the process of exploring whether an optimum level of fragmentation existed, not only was a moderate level of fragmentation generally found to be facilitative, it also appeared to enhance the effect of perceptual closure. Factors most conducive to effective closure were manipulations that involved (a) the judicious selection of levels of fragmentation, (b) repeated exposure of the same fragment level during study, (c) extending the duration of exposure, and, (d) setting no time limits for identification. Although research by Snodgrass and her colleagues with adults revealed support for the perceptual closure hypothesis, the generalization of this finding to children, beyond Gollin's loosely related work, can only be surmised.

Further, although each of the experiments reviewed above involved some form of manipulation of the prime, Snodgrass did not control for the order in which the levels of fragmentation (7, 4, 1) were viewed; the presentation sequence was always computer-randomized. Each series of fragpix was presented in a unique order of fragmentation level; for example, pictures of a bed, bus, key, and swan might be viewed by one subject at Levels 7, 7, 1 and 4, respectively, while a second subject might see the same pictures at Levels 1, 4, 7 and 1, respectively. It is possible, however, that diverse orders of presentation might differentially influence subsequent identification of fragpix. Variability in stimulus presentation (or stimulus change) is part of the broader construct of stimulus complexity. Dember and Earl (1957), Berlyne (1960), and others have examined the role of temporal and spatial variability in effecting attention and engagement responses.

Stimulus Complexity (Variability) and Attention

Humans have a fundamental need to seek out variety and change (Franken, 1982). As a consequence, an object or event that is perceived as novel elicits attention, prompting its investigation by individuals until its information value has been exhausted. In addition, both adults and children have demonstrated a preference for seeking out objects or situations that are relatively more complex than those previously encountered (Dember & Earl, 1957; May, 1963; Walker, 1964). Although theorists have argued whether this preference for variability is extrinsically motivated by properties of the stimulus (Berlyne, 1960; Dember & Earl, 1957) or is intrinsically driven, either by human beings' need to make sense of their world (Hebb, 1955; Hunt, 1963; Piaget, 1952/1971) or by feelings of efficacy gained when mastering a complex or novel experience (White, 1959), all have recognized the powerful motivational force evoked by novelty, variation, and complexity.

Regardless of their theoretical underpinnings, theorists typically acknowledge three premises that underlie the relation between attributes of a stimulus and the innate tendency of individuals to attempt to understand their world (Franken, 1982; Loewenstein, 1994). First, incongruity with one's expectations of how something should be, whether an object or event, elicits attention. Second, an inverted U-shaped function exists between stimulus complexity and engagement, with optimum amounts of variability having positive hedonic value. Low levels of variability (e.g., simple, familiar stimuli) are associated with reduced engagement while extremely high levels are likely to be associated with aversion and avoidance. Third, there are individual variations in what level of complexity is optimum for each person. Further, each individual's optimum level is undergoing constant change both as a function of experience and of natural characteristics, for example, during developmental processes. Because people tend to select an experience more complex than one previously encountered, their optimum level may be in constant transition.

Stimuli derive their power to recruit attention from the interaction between the cognitive structures of the viewer and the properties of the stimulus. Diverse characteristics of a stimulus (e.g., novelty, incongruity, amount of information, magnitude of change, suddenness of change) combine with individual perceptions that can produce differential interpretations of the degree of psychological complexity inherent in the stimulus. The stimulus will continue to be perceived as psychologically complex until the individual has discerned whatever order or lawfulness characterizes it. Once that order is discovered, the perceived (psychological) complexity of the stimulus--and the attention directed to it--will be reduced.

When a stimulus is optimally complex it elicits maximum attention. Varying the amount and degree of change in specific properties of a stimulus (i.e., stimulus change) has been demonstrated to be a major determinant of the distribution of attention (e.g., McCall & Kagan, 1967). If attention is an essential condition for learning, then optimally complex stimuli should maximize learning. It is conceivable that judicious manipulation of selected stimulus attributes may not only elicit attention but optimally sustain it as well, the consequence being further enhancement of the learning process.

<u>Stimulus change.</u> Stimulus complexity can be operationalized through stimulus change, with stimulus change defined as the magnitude or number of changes in the measure of a stimulus on one or more of its attributes (May, 1963). Different amounts of change may correspond to

different amounts of psychological complexity. For example, a black and white 36-square checkerboard is spatially and psychologically more complex to most children and adults than a similar-sized 4-square checkerboard. Brennan, Ames, and Moore (1966) found, however, that for 3-week-old infants, it was the 4-square pattern that elicited sustained visual attention (visual fixation), while a 36-square pattern, likely perceived as visually overwhelming and too difficult to process, was virtually ignored. This behavioral response appeared to undergo rapid developmental change, such that 3-month-old infants attended only briefly to the simpler, 4-square pattern, but gave sustained attention to the complex, 36-square checkerboard. This suggests that experience and maturation altered the infants' perception of what was spatially and psychologically complex.

The illustration above exemplifies stimulus change in a spatial format, that is, few versus many contrasting changes across a single stimulus of a black and white checkerboard pattern. It is also possible to manipulate change sequentially, in terms of temporal contrast. During the study phase, a subject may be presented with a series of stimuli, for example, a 4-square checkerboard pattern followed by a 9-square pattern, then a 36-square pattern. This example illustrates three types of temporal contrast, (a) magnitude of change in complexity across presentations,

(b) order of difficulty level as it changes from simple to complex, and (c) the number of times the stimulus changes. In the example above, the change from a 4- to 9- to 36-square checkerboard represents a "2-change" condition with order of difficulty shifting from simple to intermediate, then intermediate to complex.

Consider a further illustration of stimulus change with checkerboard patterns in a series of stimulus presentations. The nine-item sequence 4-4-4*36-36-36*4-4-4 represents two changes in difficulty (* = a change). Here, the order of difficulty shifts from simple to complex to simple, with a magnitude of change of 4:36. As reported by May and his associates (e.g., May, Cuddy, & Norton, 1979), when an optimum number of changes was coupled with manipulation of the order of difficulty, learning was enhanced.

May studied the effects of stimulus change with adults on list-learning (May et al., 1979; May & Tryk, 1970) and with young children on discrimination learning tasks (May & MacPherson, 1971) and Piagetian tasks of conservation (May & Norton, 1981; May & Tisshaw, 1977). In the list learning studies, adults were exposed to lists of words that intermixed commonly used and rarely used words. Recall was tested in four groups of subjects, those exposed to either (a) a list of common words, (b) a list of rare words, (c) a block of common words counterbalanced with a block of rare words, or (d) a list of words that alternated common and rare words. Alternating common and rare words in the study list facilitated recall of rare words more so than studying rare words on a homogeneous list.

Other studies by May and his colleagues combined two or more components of stimulus change, such as level of task difficulty and the number of changes occurring within the sequence. To illustrate, in May and MacPherson (1971, Experiment 2) children in kindergarten, Grade 2 and Grade 3 were trained in size-discrimination tasks under one of four conditions. One group of subjects experienced a gradual training process, practising first with an easy task (E), then a moderately difficult task (M), and finally with a very difficult, or hard, task (H). In a sequence of 12 trials, the order of difficulty level during stimulus presentation might be EEEE*MMMM*HHHH. A second group of subjects trained with more variability in the E/M sequence, EE*MM*EE*MM*HHHH, while a third group experienced the greatest variability in presentation format, E*M*E*M*E*M*E*M* HHHH. A final group trained only on a task at its most difficult level, HHHHHHHHHHHH. The number of changes between each difficulty level was varied such that the groups described above experienced two, four, eight, and zero changes, respectively.

May and MacPherson confirmed that not only did varying the level of task difficulty enhance learning, but the optimal level for amount of change varied as a function of experience. Third-grade children demonstrated optimal performance (i.e., made fewer errors on the hard task) in the 8-change condition, while optimal performance by the kindergarten occurred in the 4-change condition. For the youngest children, too many changes inhibited performance just as much as few or no changes.

Similar findings were reported using tasks of Piagetian conservation to examine transfer of learning. May and Tisshaw (1977) found that, regardless of the training prototype (i.e., a mixed versus homogeneous task training, or a 7-change versus 1-change condition), more correct answers and greater transfer of learning occurred in the condition that involved greater variability in the training process. May and Norton (1981) extended these findings by adding a third manipulation of stimulus change, order of difficulty. Learning tasks are typically presented in a graduated format for level of difficulty, that is, easy-medium-hard, under the supposition that this format is optimal for learning. Alternately, Pascual-Leone (1971) claimed that systematic ordering is the antithesis of Piagetian-based spontaneous problem-solving. He proposed a loop sequence that started with a difficult version of the task, followed by the easiest version and then the difficult version (H*E*H). This sequence was alleged to facilitate spontaneous strategy use and subsequently promote transfer of experience. May and Norton tested the loop sequence against a no-training group and two stimulus variations of an easy-medium-difficult sequence--a graduated 2-change and a multi-change format. Both of these latter conditions facilitated more transfer learning than no training or training with the Pascual-Leone loop sequence.

These outcomes support the premise that, when the changed feature is relevant to task solution, then stimulus change, defined as temporal contrast, facilitates and sustains attention to stimulus differences and optimizes learning. If stimulus changes are associated with irrelevant features of the task, then learning is retarded: changes become a distraction for the learning process.

Because their properties are easily manipulated, fragpix are well-suited for tests of stimulus change. By controlling the order of presentation of fragpix, and fixing the amount of material displayed in each fragpic, vis a vis a fixed level of fragmentation, tests of stimulus change can be combined with explorations of the perceptual closure hypothesis using young children as subjects.

Stimulus Change and Fragpix. According to the complexity theory proposed by Dember and Earl (1957), tasks that are perceived as being novel or challenging and that capture and sustain one's attention have a higher probability of promoting efficient and effective learning. Experiment 4 operationalized the principles inherent in stimulus complexity to four manipulations of the priming stimulus, and examined the ability of each manipulation to influence young children's ability to identify fragmented pictures.

The scaling studies conducted in Experiment 3, as well as previous studies by May and his associates, were used to guide decisions regarding (a) selection of levels of fragmentation, (b) number of stimulus changes, (c) inclusion of systematic and random presentation formats, and, (d) the format for order of difficulty (i.e., an easy-medium-hard sequence of presentation). Two short pilot studies were conducted to support decisions regarding the operational definitions of the manipulations. The first manipulation discussed is the selection of the three levels of fragmentation to be used during exposure.

Perceptual Closure Hypothesis: An Optimal Level of Fragmentation for the Priming Stimulus

If priming with a moderate or intermediate level of fragmentation is hypothesized to facilitate earlier identification of fragpix, then how, given eight levels of fragmentation, does one determine which level of fragmentation is "psychologically moderate?" This consideration becomes especially relevant when participants include children at varied stages of development. Subsequent to answering that question, how does one select psychologically equal intervals of fragmentation for the more extreme easy/hard levels? Snodgrass selected Levels 7-

4-1 for the test of the perceptual closure hypothesis with adult subjects (Snodgrass & Feenan, 1990), but did not determine equivalent levels for child subjects.

Parkin and Streete (1988) reported mean thresholds for child subjects, but the age groupings examined in their study differed from the age groups used in the current study. As was evidenced by Parkin and Streete and by Experiment 3 of the current study, mean threshold levels of identification differed reliably between successive age groups for each identification condition. This implies that, for the test of the perceptual closure hypothesis in Experiment 4, a set of three exposure levels should be selected that may be unique for each age group. Further, because each fragpic must have some degree of fragmentation, Level 8 (the complete picture) is eliminated by default as a potential option for the "easy" level of identification.

Four age groups were tested in the scaling study (Experiment 3) for this project. Referring to Table 8 in Chapter 2, an examination of the mean thresholds in the Train condition revealed that 3-year-olds and 4-year-olds obtained mean identification levels of 7.1 and 6.4, respectively. Given that the mean threshold level guides the selection of an intermediate (medium) level of fragmentation, the high thresholds obtained by the two younger groups limits the probability of defining an acceptable psychological distinction between an easy and medium level of fragmentation. The older children, the 5- and 8-year-olds, obtained mean thresholds of 5.9 and 5.1, respectively, in the Train condition. The lower mean threshold for the older two groups suggests that children aged 5 to 8 years could be suitable candidates for inclusion in Experiment 4.

As the respective mean thresholds of 5.1 and 5.9 suggest, a psychologically moderate level of fragmentation could be identified, for 8-year-olds, as either Level 4 or Level 5, and, for 5-year-olds, as either Level 5 or Level 6. To facilitate the appropriate selection of three levels of fragmentation, the level of fragmentation at which each child in Experiment 3 identified each fragpic was reviewed. Table 15 presents the frequency, cumulative frequency, and cumulative proportion for fragpic identification for each level of fragmentation for both 5- and 8-year-olds (N = 28 in each group and drawn from subjects who participated in Experiment 3). Inspection of the cumulative frequencies for cues of psychological equivalency in identification revealed that both age groups identified about 97% of the pictures at Level 7 making Level 7 a reasonable choice as the "easy" level of fragmentation. The subsequent selection of the "hard" level found an age differential for psychological equivalency, such that, while 8-year-olds had identified 4% of the pictures by Level 2, 5-year-olds did not identify 4% of the pictures until Level 3. Consequently, the selection

Table 15

Frequency (f), Cumulative Frequency, and Cumulative Proportion for Number of Fragpix Identified at Each Level of Fragmentation as a Function of Age Group

	Level of Fragmentation							
Age Group[a]	1	2	3	4	5	6	7	8
5-year-olds								
Frequency	1	0	9	12	68	90	62	10
Cumulative f	1	1	10	22	90	180	242	252
Cum. Proportion[b]	.00[c]	.00	.04	.09	.36	.71	.96	1.00
8-year-olds								
Frequency	4	6	21	44	67	63	42	5
Cumulative f	4	10	31	75	142	205	247	252
Cum. Proportion	.02	.04	.12	.30	.56	.81	.98	1.00

[a]N = 28 in each Age Group

[b]Cumulative Proportion or Total responses = 252 based on 9 responses given by each subject

[c]Actual value = .004

for presentation of easy and hard levels of fragmentation for 5-year-olds was Levels 7 and 3, respectively, and, for 8-year-olds, Levels 7 and 2.

The choice of a moderate level of fragmentation for the 5-year-olds was expedited by the sharp jump in cumulative proportion between Levels 5 and 6; Level 5 was chosen to represent the moderate level of fragmentation for this age group. A pilot test of these levels with 12 five-year-olds, which produced 36 responses for each of the three levels of fragmentation, revealed the number of correctly identified fragpix for Levels 7, 5, 3 to be 35, 18, 1, respectively. Attaining a 50% accuracy rate for the moderate level (Level 5) was particularly affirming not only in the selection of Level 5 for this younger age group but also to support the more difficult decision encountered in selecting a moderate level of fragmentation for the 8-year-olds.

For 8-year-olds, Level 5, with its cumulative percentage of 56% correct, might appear to represent a moderate level of difficulty for identification. Five-year-olds, however, had identified only 36% of the fragpix at this moderate level of fragmentation (Level 5), which represents a 20% differential (56% minus 36%) between age groups for Level 5. The cumulative percentage for 8-year-olds at Level 4, however, is 29.7%, only a 6% differential (36% minus 30%) from the moderate level selected for the 5-year-olds.

It appears that, for 8-year-olds, Level 4 is psychologically closer to the level chosen for 5-year-olds, and, as such, more appropriately represents an intermediate level of difficulty for them. To strengthen the rationale for this selection of Level 4, four 8-year-olds were tested on their ability to identify a set of nine fragmented pictures presented at Levels 7-5-2. As expected, all of the Level 7 and none of the Level 2 fragpix were identified; however 83% (10/12) of the Level 5 pictures were correctly identified. This percentage is too high to qualify Level 5 as reflecting a moderate level of psychological difficulty. Therefore, Level 4 was selected for 8-year-olds as a moderately difficult level of fragmentation. To conclude, to test for an optimal level of fragmentation, 5-year-olds were primed with fragpix at Levels 7-5-3 and 8-year-olds with Levels 7-4-2.

Stimulus Change: Order of Presentation and Number of Changes

Recent studies examining the effect of stimulus change derived from orders of presentation on cognitive processing are scarce. However, the work cited above by May and his colleagues and more recent unpublished studies with fragpix (Bernard, 1993; Gonzales, 1995) suggest that the potential impact of these manipulations should not be trivialized. In reference to these latter studies--modified replications of the Snodgrass and Feenan (1990) test of perceptual closure hypothesis--random versus systematic presentations of fragpix at Levels 7-4-1 produced differential patterns of response in adults. The random presentation of fragpix replicated the findings by Snodgrass producing a U-shaped function with Level 4 as the optimum prime for perceptual closure. In contrast, subjects exposed to fragpix in a systematic, easy-medium-hard sequence produced a response pattern that not only did not support Level 4 as being optimal for priming, but was either the inverse function of the random presentation (Bernard, 1993), or showed no difference across levels of fragmentation (Gonzales, 1995). Intrigued by these outcomes, Experiment 4 of the current project was designed to extend manipulations of different presentation orders with children.

Given that there are *nine* fragpix in the picture set used for the exposure phase and three levels of fragmentation, it was possible to present each level of fragmentation three times, three fragpix at Level 7, three at Level 5 (or 4) and three at Level 3 (or 2). The computer programme was adapted to control the order of stimulus presentation. Four stimulus change conditions (random, 2-change, 2-change reverse, 6-change) were selected so that the presentation order for fixed levels of fragmentation could be manipulated and the number of changes that occurred between levels could be controlled.

The Random manipulation of the exposure condition replicated the procedure of Snodgrass and Feenan (1990) in that subjects were exposed to a computer-determined random order for the presentation of the nine fragpix. For example, one random order of presentation might present a series of fragpix displayed at Levels 7*2*5-5*7*2-2*5*7, while, for the next subject, presentation of fragpix might be at Levels 2-2*7*5-5-5*7-7*2. The first subject would experience six changes, and the second subject would experience four changes during these exposures. With nine fragpix, the minimum number of possible changes is two and the maximum is eight. Thirty trial runs on the computer under a 7/5/2 condition revealed a mean of 5.4 changes (SD = 1.3, range 3 - 8) between levels of fragmentation for each exposure. Appendix E presents the data for these runs. This information contributed to the criteria utilized in the identification of three more change conditions that involved a systematic order of fragpix presentation.

The selection of 2-change and 6-change conditions reflected decisions made regarding (a) number of changes and (b) the order of difficulty level, for example, whether subjects begin with Level 7 (easy) or Level 2 (hard). One decision centred on whether to select a 4-change or a 6-change condition. Previous studies (May & MacPherson, 1971) indicated that 8-year-olds did equally well under both a 4- and 8-change condition, whereas 5-year-olds were reliably more accurate in the 4-change condition over both the 2- and 8-change condition. In May and Norton (1981), however, the same age-group demonstrated superior performance in a 7-change versus 1-change situation.

It is reasonable to assume that the amount of change suitable for a given age may vary with the type of task being studied; this suggested there was some flexibility in the choice between a 4- versus a 6-change condition. Given that stimulus change options ranging from four to seven shifts showed reliable differences over a 2-change condition for both age groups, and, that the mean number of changes in the random condition in trial runs, as reported above, was 5.4, a 6-change condition was selected. The 2-change conditions were selected because they represented the fewest number of possible changes and they could serve as a contrast to the greater number of systematic changes that occurred in the 6-change and random conditions. The rationale for two variations of a 2-change condition evolved from considerations regarding order of difficulty in stimulus presentation.

The decision regarding order of difficulty was guided by the work of May and his colleagues (May & MacPherson, 1971; May & Norton, 1981) which reported that an Easy-Medium-Hard sequence facilitated performance more effectively than, for instance, a Hard-Easy-Hard sequence. Consequently, subjects in the systematically ordered 2-change and 6-change conditions were exposed to fragpix in an easy-medium-hard sequence. In the 2-change condition the order of presentation for 5-year-olds was 7-7-7*5-5-5*3-3-3, while for 8-year-olds, it was 7-7-7*4-4-4*2-2-2. In the 6-change condition, 5- and 8-year-old subjects were exposed to the nine fragpix as follows: 7*5*7*5*7*5*3-3-3 and 7*4*7*4*7*4*2-2-2, respectively.

To counter-balance the Easy-Medium-Hard sequence, a second 2-change condition, designated 2-change reverse, or 2-change(R), transposed the order of difficulty. Subjects in this condition were exposed to fragpix in a Medium-Easy-Hard sequence, which, for example, was experienced by 5-year-olds as 5-5-5*7-7-7*3-3-3. Table 16 summarizes the orders of exposure of the priming stimulus for each age group as a function of stimulus change condition. Children from each age group were randomly assigned to either a 2-change, 2-change(R), 6-change, or random order of stimulus presentation.

With the selection of these manipulations (three levels of fragmentation, order of stimulus presentation, and number of stimulus changes) several hypotheses centring on the association between manipulations of the prime and subsequent picture identification were examined. Inherent in each hypothesis was a test for an age differential in performance. All three manipulations of the prime were examined for the influence of an optimal level of fragmentation. Would Snodgrass' finding for a moderate level of fragmentation being optimal for perceptual closure

Table 16

Orders of Exposure for Fragmented Pictures used as the Priming Stimulus for 5- and 8-year-old Children as a Function of Each Stimulus Change Condition

Change Condition	Order of Exposure
	5-Year-Old
2-Change	7 7 7 * 5 5 5 * 3 3 3
2-Change (Reverse)	5 5 5 * 7 7 7 * 3 3 3
6-Change	7 * 5 * 7 * 5 * 7 * 5 * 3 3 3
Random	Possible Range: 2 - 8 changes
	8-Year-Old
2-Change	7 7 7 * 4 4 4 * 2 2 2
2-Change (Reverse)	4 4 4 * 7 7 7 * 2 2 2
6-Change	7 * 4 * 7 * 4 * 7 * 4 * 2 2 2
Random	Possible Range: 2 - 8 changes

generalize to child subjects, and across non-random presentations of the stimulus?

The selection of four change conditions at exposure permitted several tests of stimulus change. In one test, controlling for the <u>number</u> of changes by the inclusion of a 6-change and a random condition provided an opportunity to explore a second variable of stimulus change, order of presentation: Would there be a differential influence on later identification of fragpix for a systematic versus random ordering during exposure? Perhaps a more predictable sequence of change would be preferred by the younger children. In a second test, the comparison of a 2-change versus a 6-change condition examined the efficacy of number of changes: Would the greater number of changes, and thus greater variety in presentation, be more facilitative in the identification process? A third test examined the influence of order of difficulty level at two levels; first, by comparing the combined performance in the 2-change and 6-change conditions against performance in the random condition: Would the random ordering or the systematic easy-medium-hard ordering be more facilitative for learning? And second, would the Easy-Medium-Hard sequence be more facilitative to learning than a Hard-Medium-Easy sequence as measured by comparing performance between the 2-change and 2-change reverse conditions?

A separate measure of learning was computed to examine the degree of influence of stimulus change on test performance. Magnitude of priming was measured averaged across priming levels (a difference score of New minus Old), and individually at each priming level (New minus priming level of interest, or Level i) as a function of each change condition. This latter analysis also permitted a test of optimal level for magnitude of priming. Finally, the data were examined to determine if order of exposure differentially facilitated test performance for those fragpix initially viewed in their most fragmented, and almost unidentifiable, form, that is, Level 3 (or 2).

Although neither Experiment 2 or 3 revealed an association with Gender for the two older age groups, Gender was included as a factor in Experiment 4 and attempts were made to gender-balance each condition. The factor of Closure, or showing the complete picture during exposure, was not included in Experiment 4. Its inclusion would, in essence, add a fourth level of fragmentation to each stimulus presentation and likely obscure attempts to further examine the perceptual closure hypothesis.

EXPERIMENT 4

Method

Participants

One hundred and forty four (144) children were recruited from local day care centres and elementary schools to form two gender-balanced age groups, 5-year-olds (N = 64) and 8-year-olds (N = 80). The mean age for the younger group was 65 months (range = 59 - 73 months, SD = 3.66), and for the older group, 101.3 months (range = 92 - 114 months, SD = 5.10).

Materials

The fragpix in picture sets 10 and 11, as previously adapted from Experiment 1, were used for this experiment and presented on an Apple Macintosh computer. The fragpix programme was adapted to permit the controlled selection of four exposure conditions, Random, 2-change, 2-change(R), and 6-change. The three direct memory tests of free recall, cued recall and picture recognition used in Experiment 3 were retained for Experiment 4. The record sheets were altered to permit recording of number of correct responses as a function of each priming level (see Appendix F for samples of the revised record sheets).

Procedure

With the exception of the exposure phase, the procedure was identical to Experiments 2 and 3. Each child was randomly assigned to one of four exposure conditions (Random, 2-change, 2-change reverse, 6-change). Attempts were made to gender-balance within each change group, however, this manoeuvre was only partially successful. Table 17 presents the number of males and females in Experiment 4 as a function of Age and Change condition. To control for order effects, each picture set and its related

Table 17

Experiment 4: Distribution of 144 Children as a Function of Age and Gender Trait and Stimulus Change Condition

	Change Condition			
Age Group	Random	2-Change	2-Change(R)	6-Change
5-year-olds				
Girls	10	6	6	11
Boys	10	6	6	9
8-year-olds				
Girls	12	10	10	10
Boys	8	10	10	10
Gender Subtotals				
Girls	22	16	16	21
Boys	18	16	16	19
Change Condition Totals				
	40	32	32	40

subset (e.g., 10A, 10B) was counter-balanced across all conditions. Regardless of condition, each child was presented with the same number of exposures at a given level of fragmentation, that is, three fragpix at each of three levels of fragmentation, for a total of nine fragpix. The child viewed each fragpic and was asked to identify (name) the stimulus. The child was told if the response was correct or incorrect and the correct name for the fragpic was given. The child's response was recorded as either correct or incorrect. The next fragpic was presented until all nine had been displayed. After the distracter phase--two minutes of informal conversation--the test phase commenced with the 18 fragpix being presented by the ascending method of limits. Administration of the three retention tests followed completion of fragpix identification test, as in Experiment 3. The child was then debriefed and thanked for his or her participation in the study. Formal letters summarizing the findings of the study were sent to each parent or guardian who had given permission for the child's participation, regardless of whether the data from the child were included in the experiment (see Appendix G for a sample copy of this letter.)

Scoring

Exposure phase. A count was recorded for the number of fragpix correctly named at each of the three levels of fragmentation (n = 3 for each priming level, total possible correct = 9).

Test phase: Fragpix identification. Five measures of mean threshold of identification were computed, (a) three scores were thresholds during test, one for each set of pictures presented at a given level of fragmentation during exposure (e.g., Level 7, Level 5, Level 3), (b) a threshold for "Old" items, an average of the means for the three levels mentioned above, and, (c) a threshold for "New" pictures, those not previously exposed. Using these threshold measures, three measures of magnitude of priming were computed. These measures of the size of the priming effect represent difference scores between the threshold for New fragpix and thresholds for fragpix previously viewed at a given level of the priming stimulus (New minus Level i).

Test phase: Retention tests. The number of fragpix correctly recalled or recognized as a function of exposure level or as a New picture was recorded for each subject on the record sheets. Magnitude of priming was computed from responses to the free recall and picture recognition test.

Design

Responses were recorded in a 2 (Age) X 2 (Gender) X 4 (Change) X 4 (Identification Condition: Level 7, Level 5/4, Level 3/2, New) mixed factorial design. Different combinations of the levels of the Identification factor were used for each of three analyses: one representing the three levels of the priming stimulus (Level 7, Level 5/4, Level 3/2) and designated as the repeated-measures factor of Level of Priming Stimulus, a second representing priming as a comparison between New and the priming stimulus of interest (New, Level i), and the third to examine responses to New fragpix. The dependent measure was mean threshold of identification at test for the three fragpix initially presented at each of Level 7, Level 5 (or 4), Level 3 (or 2), and for New fragpix.

As presented in Table 17, in the Age by Change matrix, six of the eight cells contained data from 20 subjects. The remaining two cells, 2-change and 2-change(R) conditions for 5-year-olds, each contained data from only 12 subjects. Preliminary analyses on these two change conditions revealed nearly identical performance across all measures of fragpix identification and retention. Given time and subject availability constraints, it was decided (in consultation) that no further subjects were needed for these two cells. All analyses involving these two cells were adjusted to reflect the unequal _n_s.

Results

Analysis was carried out in three stages. The mean number of correct identifications made by the subjects for fragpix presented at a single level of fragmentation during the Exposure phase was examined first. This was followed by a series of analyses applied to the mean threshold of identification for fragpix presented at test. The final set of analyses examined mean number correct on each of the explicit retention tests.

At each stage of these analyses, the factors of interest were first submitted to an analysis of variance, which was followed by investigations of the influence of stimulus change and of the optimal level hypothesis using single degree of freedom contrasts. The influence of the stimulus manipulations on priming were explored using the fragmentation level identification responses at test and responses to the retention tests.

The factors of Change and Level of Priming Stimulus were probed across each level of Age. To examine the effect of stimulus change on performance, the factor Change was probed with two orthogonal contrasts, (a) one examining the three systematic conditions against the random condition, and (b) a second examining whether, at each age level, one systematic condition was more facilitative than the other systematic conditions, for example comparing 6-change against the average of both 2-change conditions. When relevant, the third orthogonal comparison was carried out, a contrast between two systematic conditions.

To explore the optimal level hypothesis, all effects involving the repeated measures factor, Level of Priming Stimulus, were probed using trend analysis. Finding a significant quadratic trend would support the perceptual closure hypothesis that a moderately fragmented stimulus produced more priming than either a complete picture or a very fragmented picture. Repeated measures analyses were also tested for violations of the assumption of sphericity were the ideal value is 1.00. With one exception, values for Greenhouse-Geisser epsilon ranged from .81 to .99; the assumption of sphericity was not violated in any of the analyses of this experiment.

The rationale for post-hoc probes generally followed the guidelines identified for Experiment 3. The unequal *n*s in some cells for Experiment 4 resulted in different critical values being computed for *HSD* (as a function of *n*). When reporting a particular family of comparisons, the most conservative value for *HSD* is given. Second, when the number of means in a family of comparisons exceeded four, Neuman-Keuls test was applied. Only statistical outcomes with observed probability values < .08 and R^2 > .04 on confirmatory hypotheses are reported in the text.

Exposure Phase: Fragpix Identification

All children were exposed to nine fragpix, three at each of the three levels of the priming stimulus. Unlike Experiments 1, 2 and 3, any given picture was presented at a single level of fragmentation during the study phase. Table 18 presents the means and standard deviations across levels of the factors involved in this analysis. The percent-correct for each age as a function of priming levels 7,

Table 18-a

Means and Standard Deviations for Number of Correctly Identified Fragpix at Exposure as a Function of Age, Stimulus Change, and Level of Fragmentation for Priming Stimulus[a]. Age group: 5-year-olds

	Priming Level		
Change	Level 7	Level 5	Level 3
Random			
M	2.95	0.65	0.10
SD	0.22	0.81	0.31
2-Change			
M	2.92	1.33	0.17
SD	0.29	0.89	0.39
2-Change Reverse			
M	3.00	1.58	0.08
SD	0.00	0.90	0.29
6-Change			
M	3.00	1.90	0.20
SD	0.00	0.79	0.41
Averaged Across Change Conditions			
M	2.97	1.34	0.14
SD	0.18	0.96	0.35

[a]Maximum number of fragpix per exposure level = 3.

Table 18-b

Means and Standard Deviations for Number of Correctly Identified Fragpix at Exposure as a Function of Age, Stimulus Change, and Level of Fragmentation for Priming Stimulus[a]. Age group: 8-year-olds

	Priming Level		
Change	Level 7	Level 4	Level 2
Random			
M	3.00	0.95	0.05
SD	0.00	0.83	0.22
2-Change			
M	3.00	1.85	0.05
SD	0.00	0.74	0.22
2-Change Reverse			
M	3.00	1.60	0.05
SD	0.00	0.82	0.22
6-Change			
M	3.00	1.45	0.25
SD	0.00	0.83	0.44
Averaged Across Change Conditions			
M	3.00	1.46	0.10
SD	0.00	0.86	0.30

[a]Maximum number of fragpix per exposure level = 3.

5(4), and 3(2) were 99%, 45%, 5% for 5-year-olds, and 100%, 49%, and 3%, for 8-year-olds, respectively. These values were similar to those reported for adults primed at levels 7, 4, and 1 (Snodgrass & Feenan, 1990, Experiments 2-4). The mean number correct for Level 7 (M = 2.99, SD = 0.12) and for Level 3/2 (M = 0.12, SD = 0.32) contained some cells with no variance and reflected a ceiling and floor effect, respectively. These two extreme levels of fragmentation were dropped from the analysis.

Figure 8 illustrates the mean correct for the remaining data which were analyzed by an ANOVA on a 2 (Age) X 4 (Change) between-groups design for fragpix presented at an intermediate level of fragmentation (Level 5/4). There was a main effect for Change, $F(3, 136) = 2.36$, $MSe = 0.670$, $p < .001$, $R^2 = .17$, and Change interacted weakly with Age, $F(3, 136) = 2.36$, $p = .071$, $R^2 = .04$.

Change was examined at each level of the age variable using planned, orthogonal contrasts. For both age groups, fragpix presented in a systematic order were more likely to be named correctly than fragpix presented in a random order. A priori contrasts were reliable for 5-year-olds, $F(1, 60) = 17.64$, $MSe = 0.669$, $p < .001$, and for 8-year-olds, $F(1, 76) = 10.81$, $MSe = 0.648$, $p < .01$. The effect was more facilitative for 5-year-olds ($\eta^2 = .21$) that is, a greater proportion of the variability was accounted for with younger children, than for 8-year-olds ($\eta^2 = .12$).

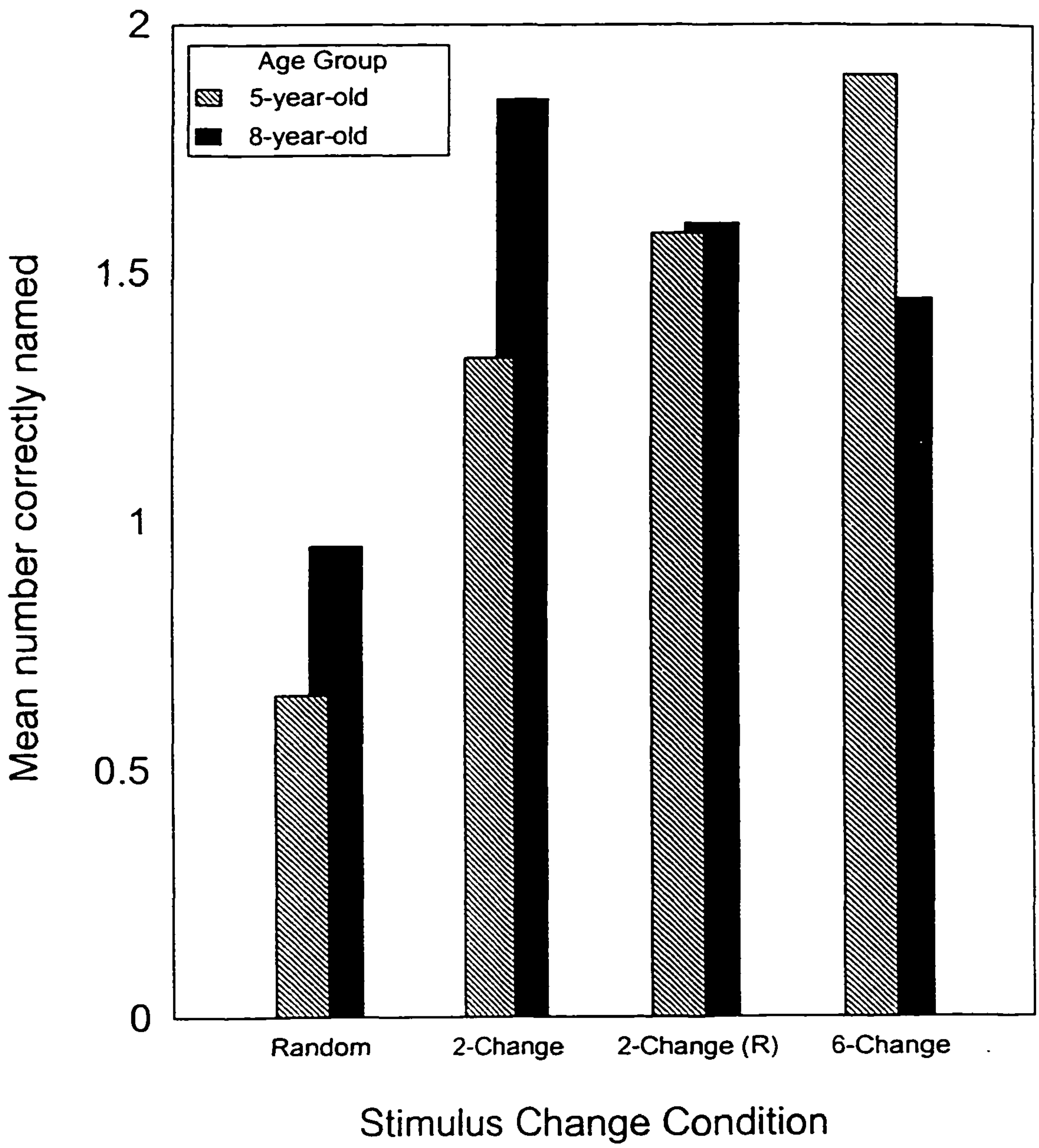

Figure 8. Exposure: Level 5 Priming stimulus. Mean number of fragpix correctly named as a function of Age and Change condition.

Among the systematic conditions, 5-year-olds in the 6-change condition correctly named more fragpix than same-aged children in the 2-change conditions, although the difference was not statistically significant at a conventional level ($p \leq .05$), $F(1, 60) = 3.04$, $p = .081$, $\eta^2 = .04$. No systematic change condition was differentially facilitative for the 8-year-olds, $p > .80$.

To summarize results from the exposure phase, when fragpix were presented at differing fixed levels of fragmentation, and little perceptual information was provided, children had significant difficulty naming the picture. When the picture was nearly complete, they named it easily. Fragpix presented at a moderate level of fragmentation were more likely to be named correctly if the child was exposed to the varying levels of fragmentation in some systematic rather than in a random manner. The effect of order was greater for the 5-year-olds than for the older children.

Fragpix Identification at Test

The dependent measure of mean threshold of identification for previously seen and novel fragpix at each level of the priming stimulus (Level i) was utilized to examine the hypotheses for the effects of stimulus change, optimal level, and prior exposure on performance. All analyses initially included the between-group factors of Age, Gender, and Change and the repeated measures factor of

Level of Priming Stimulus or of New. Gender figured in only one of these analyses. Figure 9 presents the means for the 3-way interaction between Gender, Change, and Level of Priming Stimulus, $F(6, 256) = 2.31$, $MSe = 0.916$, $p < .05$, $R^2 = .05$. When probed, the interaction appeared to have little substantive meaning. The only reliable finding was a difference between females in the random condition primed at an intermediate level of difficulty, and those in the 2-change condition primed at the most difficult level (Level 3/2). Given that all other main effects and interactions involving Gender had associated p-values > .40, it is suggested that this interaction was idiosyncratic. As a consequence, Gender was dropped from further analyses on measures for mean threshold of identification.

Age, change, and optimal level at test. Table 19 presents the means and standard deviations for 5- and 8-year-olds as a function of stimulus change conditions and five fragpix identification conditions. A 2 (Age) X 4 (Change) X 3 (Level of Priming Stimulus) mixed factorial analysis of variance was applied to the between-groups factors of Age and Change and a within-subjects factor of Level of Priming Stimulus (Levels 7, 5/4, 3/2) to examine the effects of stimulus change and level of fragmentation of the priming stimulus on fragpix identification by 5- and 8-year-olds. The outcome for the between-groups portion of the analysis was examined first, followed by the findings

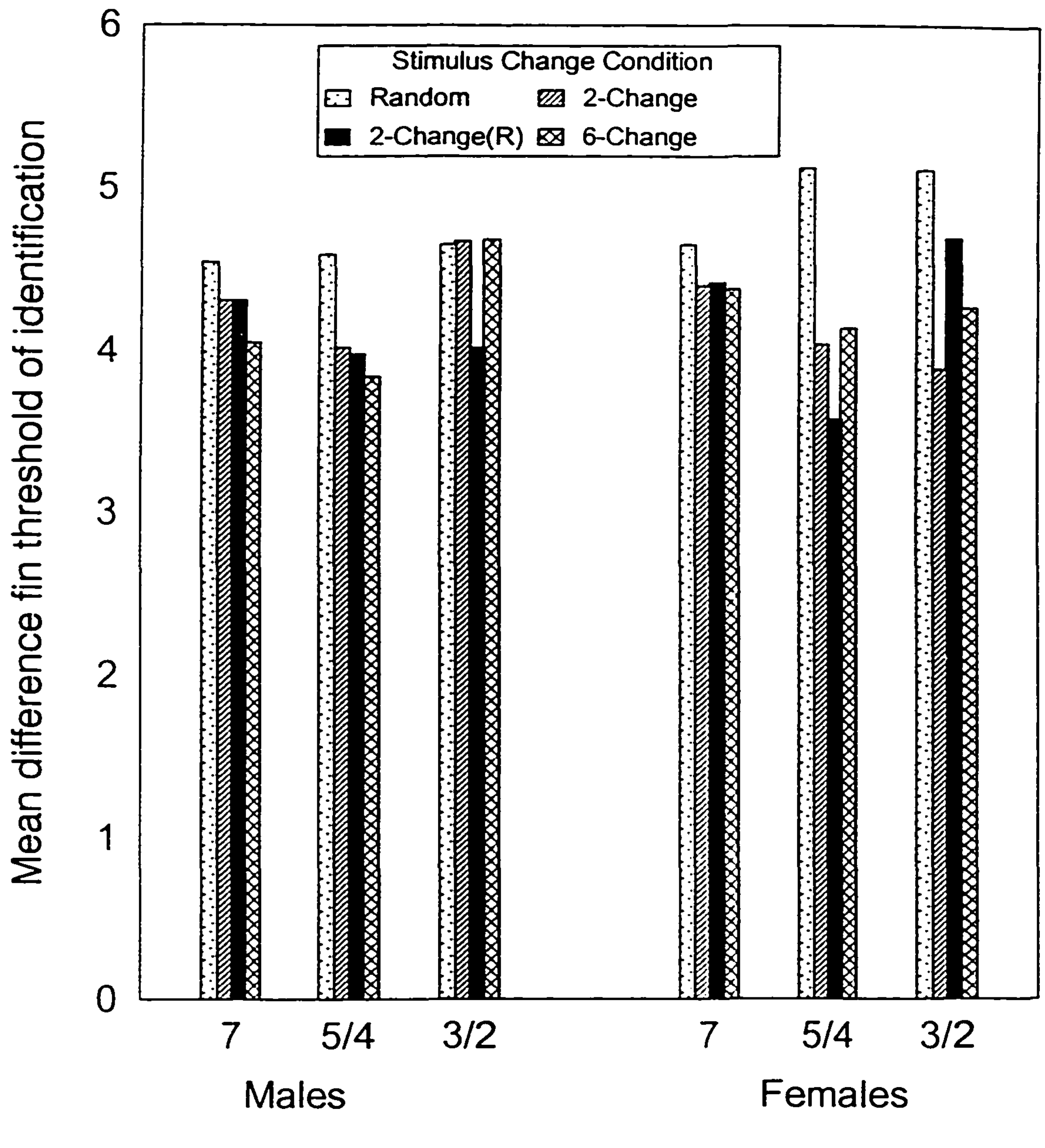

Figure 9. Mean threshold level for identification of fragpix across levels of the priming stimulus as a function of Gender and Stimulus Change condition.

Table 19-a

Mean Threshold Levels of Identification and Standard Deviations for Fragpix Identification as a Function of Stimulus Change, and Identification Condition.

Age Group: 5-year-olds

	Identification Condition				
Change	Level 7	Level 5	Level 3	Old	New
Random[a]					
M	4.86	5.65	5.65	5.39	5.88
SD	0.83	0.87	1.26	0.69	0.51
2-Change[b]					
M	5.17	4.83	5.11	5.03	5.96
SD	0.97	1.14	1.42	0.89	0.45
2-Change Reverse[b]					
M	4.94	4.92	5.17	5.01	6.01
SD	0.75	0.92	0.97	0.62	0.48
6-Change[a]					
M	4.70	4.28	4.62	4.53	5.81
SD	0.88	1.00	1.05	0.58	0.39
	Averaged Across Change Conditions				
M	4.89	4.93	5.14	4.98	5.90
SD	0.86	1.10	1.22	0.75	0.45

[a]N = 20 for Stimulus Change condition.

[b]N = 12 for Stimulus Change condition.

Table 19-b

Mean Threshold Levels of Identification and Standard Deviations for Fragpix Identification as a Function of Stimulus Change, and Identification Condition.

Age Group: 8-year-olds

	Identification Condition				
Change[a]	Level 7	Level 4	Level 2	Old	New
Random					
M	4.33	4.12	4.15	4.20	5.20
SD	0.71	1.12	1.16	0.66	0.55
2-Change					
M	3.87	3.55	3.78	3.73	4.99
SD	0.85	0.89	1.16	0.61	0.57
2-Change Reverse					
M	4.02	3.10	3.87	3.66	5.20
SD	1.04	1.18	1.08	0.66	0.53
6-Change					
M	3.75	3.72	4.32	3.92	5.17
SD	1.06	1.18	1.32	0.78	0.54
	Averaged Across Change Conditions				
M	3.99	3.62	4.03	3.88	5.14
SD	0.93	1.14	1.18	0.70	0.55

[a]N = 20 for each Stimulus Change condition.

for the within-subjects analysis.

The between-groups analysis examined the factors of Age and Change on the mean threshold of identification averaged across the three priming levels (Old). The interaction between Age and Change was not statistically significant, $F(3, 136) = 2.33$, $p > .07$, $R^2 = .03$. The finding of an age main effect, $F(1, 136) = 90.15$, $MSe = 1.41$, $p < .001$, $R^2 = .36$, replicated the results of Experiment 3. Eight-year-olds identified fragpix at a lower level of fragmentation $M = 3.88$, $SD = 0.70$) than 5-year-olds ($M = 4.98$, $SD = 0.75$).

A differential effect of stimulus change on fragpix identification was revealed in a reliable main effect for Change $F(3, 136) = 5.11$, $p < .01$, $R^2 = .06$. Probes of this factor across each level of Age revealed that, for both ages, fragpix initially presented in a systematic order were identified at a lower mean threshold than fragpix presented in a random order; this effect was more facilitative for younger children. The results of orthogonal contrasts were, for 5-year-olds, $F(1, 60) = 8.05$, $MSe = 0.474$, $p < .01$, $\eta^2 = .11$, and for the 8-year-olds, $F(1, 76) = 5.95$, $MSe = 0.463$, $p < .02$, $\eta^2 = .07$. Among the systematic conditions, the 6-change condition was reliably more facilitative for 5-year-olds than the other two conditions, $F(1, 60) = 5.39$, $p < .03$, $\eta^2 = .07$. None of the systematic change conditions were differentially effective for 8-year-olds, $p > .35$.

The pattern of means for seven of the eight conditions (age as a function of change) was in the direction to support the hypothesis for an optimal level for priming, the exception being 5-year-olds in the random condition. The within-subjects portion of the ANOVA revealed only a main effect for level of priming stimulus, $F(2, 272) = 3.57$, $MSe = 0.943$, $p < .03$, $R^2 = .03$, with Level 5(4) resulting in best performance.

Trend analysis at each level of the Age factor revealed no differential effect for Level of Priming Stimulus for 5-year-olds, both ps > .20, that is, neither a linear nor a quadratic trend was found. In contrast, for 8-year-olds, exposure to a moderate level of fragmentation (Level 4) during study promoted identification of fragpix at lower levels of fragmentation; the quadratic trend was reliable at $F(1, 76) = 7.36$, $p < .01$, $\eta^2 = .05$. Similar to the results for adults reported by Snodgrass and Feenan (1990) and Snodgrass and Hirshman (1994), a moderately fragmented picture presented at exposure to 8-year-olds promoted later identification of the fragpic at a lower level of fragmentation than did presentation of a nearly complete or very incomplete picture. This same effect was not found with the younger children.

A post-hoc inspection of mean thresholds at Level 4 indicated that, for the older children, one change condition might have been more facilitative than the other change conditions. Post-hoc pairwise comparisons revealed that, for 8-year-olds, the mean threshold for the 2-change(R) condition was lower than for the random condition, (MSe = 1.208), HSD = .92, $p < .05$, Tukey's test; no other pairwise comparisons were reliable, all ps > .05.

Identification of New fragpix. A 2 (Age) by 4 (Change) between-groups ANOVA was applied to children's mean threshold of identification on New fragpix. The only reliable finding was a main effect for Age, $F(1, 136) = 78.65$, MSe = 0.261, $p < .001$, $R^2 = .37$, all other ps > .50. Across all change conditions, 8-year-olds identified New fragpix at a lower level of fragmentation ($M = 5.14$) than 5-year-olds ($M = 5.90$). Neither stimulus change nor the level of the priming stimulus influenced the identification of novel fragpix.

Priming. The impact of prior exposure on fragpix identification was demonstrated to be a robust phenomenon in Experiment 3. All 96 children identified previously seen (Old) fragpix at a lower level of fragmentation than New fragpix. Experiment 4 also examined whether exposure to fragpix at different fixed levels of fragmentation facilitated identification, at test, of the same fragpix relative to novel fragpix. Table 19 provides the means and standard deviations for the factors submitted to a series of 2 (Age) X 4 (Change) X 2 (Priming: New, Level i) mixed-factorial ANOVAs at each level of the priming stimulus. Given that information in the between-groups portion of this analysis represents an average across the values for identification of New and Old items, the only meaningful part of the priming analysis is from the repeated measures factor which compares the difference between New and 'Old' responses. Therefore, only the within-subjects portion of these series of mixed factorial ANOVAs are reported here.

Table 20 provides a summary of the statistical findings for the main effect of Priming, which was reliable at each of the three levels of the priming stimulus. In addition, Table 20 lists the statistical values for tests of the age-related association between priming at each level of the priming stimulus. Five- and 8-year-olds demonstrated a similar effect for priming when presented with nearly complete pictures during exposure. When the picture was moderately or very fragmented, then there were age associated differences, with the effect being stronger for the older children and especially for a moderately fragmented stimulus.

No other main effects or interactions reached significance for the easy and difficult priming levels (7 and 3/2, respectively). At Level 5/4, as well as the Age by Priming interaction reported in Table 19, a Change by Priming interaction was reliable. Figure 10 gives the mean thresholds for fragpix identification at Level 5/4 and New as a function of Age and Change, $F(3, 136) = 6.81$, $R^2 = .13$, $p < .01$. The interaction among Age, Change, and Priming was

Table 20

Statistical Values for Within-Groups ANOVA on Priming (New versus Level i) at Each Level of Fragmentation of the Priming Stimulus, and in Interaction with Age, on the Dependent Measure of Mean Threshold of Identification

	Statistical Values			
Priming Level	F[a]	Mse	R^2	p
Level 7	200.26	0.394	0.60	< .001
Level 5/4	224.89	0.482	0.62	< .001
Level 3/2	101.01	0.606	0.43	< .001
Age X Priming Level	F[a]	Mse	R^2	p
Level 7	1.02	0.394	0.01	> .30
Level 5/4	9.84	0.482	0.07	< .01
Level 3/2	3.12	0.606	0.02	> .07

[a]df = 1, 136.

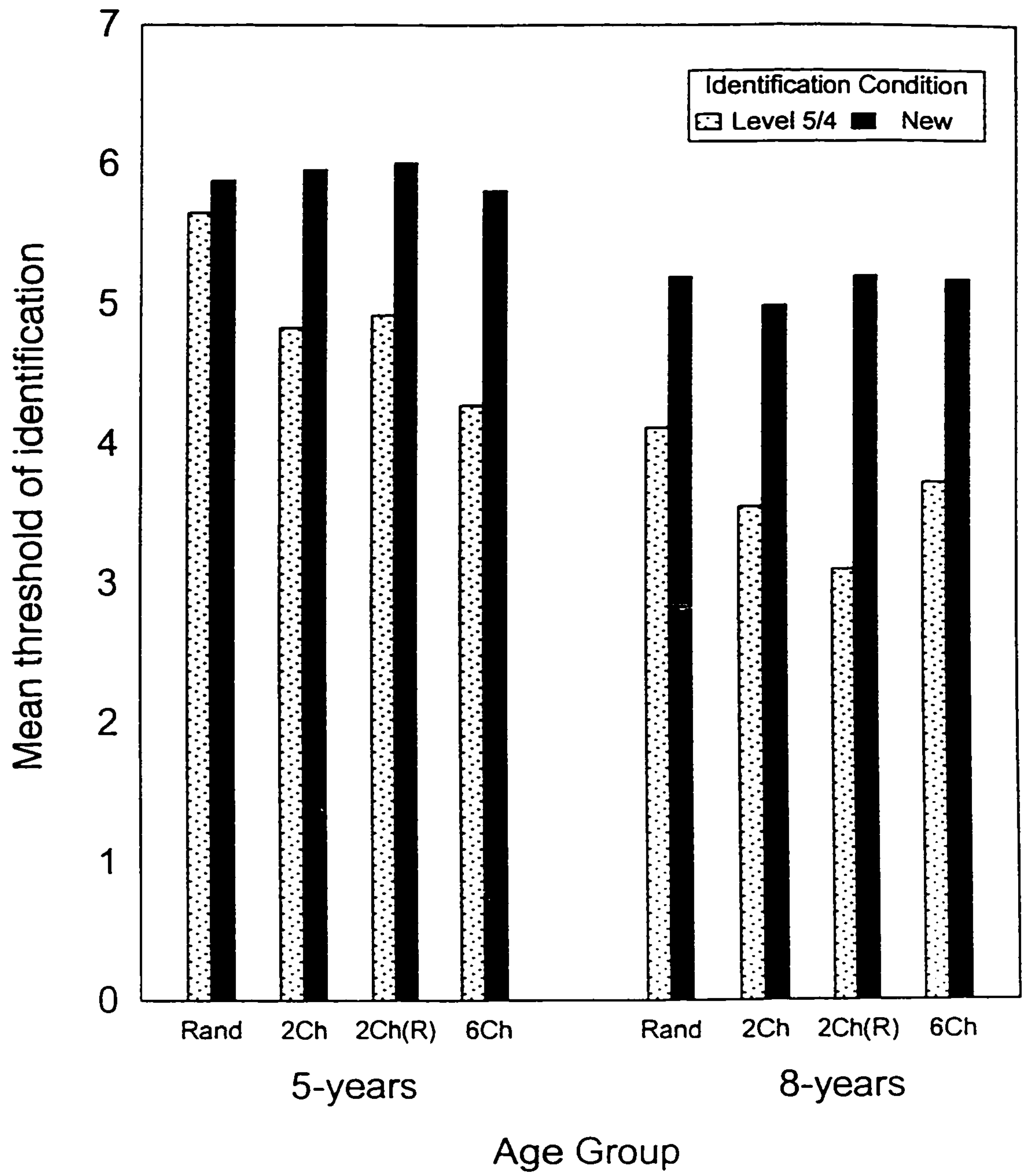

Figure 10. Priming: Mean threshold level for identification of fragpix at Level 5 and New as a function of Age and Change.

not reliable, $F(3, 136) = 2.36$, $p > .07$, $R^2 = .05$.

The effect of priming with a moderately fragmented picture was examined as a function of Change on each level of Age using orthogonal contrasts. The analysis revealed that, for each age, systematic conditions were more facilitative for priming than the random condition; for 5-year-olds, $F(1, 60) = 13.43$, $MSe = 0.418$, $p < .01$, $R^2 = .18$, and for 8-year-olds, $F(1, 76) = 5.42$, $MSe = 0.532$, $p < .03$, $R^2 = .07$. In addition, for 5-year-olds, among the three systematic conditions, the 6-change condition was most effective for priming, $F(1, 60) = 4.02$, $p < .05$, $R^2 = .06$. Although the 2-change(R) condition appeared to be most facilitative for 8-year-olds, its comparison with the other two systematic conditions did not reach significance, $p > .08$.

A post-hoc inspection of the means in Table 19-a for 5-year-olds in the Random condition suggested that the differences between New and Level 5, and New and Level 3 were minimal. Dependent samples t-tests comparing the means from Table 19-a revealed no reliable differences for either comparison: for New versus Level 3, $t < 1$, and New versus Level 5, $t(19) = 1.20$, $p > .20$. This suggests that there was no effect of priming for this specific condition, a rather intriguing outcome. As reported above, all 5-year-olds identified New pictures at a similar mean threshold regardless of Change condition. Further, an effect for priming was demonstrated in all other conditions at each level of the priming stimulus. Therefore, the lack of statistical difference between Level 5 (Old) and New and Level 3 (Old) and New in the Random condition appears to be a function of poor performance specific to the exposure experience in the Random condition. Although these non-reliable differences for priming at Levels 5 and 3 might represent a Type II error, it is also possible that, given the robust nature of priming and the fact that both outcomes occurred in the same change condition, the random condition differentially--and detrimentally--interfered with young children's perceptual and cognitive processing in a manner not observed with systematic orders of presentation.

Magnitude of priming. To further explore the priming effect, the data were re-computed to produce three measures of the magnitude of priming, a difference score between New and the priming level of interest, Level i (New minus Level i). Table 21 presents the means and standard deviations for this analysis across the factors Age and Change. The data were submitted to a 2 (Age) X 4 (Change) X 3 (Level of Priming Stimulus) mixed factorial ANOVA.

The between-groups portion of the analysis examined the hypothesis that variations in stimulus change conditions differentially influenced the size of the overall priming effect. There was a main effect for Age, with 8-year-olds demonstrating a larger overall priming effect (M = 1.26)

Table 21-a

Means and Standard Deviations for Magnitude of Priming (New minus Level i) on Fragpix Identification as a Function of Stimulus Change and Identification Condition. Age Group: 5-year-olds

	Priming Level			
Change	Level 7	Level 5	Level 3	Old[a]
Random[b]				
M	1.02	0.23	0.23	0.50
SD	0.83	0.87	1.15	0.63
2-Change[c]				
M	0.80	1.13	0.85	0.93
SD	0.82	1.05	1.23	0.67
2-Change Reverse[c]				
M	1.06	1.08	0.83	0.99
SD	0.86	0.71	0.87	0.52
6-Change[b]				
M	1.11	1.53	1.20	1.28
SD	0.83	0.98	1.15	0.61
Averaged Across Change Conditions				
M	1.01	1.08	0.76	0.91
SD	0.82	1.04	1.16	0.68

[a]Represents the average across the three priming levels

[b]N = 20 for Change condition.[c]N = 12 for Change condition.

Table 21-b

Means and Standard Deviations for Magnitude of Priming (New minus Level i) on Fragpix Identification as a Function of Stimulus Change and Identification Condition. Age Group: 8-year-olds

	Priming Level			
Change[a]	Level 7	Level 4	Level 2	Old[b]
Random				
M	0.87	1.09	1.05	1.00
SD	0.77	1.12	1.13	0.67
2-Change				
M	1.12	1.44	1.20	1.25
SD	0.75	0.84	1.02	0.44
2-Change Reverse				
M	1.18	2.10	1.33	1.54
SD	1.00	0.98	1.02	0.46
6-Change				
M	1.42	1.45	0.86	1.24
SD	1.13	1.15	1.16	0.72
Averaged Across Change Conditions				
M	1.15	1.52	1.11	1.26
SD	0.93	1.08	1.08	0.61

[a]N = 20 for each Stimulus Change condition.

[b]Represents the average across the three priming levels

than 5-year-olds (M = 0.91), $F(1, 136) = 10.86$, MSe = 1.077, $p < .01$, $R^2 = .06$. There was also a reliable effect for Change, $F(3, 136) = 6.23$, $p < .01$, $R^2 = .11$. The two factors did not interact, $p > .10$.

Probes of the factor Change at each level of Age replicated the earlier findings that systematic change was more facilitative on performance than random orders of stimulus presentation. The magnitude of priming was larger at each age in the systematic conditions than those in the random condition, $p < .001$ and $p < .03$, for 5- and 8-year-olds, respectively. The proportion of variability accounted for was larger for the 5-year-olds (.15) than for the 8-year-olds (.06). The largest value for the mean magnitude of priming occurred in the 6-change condition for 5-year-olds and the 2-change(R) condition for 8-year-olds. However, within each age-related analysis, the comparisons of each mean value to the mean values for the other systematic conditions were not statistically significant, all $ps > .08$. Reliable differences were not found in the size of the priming effect among the three systematic change conditions.

The within-subjects portion of the mixed-factorial analysis was explored, as a function of Age and Change, to test the hypothesis that there is an optimal level of priming; that is, that one level of fragmentation resulted in a larger magnitude of priming than the other two levels.

The only reliable finding from the ANOVA was a main effect for Level of Priming Stimulus, $F(2, 272) = 3.57$, MSe = 0.943, $p < .03$, $R^2 = .03$.

Trend analyses on this factor revealed no optimal level for the younger children, both ps > .20, but the presence of a quadratic trend for 8-year-olds, $F(1, 76) = 7.36$, MSe = 1.101, $p < .01$, $R^2 = .05$. Exposure to a moderately fragmented stimulus led to greater priming experienced by 8-year-olds than did presentation of a nearly complete or very incomplete picture. This effect was not replicated with 5-year-olds.

The magnitude of priming was also examined using the transformation formula suggested by Snodgrass (1989a) to compensate for varying baselines in performance. When applied in Experiment 3, the resulting proportionate values modified the outcome. For the current experiment, however, the analysis on this transformation [(New - Level i) ÷ (New - 1)] produced findings identical to those reported above for the magnitude of priming, and thus it was not necessary to duplicate a report of this information.

Exposure at Level 3/2 and later fragpix identification. When fragpix are presented at a nearly unidentifiable level of fragmentation, it is possible that the occurrence within the temporal sequence in which children viewed them might differentially influence their later identification at test. To examine whether order of exposure was associated with test performance for those Level 3/2 fragpix a series of correlations was carried out between the number of Level 3/2 fragpix correctly identified during exposure and the mean threshold of identification for those same fragpix at test. An inverse relationship occurred between the two variables, such that, the larger the number of fragpix identified during exposure, the lower was the mean threshold for identification.

The values for Pearson correlation in the random, 2-change, 2-change(R), and 6-change conditions for 5-year-olds were, -.31, -.07, -.70, -.34, respectively, and for 8-year-olds, -.30, -.16, -.04, -.05, respectively. Only the value for the 5-year-olds in the 2-change(R) condition was statistically significant, $r(10) = .704$, $p < .02$. For the younger children, some aspect of having first been presented with three nearly unidentifiable pictures transferred to the test phase and was more facilitative for later fragpix identification than were the other orders of exposure.

Summary: Fragpix identification. The results of Experiment 4 revealed some age-associated differences in priming and in the size of the priming effect, partially replicating the outcome of Experiment 3. In addition, developmental differences were revealed in the facilitative effect of stimulus change and in the presence of an optimal level for priming.

For each age level, and on all dependent measures, a systematic order of stimulus presentation resulted in improved performance for identifying pictures at exposure, for identification of previously seen pictures at test, for priming, and for the magnitude of priming. This effect was consistently larger for the younger children (R^2s ranging from .11 to .21), than for older children (R^2s ranging from .06 to .12). The random order of presentation was typically associated with a lower level of performance and, at best only equalled the performance level of systematic change.

Age-related findings also emerged for the impact of stimulus change on performance. Although these differences did not always reach statistical significance, the pattern of means was consistently in that direction, and the observed probability values were typically $< .09$. In general, 5-year-olds in the 6-change condition performed better than their peers in any of the other three conditions, replicating May and Tisshaw (1977) who reported that the multi-change condition was optimal for the same-aged children. Even though the Random order of presentation was also a multi-change condition, it was the least facilitative of all change conditions. For 8-year-olds, the 2-change(R) condition, in which children were exposed to fragpix in a moderately difficult, easy, then difficult-to identify sequence, tended to be optimal. This latter finding lends support to Pascual-Leone (1976) position that spontaneous problem-solving is not always appropriately facilitated by an easy-medium-hard sequence of task presentation.

The final hypothesis, exploration of an optimal level for priming, demonstrated a developmental trend. It was not detected for 5-year-olds, but was present with 8-year-olds, representing a downward extension from the adults tested by Snodgrass and her colleagues. Priming with a moderately fragmented picture enabled the older children to identify fragpix at a lower level of fragmentation at test than priming with a nearly complete or very incomplete stimulus. In addition, this effect enhanced the experience of priming and the size of the priming effect.

Direct Tests of Memory

As in Experiment 3, only the data from the free recall and picture recognition tests were submitted for analysis. Means and standard deviations for the cued recall test as a function of Age, Change, and Level of the Priming Stimulus can be found in Appendix H. Also similar to Experiment 3, picture recognition data were converted to indices of discrimination (A") and response bias (B''_D) prior to analysis. The analyses for measures of direct memory followed a similar pattern as for fragpix identification above with one exception. The factor, Gender, figured in some effects involving picture recognition and was retained for all analyses on data from direct memory tests.

Free recall. Table 22 presents the means and standard

Table 22-a

Means and Standard Deviations for Number of Fragpix Correctly Recalled for Free Recall Test as a Function of Stimulus Change and Identification Condition.

Age Group: 5-year-olds

	Identification Condition[a]			
Change	Level 7	Level 5	Level 3	New
Random[b]				
M	1.25	0.80	1.15	1.20
SD	0.79	0.77	0.74	1.15
2-Change[c]				
M	0.75	0.75	0.75	1.25
SD	0.75	0.75	0.75	1.29
2-Change Reverse[c]				
M	1.17	1.00	0.75	1.25
SD	0.84	0.60	0.75	0.87
6-Change[b]				
M	0.85	1.45	1.10	1.70
SD	0.88	0.83	0.91	1.23
Averaged Across Change Conditions				
M	1.02	1.03	0.98	1.34
SD	0.83	0.80	0.81	1.15

[a]Total possible at each level (N = 3); Total possible for New (N = 9). [b]N = 20. [c]N = 12.

Table 22-b

Means and Standard Deviations for Number of Fragpix Correctly Recalled for Free Recall Test as a Function of Stimulus Change and Identification Condition.

Age Group: 8-year-olds

	Identification Condition[a]			
Change[b]	Level 7	Level 4	Level 2	New
Random				
M	1.45	1.70	1.25	1.70
SD	0.83	0.98	0.85	1.08
2-Change				
M	1.40	1.40	2.00	2.80
SD	0.82	0.88	0.86	1.32
2-Change Reverse				
M	1.35	1.80	1.60	2.20
SD	0.67	1.06	0.75	1.28
6-Change				
M	1.20	1.35	1.20	2.10
SD	1.06	0.93	0.77	1.33
Averaged Across Change Conditions				
M	1.35	1.56	1.51	2.20
SD	0.84	0.97	0.86	1.30

[a]Total possible for each level of priming stimulus (N = 3); Total possible for New (N = 9). [b]N = 20 for each condition.

deviations for number of correctly recalled fragpix for the factors Age and Change across the three levels of the priming stimulus, and on New fragpix. To explore the influence of exposure to single levels of fragmentation on children's ability to later recall these same fragpix, the data were submitted to a 2 (Age) X 2 (Gender) X 4 (Change) X 3 (Level of Priming Stimulus) mixed factorial ANOVA, with Age, Gender, and Change as the between-group factors and level of priming stimulus (Levels 7, 5/4, 3/2) as the repeated-measures factor. Gender did not figure in any of the statistical effects for free recall, therefore it was dropped from further analysis.

An Age by Change by Level of Priming Stimulus design was submitted to ANOVA. The only reliable findings were an Age main effect and an interaction between Age and Change. Figure 11 presents the means for the interaction of Age with Change averaged across the three priming levels (i.e., a measure of Old), $F(3, 128) = 3.41$, $MSe = 0.742$, $p < .03$, $R^2 = .07$. A priori orthogonal contrasts on number of correct responses at each level of age revealed no definitive influence of stimulus change, with one possible exception. For 5-year-olds, the 6-change condition resulted in more correct responses than the other two systematic conditions, $F(1, 60) = 3.66$, $p = .06$, $\eta^2 = .06$. No change condition was differentially facilitative for the 8-year-olds.

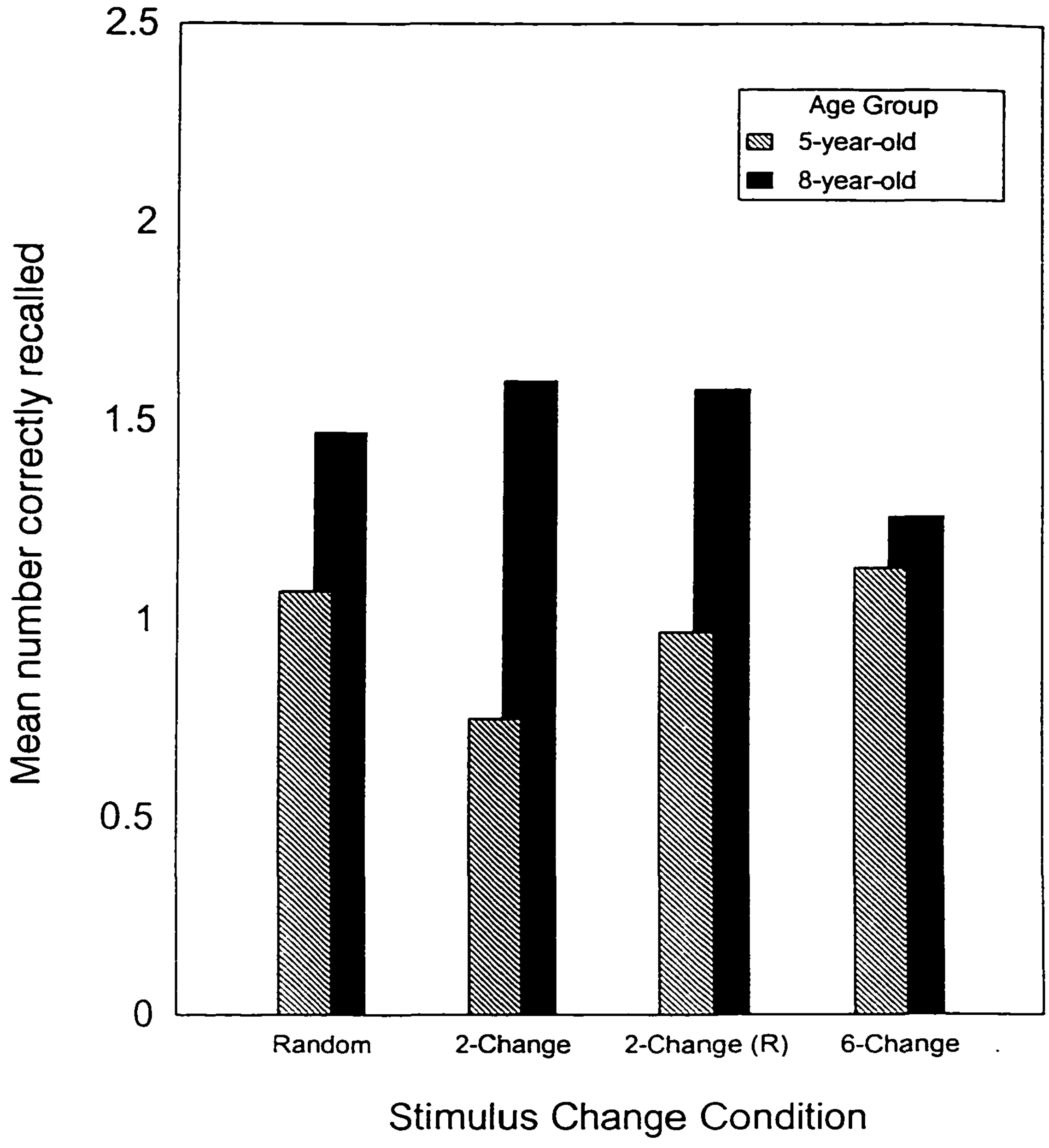

Figure 11. Mean number of fragpix correctly recalled in free recall test as a function of Age and Change condition.

Age was a reliable main effect with 8-year-olds recalling more fragpix on average (M = 4.42, SD = 1.58) than 5-year-olds (M = 3.03, SD = 1.44), $F(1, 128) = 33.90$, $p < .001$, $R^2 = .20$. No other between-groups effects and none of the within-subjects effects reached statistical significance, all ps > .10.

To test for the presence of an optimal level of priming, trend analysis was applied to the within-subjects portion of ANOVA at each level of age. No optimal level of priming for free recall responses was revealed for the 8-year-olds, but an isolated quadratic trend was found for younger children. The Level of Priming Stimulus showed a reliable quadratic trend in the 6-change condition, $F(3, 60) = 2.73$, $p < .06$, $R^2 = .06$.

To examine children's memory for fragpix viewed only at test, a 2 X 2 X 4 (Age, Gender, Change) between-groups ANOVA was carried out on the mean number recalled for New fragpix. The only reliable finding was an Age main effect, with 8-year-olds recalling more New fragpix (M = 2.20, SD = 1.30) than 5-year-olds (M = 1.38, SD = 1.15), $F(1, 128) = 15.56$, MSe = 1.498, $p < .001$, $R^2 = .10$.

Priming and the size of the priming effect for free recall. Priming, and the magnitude of priming as a function of the level of fragmentation during exposure was explored for free recall. Similar to the analysis of priming on fragpix identification tasks, to explore the effect of priming on direct memory for the pictures, only the analyses of the repeated-measures portion of the ANOVAs (Level of Priming Stimulus) is reported. Table 23 gives the ANOVA summary values for the within factor of Priming at each level of the priming stimulus.

Free recall: Priming. Table 22 presents the means and standard deviations for the factors involved in the mixed factorial ANOVAs applied, at each level of the priming stimulus, to a series of 2 (Age) X 4 (Change) X 2 (Priming: Level i, New÷3) on the free recall tests. For free recall, the factor of Priming was reliable at each individual level of fragmentation of the priming stimulus. It did not interact with either Age or Change across any of the levels of the priming stimulus. Prior exposure to the stimuli facilitated children's ability to recall previously seen fragpix at a lower mean threshold of fragmentation than novel fragpix.

Free recall: Magnitude of Priming. Table 24 presents the means and standard deviations for the magnitude of Priming (Level i - New÷3) for the number of items correctly recalled in the free recall test as a function of Age and Change. To examine whether the size of the priming effect differed as a function of age, stimulus change or level of priming stimulus, a 2 (Age) X 4 (Change) X 3 (Level of Priming Stimulus) mixed factorial was applied to the difference score for magnitude of priming (Level i minus

Table 23

Statistical Values for Priming at Each Level of Fragmentation of the Priming Stimulus for Free Recall Test

	Statistical Values			
Retention Test	F	Mse	R^2	p
Free Recall[a]				
Level 7	48.64	0.483	0.26	< .001
Level 5/4	66.53	0.490	0.33	< .001
Level 3/2	66.76	0.412	0.49	< .001

[a]Within-subjects factor, df = 1, 136.

Table 24-a

Means and Standard Deviations for Magnitude of Priming (Level i minus New÷3) for Number Correct of Fragpix Recalled in Free Recall Test as a Function of Stimulus Change and Level of the Priming Stimulus for 5-year-olds

	Priming Level		
Change	Level 7	Level 5	Level 3
Random[a]			
M	0.85	0.40	0.75
SD	0.90	0.94	0.91
2-Change[b]			
M	0.33	0.33	0.33
SD	0.97	1.13	0.91
2-Change Reverse[b]			
M	0.75	0.58	0.33
SD	1.03	0.67	0.65
6-Change[a]			
M	0.28	0.88	0.53
SD	1.02	0.93	0.97
Averaged Across Change Conditions			
M	0.56	0.57	0.53
SD	0.99	0.92	0.88

[a]N = 20 for Stimulus Change condition.

[b]N = 12 for Stimulus Change condition.

Table 24-b

Means and Standard Deviations for Magnitude of Priming (Level i minus New÷3) for Number of Fragpix Recalled in Free Recall Test as a Function of Stimulus Change and Level of the Priming Stimulus for 8-year-olds

	Priming Level		
Change[a]	Level 7	Level 4	Level 2
Random			
M	0.88	1.13	0.68
SD	1.00	1.06	0.93
2-Change			
M	0.47	0.47	1.07
SD	1.01	1.01	0.98
2-Change Reverse			
M	0.62	1.07	0.87
SD	0.87	1.05	0.91
6-Change			
M	0.50	0.65	0.50
SD	1.07	1.06	0.86
Averaged Across Change Conditions			
M	0.62	0.83	0.78
SD	0.98	1.06	0.93

[a]N = 20 for each Stimulus Change condition.

[b]Represents the average across the three priming levels.

New÷3) for number of items freely recalled. Because of the large within-cell variance, no main effects or interactions were reliable, all $\underline{p}$s > .07.

All single degree of freedom contrasts applied, at each level of Age, to examine the hypotheses of stimulus change and optimal level were non-reliable. Not only do these findings suggest there was no differential influence of these two stimulus manipulations, but, even more notable, they indicate that, despite finding age differences in the magnitude of priming for fragpix identification, the magnitude of priming for free recall was developmentally invariant. This dissociation is the reverse of what is typically reported in the literature between data-driven and conceptually driven tasks.

<u>Picture recognition.</u> All children were asked to circle the pictures that they recognized as having been displayed on the computer screen. Included among the nine twice-seen (Old) pictures and nine once-seen (New) pictures were nine distracters. Table 25 presents the means and standard deviations for number of correct responses for each identification condition and for distracters as a function of age and stimulus change condition. Scores for only 62 five-year-olds and 80 eight-year-olds are included in Table 23 because two subjects (both 5-year-old males in the Random condition) responded with indiscriminate marking.

Data were converted to indices of discrimination (A")

Table 25-a

Means and Standard Deviations for Number of Fragpix Correctly Recognized in Picture Recognition Test as a Function of Stimulus Change, Level of Priming Stimulus, New, and Distracters. Age Group: 5-year-olds

	Level Of Priming Stimulus[a]				
Change[b]	Level 7	Level 5	Level 3	New	Distracters
Random					
M	3.00	2.78	3.00	8.12	8.11
SD	0.00	0.55	0.00	1.06	1.37
2-Change					
M	2.92	2.83	3.00	7.92	8.08
SD	0.29	0.39	0.00	1.16	1.00
2-Change-Reverse					
M	2.92	3.00	2.67	8.33	8.17
SD	0.29	0.00	0.50	0.78	0.94
6-Change					
M	3.00	2.95	2.90	8.50	8.60
SD	0.00	0.22	0.31	0.76	0.68
Averaged Across Change Conditions					
M	2.97	2.89	2.91	8.30	8.02
SD	0.18	0.36	0.29	0.94	1.77

[a]Total possible for each level of priming stimulus (N = 3); for New (N = 9); for Distracters (N = 9). [b]Random (N = 20); 2-Change & 2-Change Reverse (N = 12); 6-Change (N = 20).

Table 25-b

Means and Standard Deviations for Number of Fragpix Correctly Recognized in Picture Recognition Test as a Function of Stimulus Change, Level of Priming Stimulus, New, and Distracters. Age Group: 8-year-olds

	Level Of Priming Stimulus[a]				
Change[b]	Level 7	Level 5	Level 3	New	Distracters
Random					
M	3.00	2.78	3.00	8.12	8.11
SD	0.00	0.55	0.00	1.06	1.37
2-Change					
M	2.92	2.83	3.00	7.92	8.08
SD	0.29	0.39	0.00	1.16	1.00
2-Change-Reverse					
M	2.92	3.00	2.67	8.33	8.17
SD	0.29	0.00	0.50	0.78	0.94
6-Change					
M	3.00	2.95	2.90	8.50	8.60
SD	0.00	0.22	0.31	0.76	0.68
Averaged Across Change Conditions					
M	2.97	2.89	2.91	8.30	8.02
SD	0.18	0.36	0.29	0.94	1.77

[a]Total possible for each level of priming stimulus (N = 3); for New (N = 9); for Distracters (N = 9). [b]Random (N = 20); 2-Change & 2-Change Reverse (N = 12); 6-Change (N = 20).

and response bias (B''_D) using the formulas detailed in Experiment 3. The data from all 64 five-year-olds were retained for this analysis. The results of these analyses are presented in the following order: Probabilites of hits and of false alarms, followed by measures of sensitivity (discrimination), and finally by measures of response bias.

Picture recognition: P(Hits) and p(False alarms). Table 26 presents means and standard deviations for probabilites of hits for each level of the priming stimulus, and for New, as well as probabilities for false alarms (p/FA). For both ages, 8-year-olds were more accurate than 5-year-olds in correctly circling previously seen pictures and correctly rejecting distracter pictures. The mean probability for hits on Old items was 0.82 (SD = 0.03) for 5-year-olds, and 0.83 (SD = 0.02) for 8-year-olds; similarly, the mean probability for hits on New items was 0.89 (SD = 0.08) for 5-year-olds, and 0.92 (SD = 0.04) for 8-year-old. Correct rejection of pictures (false alarms) also reported age-related findings, the mean value was 0.14 (SD = 0.17) for 5-year-olds, and 0.07 (SD = 0.04) for 8-year-olds. All values for p were < .01 while values for R^2 ranged from .07 to .09.

To examine the influence of stimulus change, and of level of priming stimulus, an ANOVA was applied to the 2 (Age) X 2 (Gender) X 4 (Change) X 3 (Level of Priming Stimulus) mixed factorial design, which was explored further at each level of the factor for Age. The main effect for

Table 26-a

Means and Standard Deviations for Proportion of Correct Response (P/Hits) as a Function of Stimulus Change and Level of Priming Stimulus and New, and Proportion of Incorrect Responses (P/False Alarms) on Picture Recognition Test. Age Group: 5-year-olds

	Level Of Priming Stimulus				
Change[a]	Level 7	Level 5	Level 3	New	P/FA
Random					
M	0.83	0.79	0.83	0.89	0.21
SD	0.00	0.12	0.00	0.09	0.28
2-Change					
M	0.82	0.80	0.83	0.86	0.12
SD	0.05	0.07	0.00	0.11	0.09
2-Change-Reverse					
M	0.82	0.83	0.78	0.90	0.12
SD	0.05	0.00	0.08	0.06	0.08
6-Change					
M	0.83	0.82	0.82	0.91	0.08
SD	0.00	0.04	0.05	0.06	0.05
Averaged Across Change Conditions					
M	0.83	0.81	0.82	0.89	0.14
SD	0.03	0.08	0.05	0.08	0.17

[a]Random (N = 20); 2-Change & 2-Change Reverse (N = 12); 6-Change (N = 20).

Table 26-b

Means and Standard Deviations for Proportion of Correct Response (P/Hits) as a Function of Stimulus Change and Level of Priming Stimulus and New, and Proportion of Incorrect Responses (P/False Alarms) on Picture Recognition Test. Age Group: 8-year-olds

	Level Of Priming Stimulus				
Change[a]	Level 7	Level 5	Level 3	New	P/FA
Random					
M	0.83	0.83	0.82	0.92	0.07
SD	0.00	0.00	0.04	0.03	0.02
2-Change					
M	0.83	0.83	0.83	0.92	0.07
SD	0.00	0.00	0.00	0.04	0.04
2-Change-Reverse					
M	0.83	0.83	0.82	0.93	0.08
SD	0.00	0.00	0.05	0.03	0.07
6-Change					
M	0.83	0.82	0.82	0.90	0.06
SD	0.04	0.04	0.00	0.05	0.02
Averaged Across Change Conditions					
M	0.83	0.83	0.83	0.92	0.07
SD	0.00	0.00	0.01	0.04	0.04

[a]N = 20 for each Change condition.

Age was reported above. There were no reliable main effects or interactions for 8-year-olds, while for the younger-aged children, only an interaction of Change by Level of Priming Stimulus was reliable, $F(6, 112) = 2.57$, $MSe = .003$, $p < .03$, $R^2 = .12$. above. Table 26-a gives the means for this interaction which, when probed by Neuman Keuls test, revealed only an idiosyncratic difference at Level 3 between the 2-change(R) condition and all other conditions, $Q_{crit} = .058$.

The 2 X 2 X 4 between groups analysis on probability of recognizing New pictures revealed only the Age effect noted above. Neither stimulus change or level of the priming stimulus differentially influenced ability to recognize previously seen pictures. Stimulus change was a factor, however, in the ability to recognize distracters.

The ability to distinguish between previously seen and never-seen pictures was assessed in the measure of probability of false alarms, that is p(FA). As noted above, older children were more accurate than younger children on this task. The 2 (Gender) X 4 (Change) between-groups design was submitted to ANOVA, at each level of Age, for probability of false alarms. Figure 12 gives the means for the interaction between Change and Gender which was, for 5-year-olds, $F(3, 56) = 3.31$, $MSe = .023$, $p < .03$, $R^2 = .15$, and for 8-year-olds $F(3, 72) = 2.72$, $p < .06$, $R^2 = .10$. Probes by Neuman Keuls test revealed that girls performed

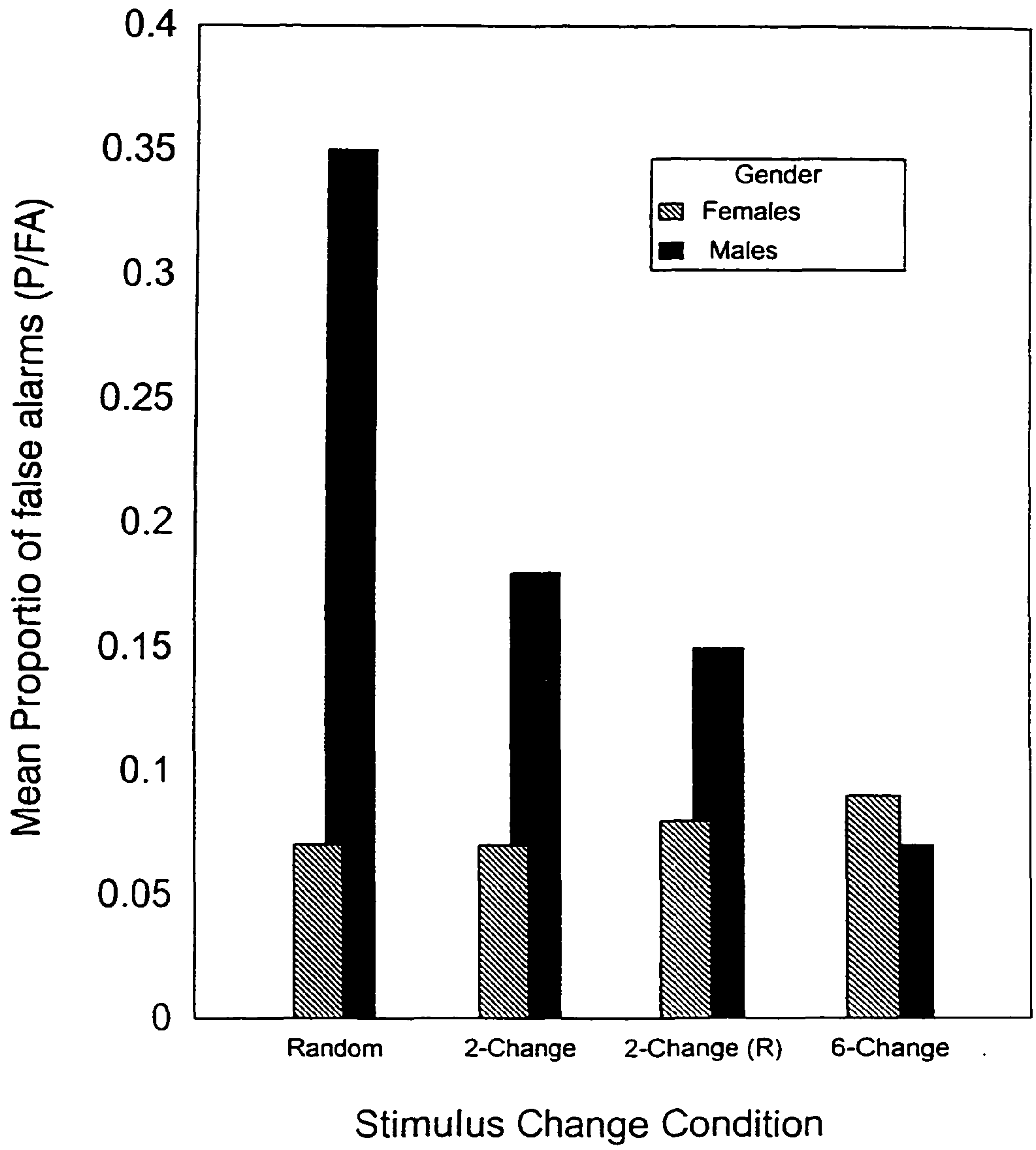

Figure 12. Proportion of false alarms (P/FA) for 5-year-olds on picture recognition test as a function of Gender.

similarly regardless of Change condition, whereas boys made more errors than girls in all change conditions except 6-change, $Q_{crit} = .21$, all $ps < .01$. Girls and boys in the 6-change condition had the lowest proportions of false alarms.

Picture recognition: Index of sensitivity (A"). Table 27 presents means and standard deviations for discrimination indices (A") at each level of the priming stimulus and for New. Age-related improvements were noted in children ability to discriminate between previously seen (either Old or New) and never-seen pictures. Eight-year-olds (M = 0.92, SD = .02) were more accurate than 5-year-olds (M = 0.87, SD = .17) in their ability to discriminate between twice-seen (Old) and never-seen pictures, $F(1, 128) = 7.00$, $MSe = .032$, $p < .01$, $R^2 = .05$. Similarly, 8-year-olds (M = 0.95, SD = .02) correctly discriminated between once-seen (New) and never-seen pictures better than 5-year-olds (M = 0.91, SD = .08), $F(1, 128) = 15.00$, $MSe = .003$, $p < .001$, $R^2 = .11$.

As above, a series of ANOVAS were applied to the mixed factorial design to explore for the influence of level of priming stimulus and stimulus change on indices of discrimination. No reliable effects or interactions were found for 8-year-olds, so only the outcomes for 5-year-olds are reported. The analysis of the 4 (Change) X 2 (Gender) X 3 (Level of Priming Stimulus) revealed only one reliable effect in the within-subjects portion, an interaction between Change and Level of the Priming Stimulus, $F(6, 112)$

Table 27-a

Means and Standard Deviations for Indices of Discrimination (A") as a Function of Stimulus Change and Level of Priming Stimulus and New on Picture Recognition Test.

Age Group: 5-year-olds

	Level Of Priming Stimulus			
Change[a]	Level 7	Level 5	Level 3	New
Random				
M	0.80	0.79	0.80	0.88
SD	0.29	0.28	0.29	0.14
2-Change				
M	0.89	0.89	0.90	0.91
SD	0.04	0.05	0.04	0.04
2-Change-Reverse				
M	0.90	0.90	0.88	0.92
SD	0.04	0.04	0.04	0.03
6-Change				
M	0.91	0.91	0.91	0.94
SD	0.02	0.03	0.04	0.04
Averaged Across Change Conditions				
M	0.87	0.87	0.87	0.91
SD	0.17	0.17	0.17	0.08

[a]Random (N = 20); 2-Change & 2-Change Reverse (N = 12); 6-Change (N = 20).

Table 27-b

Means and Standard Deviations for Indices of Discrimination (A") as a Function of Stimulus Change and Level of Priming Stimulus and New on Picture Recognition Test.

Age Group: 8-year-olds

	Level Of Priming Stimulus			
Change[a]	Level 7	Level 5	Level 3	New
Random				
M	0.92	0.92	0.92	0.95
SD	0.01	0.01	0.02	0.01
2-Change				
M	0.92	0.92	0.92	0.95
SD	0.02	0.02	0.02	0.01
2-Change-Reverse				
M	0.92	0.92	0.91	0.95
SD	0.03	0.03	0.03	0.02
6-Change				
M	0.92	0.92	0.92	0.94
SD	0.02	0.02	0.01	0.02
Averaged Across Change Conditions				
M	0.92	0.92	0.92	0.95
SD	0.02	0.02	0.02	0.02

[a]N = 20 for each Change condition.

= 2.35, *MSe* = .0001, *p* $< .05$, R^2 = .12. The means for this interaction are in Table 27-a. Probes by Neuman Keuls test found that, for 5-year-olds, each systematic change condition facilitated picture discrimination better than the random condition; in addition, the ability to discriminate between seen and never-seen pictures was optimum in the 6-change condition for the 5-year-olds, Q_{crit} = .015, *p* $< .05$. In contrast, no optimal level of priming stimulus emerged among any of the change conditions.

When responses were examined for discrimination between New and never-seen pictures, the only reliable finding for 5-year-olds was for Gender with girls (*M* = .93, *SD* = .04) more sensitive and less variable in their performance than boys (*M* = .89, *SD* = .11), $F(1, 56) = 4.09$, *MSe* = .006, *p* $<$ .05, R^2 = .07. In summary, on measures of sensitivity between seen and never-seen pictures, no influence of level of priming stimulus was noted for either age; stimulus change had no differential impact for 8-year-olds, but for the younger children, systematic conditions facilitated performance better than a random presentation of stimuli, with the 6-change condition being particularly effective for twice-seen pictures.

Picture recognition: Measures of response bias. Table 28 presents means and standard deviations for response bias indices (B''_D) at each level of the priming stimulus, and for New. In addition to an exploration of the optimal level

Table 28-a

Means and Standard Deviations for Indices of Response Bias (B''_D) as a Function of Stimulus Change and Level of Priming Stimulus and New on Picture Recognition Test.

Age Group: 5-year-olds

	Level Of Priming Stimulus			
Change[a]	Level 7	Level 5	Level 3	New
Random				
M	0.15	0.19	0.15	-0.10
SD	0.54	0.58	0.54	0.57
2-Change				
M	0.27	0.30	0.24	0.06
SD	0.35	0.34	0.34	0.51
2-Change-Reverse				
M	0.29	0.27	0.38	-0.03
SD	0.34	0.31	0.38	0.41
6-Change				
M	0.41	0.43	0.44	0.04
SD	0.24	0.24	0.21	0.29
	Averaged Across Change Conditions			
M	0.28	0.30	0.30	-0.01
SD	0.40	0.41	0.40	0.45

[a]Random (N = 20); 2-Change & 2-Change Reverse (N = 12); 6-Change (N = 20).

Table 28-b

Means and Standard Deviations for Indices of Response Bias (B''_D) as a Function of Stimulus Change and Level of Priming Stimulus and New on Picture Recognition Test.

Age Group: 8-year-olds

	Level Of Priming Stimulus			
Change[a]	Level 7	Level 5	Level 3	New
Random				
M	0.48	0.48	0.49	0.05
SD	0.13	0.13	0.15	0.27
2-Change				
M	0.49	0.49	0.49	0.05
SD	0.17	0.17	0.17	0.28
2-Change-Reverse				
M	0.44	0.44	0.47	0.02
SD	0.27	0.27	0.29	0.32
6-Change				
M	0.52	0.52	0.50	0.16
SD	0.10	0.10	0.12	0.24
Averaged Across Change Conditions				
M	0.48	0.48	0.49	0.07
SD	0.18	0.18	0.19	0.28

[a]N = 20 for each Change condition.

hypothesis and stimulus change, the effect of prior exposure on response bias was examined. The developmental association for response bias with age was mixed on this measure. An age-associated difference was found for response bias to Old pictures but not for New pictures. Eight-year-olds (*M* = 0.49, *SD* = 0.18) were more conservative in their responses than 5-year-olds (*M* = 0.49, *SD* = 0.18), $F(1, 128) = 8.12$, *MSe* = 0.155, $p < .01$, $R^2 = .06$. In addition, there was a reliable difference on performance between Gender, with girls (*M* = 0.46, *SD* = 0.20) being more conservative and less variable in their responses than boys (*M* = 0.33, *SD* = 0.38), $F(1, 128) = 5.48$, $p < .05$, $R^2 = .04$.

The series of analyses (n = 4) at each level of Age on the 4 (Change) X 2 (Gender) design, first on the within factor of Level of Priming Stimulus and then on the measure for New produced, with two exceptions, no statistically significant main effects or interactions. In the between-groups portion of the analysis, the Change by Gender interaction was reliable in all for analyses. As well, there was a within-subjects interaction for 5-year-olds between Change and Level of the Priming Stimulus. This latter analysis is addressed first.

Table 28-a provides the means for the Change by Level of Priming Stimulus interaction for values of response bias to twice-seen pictures, $F(6, 112) = 2.61$, *MSe* = .007, $p < .03$, $R^2 = .12$. Probes by Neuman Keuls test revealed that

all three systematic change conditions were associated with more conservative responses for identifying twice seen pictures, whereas children in the Random condition moved toward anon-biased response, $Q_{crit} = .08$, $p < .05$. In addition, the 6-change condition resulted in the most conservative response bias relative to all other conditions. No differential responses occurred with New items for either the 5-year-olds or the 8-year-olds.

Figure 13 presents the mean values for response bias (B''_D) for 5-year-olds on Old and New pictures as a function of Age and Gender. The means for these same factors are presented in Figure 14 for 8-year-olds. Examining responses for 5-year-olds on Old [$F(3, 56) = 3.24$, $MSe = .340$, $p < .05$, $R^2 = .15$], probes by Neuman Keuls revealed that females were more conservative in their responses than males, and did not differ across Change, all ps > .05. Boys were more variable; they tended to not display a response bias in any condition except for the 6-change condition where their performance matched that of girls.

On bias measures for New items, 5-year-olds tended to respond in a neutral manner, except for the boys in the Random condition who were more likely to circle pictures regardless of whether they had seen them, $F(3, 56) = 3.93$, $MSe = .175$, $p < .02$, $R^2 = .17$. This outcome probably reflects, in part, the indiscriminate marking done by the two boys mentioned earlier. Probes by Neuman Keuls (Q_{crit} =

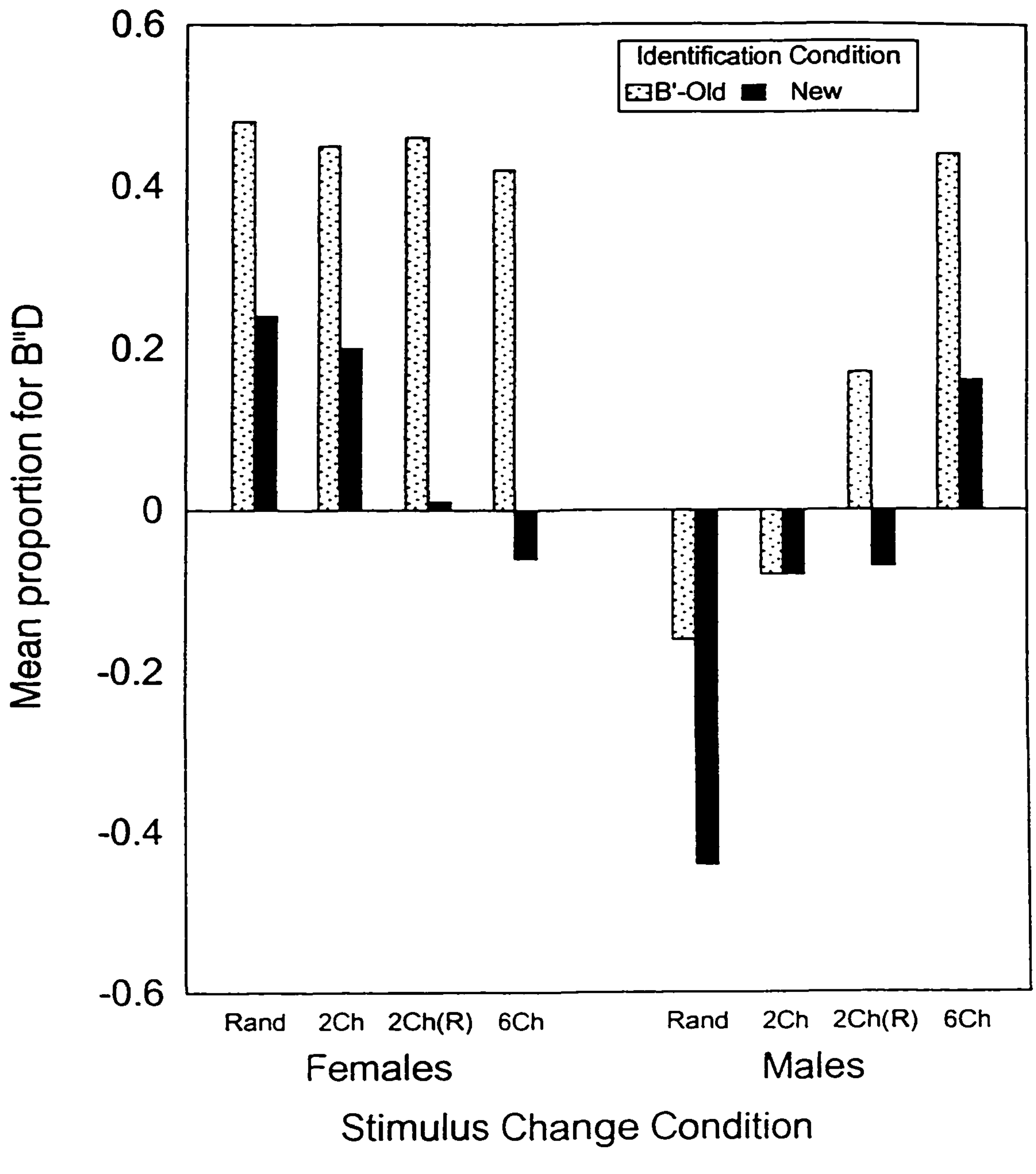

Figure 13. 5-year-olds: Mean proportionate values for response bias index (B'D) for Old and New items as a function of Change and Gender.

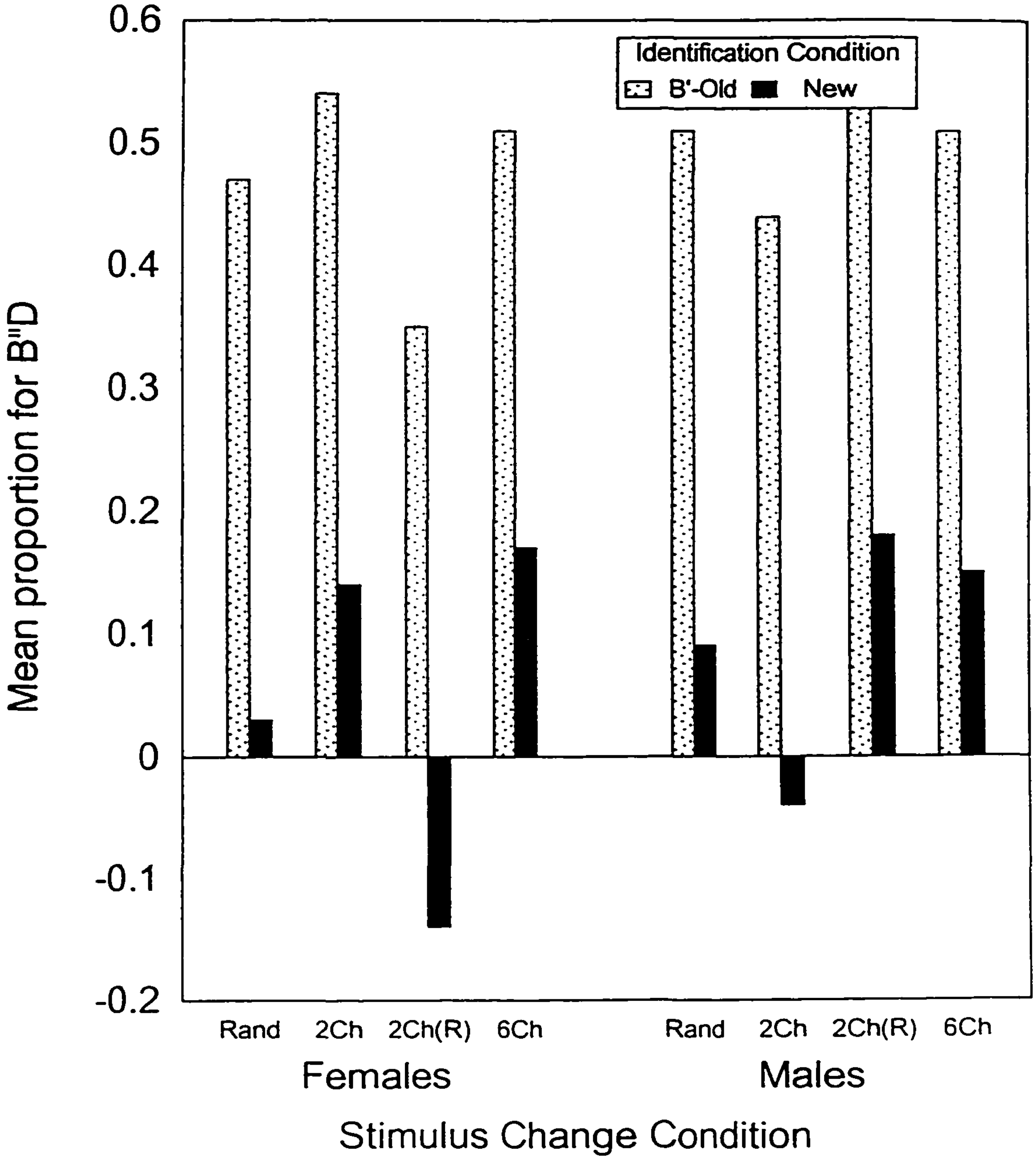

Figure 14. 8-year-olds: Mean proportionate values for response bias index (B'D) for Old and New items as a function of Change and Gender.

.50) revealed that boys in the Random condition differed most markedly from the girls in the same condition, $p < .05$.

Figure 14 presents the means for the same analysis carried out with 8-year-olds on Old [$F(3, 72) = 2.61$, MSe = .093, $p < .06$, $R^2 = .10$] and New [$F(3, 72) = 3.11$, MSe =.072, $p < .05$, $R^2 = .12$]. In general, 8-year-olds of both genders had similar levels of response bias as 5-year-old girls for both Old and New items. Differential performance for the older group occurred in the 2-change(R) condition with both Old and New pictures. For the twice-seen pictures, boys were more conservative than girls, although none of the differences were statistically significant, $Q_{crit} = .28$, Neuman Keuls, all ps > .05. For New pictures, both males and females in the 2-change(R) exhibited a greater tendency to say yes than children in any other condition; this difference was statistically reliable in comparison to the 6-change condition, $Q_{crit} = .30$, $p < .05$.

Picture recognition: Priming. The near-ceiling performance on the picture recognition task made it difficult to examine the effect of prior exposure on measures of correct response such as probability of hits or discrimination. It was possible to examine the influence of priming on response bias by applying an ANOVA to the 2 (Age) X 2 (Gender) X 4 (Change) mixed factorial on the repeated measures factor of Priming (Old: the averaged responses across the three priming levels, and New). The within-subjects portion of the analysis revealed a main effect of priming which was qualified by an interaction between Age and Priming, $F(1, 128) = 7.75$, $MSe = .029$, $p < .01$, $R^2 = .06$. Figure 15 illustrates the means for this analysis which reflect the fact that for New pictures, both age groups responded at a near-neutral level while for Old pictures, both ages tended to be conservative when circling the pictures. When probed with Tukey's test, 8-year-olds were found to be more conservative than 5-year-olds on their response to Old pictures, $HSD = .164$, $p < .01$, while they did not differ in their bias response to New items.

Summary: Direct tests of Memory. The primary findings for the retention tests were attenuated to some degree by three factors: first, cued recall provided a crude and unreliable measure of memory; second, the picture recognition test resulted in ceiling effects, although conversion to indices of sensitivity and response bias significantly reduced this disadvantage; and, third, the within-cell variability, particularly among 5-year-old boys, resulted in some possibly spurious interactions involving Gender. Some of the more salient findings, particularly the main effect for Age on nearly all measures of free recall and picture recognition were predictable and replicated previous research. For these two measures of direct memory, older children provided more correct responses than the younger children on twice-seen, new, and distracter items.

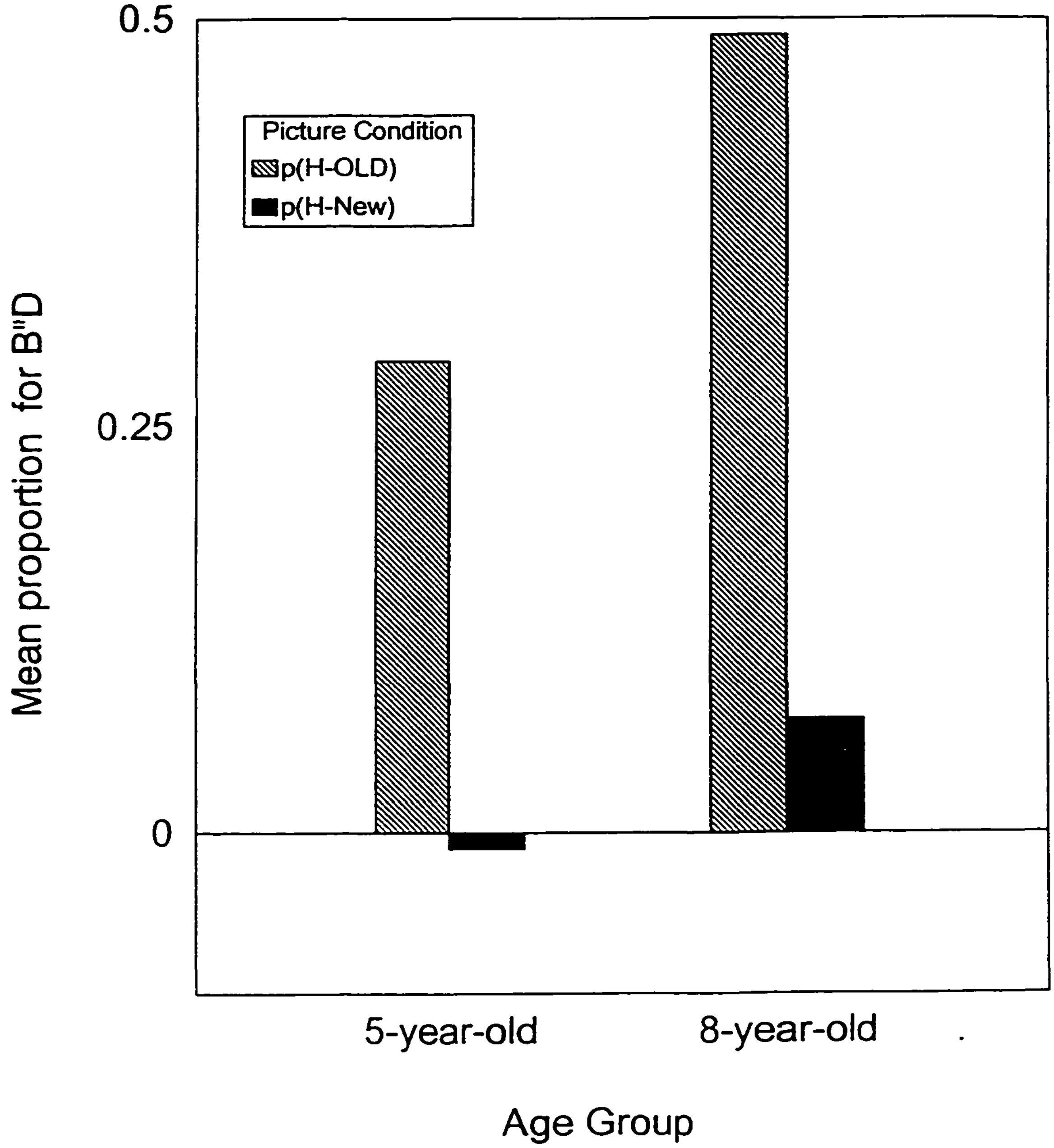

Figure 15. Mean proportion for Age X Priming interaction on response bias (B"D) index.

Stimulus change did not emerge as a consistent influence on memorial performance the way it did in fragpix identification. Similar to the findings on the fragpix identification task, 8-year-olds rarely demonstrated a differential impact of order of presentation or number of changes of the priming stimulus. In contrast, consistent effects of stimulus change were revealed among the 5-year-olds. As with fragpix identification, the 6-change condition was optimally facilitative in terms of discrimination among twice-seen (Old) and never-seen pictures and was associated with the lowest level of false alarms. In addition, whereas 5-year-old boys in the other change conditions tended to less well than same-aged girls, boys in the 6-change condition performed in a similar manner as their female peers, and sometimes, as well as the 8-year-olds.

Priming had a robust effect, at each level of the priming stimulus on tests of free recall, accounting for a large proportion of the variability (R^2s ranged from .26 to .44). Its influence was less apparent for picture recognition task, although it did influence children to be more conservative in their responses to the task. There was no meaningful association between age and an optimal level of priming. No specific level of the priming stimulus was uniquely facilitative for later performance on the retention tests.

Discussion

In Experiment 4, the priming stimulus was manipulated to examine its influence on children's ability to identify fragmented pictures and on memorial responses for free recall and picture recognition of Old and New fragpix viewed at test. Manipulations of the prime included presenting nine fragpix during the exposure phase in either a very fragmented, moderately fragmented, or nearly complete state, and varying the temporal sequence in which the three fixed levels of fragmentation were experienced by the child. The association of two trait variables, age and gender, with performance was also explored. Finally, the effect of these manipulations on priming and on the size of the priming effect was evaluated.

Age, Gender, and Priming

Eight-year-olds outperformed 5-year-olds on measures of fragpix identification, free recall, and picture recognition. Only the mean number of fragpix correctly named during exposure revealed no age differences. Not only did 5- and 8-year-olds perform similarly when initially naming fragpix at each of the three levels of difficulty, but their percent-correct responses were similar to the values reported for adults. This similarity reinforced the developmentally associated selection for levels of fragmentation, as detailed earlier in the chapter, which were designed to be perceived psychologically as easy, medium, and hard-to-identify.

Responses to the implicit and explicit tests in Experiment 4 displayed some dissociation, but not in the manner typically reported in the literature. On direct measures of memory, for example, mean threshold of identification or mean number correct in recall, and as commonly reported for other studies, 8-year-olds did better than 5-year-olds. For Experiment 4, the strength of the association between age and test was substantially greater for fragpix identification ($\underline{R}^2$ = .36) than for the mean number correct on retention tests. The $\underline{R}^2$ values for free recall of Old and New fragpix were .20 and .10, respectively, and for indices of discrimination and response bias on picture recognition they ranged from .05 to .10 for Old pictures, .10 for New pictures, and for correct rejection of never-seen pictures, $\underline{R}^2$ =.15. Of interest here is the dissociation in effect size between picture recognition and fragpix identification, although ceiling effects on the recognition task might have masked some of the strength of its association with age.

Also comparable with published results was the robust finding for priming when responses to old items represented the averaged thresholds across levels of fragmentation. Conversion of scores to magnitude of priming, however, typically reveals developmental stability for the effect of priming. In the current study, when the effect of prior exposure was examined as a function of age, the effect of priming was found to be larger for 8-year-olds than 5-year-olds. It was therefore not unexpected that the magnitude of priming demonstrated developmental differences on picture identification. In contrast, on the free recall, measures of priming and the magnitude of priming were developmentally stable. Although older children recalled more items than younger children, the degree of influence enacted by prior exposure to the stimulus was equally beneficial for both ages. When the relationship between age and priming was examined as a function of each level of the priming stimulus, the results were more variable and are discussed under the subheading of optimal levels for priming.

In Experiment 4, as in Experiment 3, Gender had little substantive influence on outcome, except for picture recognition on measures of discrimination and response bias. Although the large within-cell variability contributed by 5-year-old boys on some tasks likely resulted in some spurious interactions, on other measures, especially response bias, it appeared to be differentially associated with Change. For example, the finding that little boys made more errors than little girls when identifying picture distracters is likely indicative of the greater variability in their developmental maturity as expressed through attention to task. It is notable that gender differences did not meaningfully impact on the picture identification task.

The persistence of developmental differences on what is widely accepted to be a data-driven task suggests that the identification of fragmented pictures is facilitated by conceptually driven processes to a much greater degree than has been appreciated to date. Examining the findings for each manipulation of the priming stimulus might clarify this dilemma.

Stimulus Complexity

The manipulation of attributes of the priming stimulus resulted in both age-associated and age-invariant influences on fragpix identification and, for 5-year-olds, on picture recognition, but had little definitive impact on free recall. Three types of manipulations were carried out, one varying the number of changes among levels of fragmentation, a second varying order of difficulty, and, a third, varying the nature of stimulus complexity (random or systematic). The number of changes had a significant effect for 5-year-olds, and order of difficulty had an effect for 8-year-olds. Only the manipulation of systematic versus random orders of presentation enhanced performance for both age groups.

Stimuli presented in a systematic order were more facilitative than a random order of presentation for naming fragpix at exposure, on level of fragpix identification, on the effect of priming, and on the magnitude of this effect. Both ages benefitted from systematic, temporal changes in the presentation of the stimuli. For 5-year-olds the variability accounted for by stimulus change, on each related measure, was nearly twice that of 8-year-olds; $\underline{R}^2$s ranged from .11 to .21 for 5-year-olds, and, from .06 to .12 for 8-year-olds. Order of presentation had no carry-over effect for either age group in terms of identification of novel fragpix. Similar findings for 5-year-olds on the picture recognition tasks further reinforces the conclusion that improvement in performance was not a spurious finding; rather, it reflected the impact of stimulus presentation.

A comparison between random and systematic orders of presentation was not explicitly tested by May and his associates. In their studies, all learning conditions were manipulations of various systematic orders of task difficulty for training sequences, for example, E-M-E-M-H-H or EE-MM-HH. Only the May and Norton study (Experiment 1, 1980), without intending to do so, included a condition that might be considered somewhat analogous to a random presentation. The loop sequence, which involved nine changes over 12 presentations (H-M-EE-M-H-E-M-E-M-HH), might have had a comparable impact on children to that of the random sequence generated by the computer for the current experiment. In May and Norton, as with the current study, these conditions were associated with the poorest performance.

In the current study, even among the three systematic conditions, age-specific differences emerged for the change condition most facilitative for children on measures of fragpix identification. Five-year-olds were most sensitive to the number of stimulus changes across the order of presentation. They performed best in the 6-change condition in which the levels of fragmentation were presented in the following sequence, Levels 7-5-7-5-7-5-333, or E-M-E-M-E-M-HHH. On each measure of picture identification and recognition, the means for the 6-change condition were either reliably different from those in the other systematic conditions or they approached conventional statistical significance. A similar finding was reported by May and Tisshaw (1977) for 5-year-olds, using a systematic temporal sequence of 7-changes across presentations of the stimulus. In addition, an impact of stimulus change for 5-year-olds in the 6-change condition was evident on the free recall test ($p = .06$, $R^2 = .06$). Although the effect of this change condition was sometimes small, values for R^2 ranged from .04 to .11, relative to the overall effect of systematic temporal change, it still emerged repeatedly as the most facilitative change condition for 5-year-olds. In contrast, for 8-year-olds, however, no change condition was differentially relevant to performance on tests of explicit memory.

It is proposed that several aspects of the 6-change condition in the current study contributed to its optimum effect. Mendel (1965) demonstrated the importance of novelty in prompting the spontaneous engagement of young children in tasks. Given the enthusiastic response observed by this researcher with participants who ranged from very young children to somewhat elderly professors, it was concluded, with confidence, that the task itself is engaging. When a positive affect is heightened by high levels of temporal contrast, as occurred for this particular change condition, the combination was likely highly effective in capturing and sustaining the young child's attention. Further, as suggested by White (1959) and in contrast to Pascual-Leone (1976) the systematic ordering of stimuli from easy-to-medium difficulty likely facilitated feelings of competence in young children, motivating them to continue even when the task became more challenging. Thus, for this age-group, the multi-change condition was most effective in promoting the explicit and implicit learning behaviours needed to identify each fragpic, and for retaining it in memory for easier retrieval during free recall.

The pattern of means for 8-year-olds indicated that the 2-change(R) condition was differentially facilitative for them, although on some measures (priming and magnitude of priming) the effect of change did not quite achieve statistical significance (ps ranged between .07 and .09, R^2s $< .05$). In the 2-change(R) condition, it was not the number of temporal changes that was instructive, but rather the order in which levels of fragmentation were experienced. The 2-change(R) condition presented levels of fragmentation in a systematic reversed order of difficulty: Levels 444-777-222 or MMM-EEE-HHH. That 8-year-olds tended to perform better in this condition relative to all the other conditions provides support for Pascual-Leone's (1976) assertion that a difficult to easy to difficult sequence is more sometimes more suitable for a Piagetian explanation for spontaneous problem-solving.

Perhaps 8-year-olds were differentially responsive to this ordering because the initial challenge of the most difficult items engaged their attention, while the easier-to-identify items that followed allowed them to complete the task successfully, enhancing feelings of competence. Only one study on stimulus change by May and his associates (May & MacPherson, 1971) included 8-year-olds. All tests of temporal contrast in their study included easy-medium-hard sequences which varied only in the number of changes experienced across the presentation sequence. In both experiments, more changes (four or eight) were better than fewer changes (two or none) in promoting accuracy on a stimulus discrimination task. This suggests that, for optimal performance with older children, a task should be sufficiently challenging to engage their attention while employing meaningful change sufficient to sustain attention.

In summary, systematic orders of temporal contrast facilitated performance for both age groups. Optimum sequences of stimulus change were age-specific, with the effect more apparent on picture identification than the retention tests. The differential effect of a specific change condition was larger for 5-year-olds than for 8-year-olds on measures of fragpix identification and picture recognition, while the beneficial effect of stimulus change on retention tests for 8-year-olds appeared to be minimal or absent. Thus it was not solely prior experience that facilitated performance, but also the temporal shift from one level of fragmentation to another that enhanced their ability to identify the fragmented pictures.

An Optimal Level of Fragmentation for the Priming Stimulus

In the current study, the optimal level hypothesis examined whether priming with a nearly complete, moderately complete, or a nearly unidentifiable fragmented stimulus had differential influences on fragpic identification and retention tests. In general, age-specific findings were observed: The quadratic function evident for 8-year-olds did not consistently emerge with younger children.

The data suggested that, for 8-year-olds, a moderate level of fragmentation (Level 4) facilitated the level at which those same fragpix were identified at test. Fragpix presented at Level 4 during exposure were identified at a lower level of fragmentation at test than fragpix presented at Levels 7 or 2. This finding was replicated for the magnitude of priming as well. Although the pattern of means corresponded with Level 4 being optimal for each change condition, the effect was particularly impressive for the 2-change(R) condition. For 8-year-olds, priming with a moderate level of fragmentation was especially facilitative for fragpix identification in the stimulus change condition that also produced optimum performance.

The results for the retention tests were less definitive in terms of identification of an optimal level of priming. Although the pattern of means across priming levels for free recall suggested that Level 4 prompted better recall of Old fragpix, the quadratic function was not statistically reliable. Ceiling effects on the picture recognition test suggested that all priming levels were equally facilitative for recognition of Old pictures, and even the conversion of scores to indices of sensitivity and response bias, which attenuated ceiling effects, did not result in the emergence of an optimal level for the priming stimulus.

No reliable function was observed for 5-year-olds, as a group, on either the fragpix identification task or the retention tests. Performance for this age was typically revealed to be an inverse monotonic relationship between level of fragmentation of the priming stimulus and the mean threshold at test. The more pictorial information available for 5-year-olds during exposure, the more likely they were to identify the picture at a lower level of fragmentation. A similar, but understandably reversed, pattern was revealed through the monotonic relationship between level of priming stimulus and both (a) the magnitude of priming and (b) memory for Old items on the free recall test. The more complete the picture was during exposure, the larger the value was for magnitude of priming and the more items were remembered during free recall. For picture recognition, being exposed to the nearly complete picture at study increased the likelihood that these pictures were recognized at test, while the moderately fragmented and very fragmented stimulus were about equally effective in promoting recognition.

The optimum stimulus change condition for 5-year-olds, the 6-change condition, proved to be an exception to the findings just reported. In the 6-change condition, a priming stimulus presented at a moderate level of fragmentation (Level 5) consistently facilitated optimum performance on measures of (a) threshold of fragpix identification, (b) magnitude of priming, and, (c) free recall. Level 5 was not only optimally facilitative within this change group on these measures, but it also represented optimum performance for 5-year-olds across all change groups.

The phenomenon of perceptual closure is evident when a moderately fragmented stimulus successfully promotes optimum performance for the identification of fragmented pictures. Just enough information has been presented to promote closure, that is, the person mentally completes the previously unrecognized picture. Priming with a partially fragmented stimulus promoted closure at a lower level of fragmentation during test in a way that an almost complete picture (level 7) or never identified picture (Level 3/2) could not. It is of interest that this perceptually based phenomenon appeared to have such age-specific findings.

A moderate level of fragmentation was generally optimal on implicit tests for adults (Snodgrass & Feenan, 1990; Snodgrass & Hirshman, 1994) and for 8-year-olds but not for most 5-year-olds. This developmental difference suggests that some conceptually based process is associated with performance. For the children in the current study, differential performance on the free recall test provides further support for this possibility. Overall, 5-year-olds expressed a monotonic relationship between level of priming stimulus and number of items recalled, while 8-year-olds tended toward a quadratic function.

Manipulations of the Priming Stimulus: A Summary

Experiment 4 manipulated several perceptual attributes of the priming stimulus with the intent of identifying factors that would enhance the experience of prior exposure on performance. The deliberate selection of perceptually focused changes was an attempt to minimize the confounds of conceptual influences. That is, the child should not be explicitly aware that the variations experienced across presentations of the stimuli differentially impacted on test performance. In terms of a conscious level of awareness, this appeared to be successful, in that none of the 144 participants commented on any aspects of the order of stimulus presentation or the varied levels of fragmentation of the priming stimulus as being especially facilitative, or detrimental, to them.

Regardless, these perceptual manipulations produced both age-invariant and age-specific findings. Both ages, and particularly the younger group, performed better when stimuli were presented in some systematic fashion. However, the optimal order of stimulus presentation was unique for each age group. Younger children preferred many changes and older children thrived when they were challenged at the beginning of the task. Manipulating the level of fragmentation of the priming stimulus was clearly more advantageous for older children. A similar impact was only selectively evident for 5-year-olds, and that occurred in the change condition that optimized their performance.

The frank dissociation between performance on implicit and explicit tests typically reported in the literature was not apparent in the current study. Further, when there was dissociation among the tests, it was in the direction opposite of what has been reported. The magnitude of priming was not stable for fragpix identification, but was for free recall. It appeared that both perceptual and cognitive components contributed to performance across the tests, and that none of the tests were process-pure. The final discussion of this dissertation examines this thesis further within the context of the four experiments in this study.

General Discussion and Recommendations

In this dissertation, five perceptual attributes of the priming stimulus were manipulated to explore the effect of prior exposure on indirect and direct measures of memory. Two trait variables, Age and Gender, were also included to examine the association of these factors with performance. Similar to findings from studies of adults (Salthouse & Prill, 1988; Whitfield & Elias, 1992). Except for measures of response bias in Experiment 4, Gender had little substantive association with performance and thus is not addressed further in this discussion. After modifying two sets of fragmented pictures for use with very young children (Experiments 1 and 2), two experiments were carried out (Experiments 3 and 4). Response to tests of fragpix identification, free recall, cued recall, and picture recognition were recorded. Data from cued recall were of limited value and are not reviewed further. The discussion begins with a brief review of the findings.

Experiment 3 included children aged 3, 4, 5, and 8 years old and examined the effect of perceptual closure. Following correct identification of the fragmented picture, half of the children were shown the completed picture. This manipulation of the priming stimulus had no influence on overall performance, other than to act unexpectedly as a form of repetition priming for 3-year-olds, facilitating their ability to distinguish between seen and never-seen pictures (the distracter pictures) on the picture recognition test.

Experiment 4 involved 5- and 8-year-old children and manipulated four attributes of the prime: level of fragmentation (testing for an optimal level of fragmentation for the priming stimulus), and three variations of how stimuli were presented at study (order of difficulty, number of changes between levels of fragmentation, and a systematic versus random order of presentation). Each manipulations had a greater impact on fragpix identification than on responses on direct tests of memory. Among the direct tests, the most definitive effect was on picture recognition for 5-year-olds.

Exposure to the stimuli in a systematic manner enhanced performance on picture identification for both age groups, although the effect of this manipulation was smaller for 8-year-olds. In addition, each age group responded preferentially to a particular manipulation of the stimulus. The younger group was most responsive to the multi-change or 6-change condition, while the older group performed best when initially challenged by the most difficult to identify fragmented pictures, that is, the 2-change(R) condition. For the older children, similar to the findings for adults reported by Snodgrass and Feenan (1990), Snodgrass and Hirshman (1994), Snodgrass, Hirshman, and Fan (1996), a moderately fragmented stimulus facilitated performance for picture identification.

In support of what is typically reported in the literature, both experiments found that prior exposure to the fragmented picture facilitated later performance on picture identification and on recognition memory for Old and New pictures. In addition, both studies demonstrated the expected age differences on raw score values for mean threshold of fragpix identification and for mean number of pictures recalled or recognized. When examining the effect of prior exposure across age, however, dissimilarities were revealed between the current study and other studies.

The magnitude of priming in data-driven tasks, such as identification of fragmented pictures, is typically reported to be developmentally stable, while age-related differences are demonstrated on direct memory tests. In this study, few dissociation among tests occurred, and even these were in the opposite direction from what is typically reported (Mitchell, 1993). In Experiment 3, and as reported by Parkin (1993), the effect of prior exposure on picture identification increased in a monotonic function with age; in addition, age-associated improvement was found in Experiment 4. In contrast, developmental differences were less evident on the picture recognition task, accounting for a smaller proportion of variability, although it is probable ceiling effects obscured age differences on this task. A major contribution to the presence of ceiling effects in this recognition task may have been its temporal sequence in the testing procedure.

Presentation of the template for picture recognition provided the child with a third visual exposure to Old pictures and a second visual exposure to New pictures. In addition, the free and cued recall tasks preceded the recognition test, and it is possible they facilitated explicit memory for at least some of the pictures. This timing differs markedly from tasks, such as the one used in Parkin and Streete (1988) in which the child judges a picture as Old or New at the same time each picture is named in the identification test. Repeated exposure to stimuli in the current experiments most certainly attenuated findings for age differences on this task.

The magnitude of priming for free recall revealed age differences for Experiment 3, but not Experiment 4, although the discrepant finding in the latter experiment might be a Type II error. The value for the magnitude of priming in Experiment 4 was larger for 8-year-olds than for 5-year-olds, and the observed probability value for the Age main effect, $p = .071$, was marginally beyond accepted statistical convention. The pattern of means from both experiments favours an interpretation of developmental differences in the size of the priming effect for free recall as well as for picture identification and recognition.

Sequential versus Fixed Exposure to Fragpix

Of interest to this experimenter was whether the difference in exposure conditions between Experiments 3 and 4 differentially influenced performance for same-aged children. That is, was exposure to fragpix in descending degrees of fragmentation more facilitative for priming than presentation of fragpix at a fixed level of fragmentation? To explore this possibility, the scores from 5- and 8-year-olds from Experiment 3 were compared to those age-specific change conditions that represented the optimum performance conditions for children in Experiment 4, 5-year-olds from the 6-change condition and 8-year-olds from the 2-change(R). Table 29 presents the means and standard deviations for the dependent measure of magnitude of priming on fragpix identification and free recall, and the probability values for hits for twice-seen (P/H-Old), once-seen (P/H-New) and false alarms (never-seen) pictures on the recognition test. Each dependent measure was submitted to a 2 (Age) X 2 (Experiment) between-groups ANOVA.

The superior performance by 8-year-olds compared to 5-year-olds persisted across experiments on the magnitude of priming for fragpix identification and free recall. Analyses on each measure revealed that only the Age main effects were reliable. For the magnitude of priming on fragpix identification, based on Snodgrass' transformation, the main effect for Age was $F(1, 84) = 11.64$, $MSe = 0.02$,

Table 29

Means and Standard Deviations for Magnitude of Priming on Fragpix Identification and Free Recall. Values for Hits and False Alarms on Picture Recognition Task for 5- and 8-year-olds: Experiments 3 and 4

	Test Measure				
	Fragpix	Free	Picture Recognition		
Age	Identification[a]	Recall	P/H-Old	P/H-New	P/FA
			Experiment 3		
5-years					
M	0.27	1.19	0.94	0.88	0.18
SD	0.15	2.06	0.02	0.12	0.18
8-years					
M	0.38	2.92	0.94	0.92	0.07
SD	0.19	2.16	0.02	0.03	0.03
			Experiment 4[b]		
5-years					
M	0.26	1.70	0.82	0.91	0.08
SD	0.12	2.16	0.02	0.06	0.05
8-years					
M	0.37	2.55	0.83	0.93	0.08
SD	0.12	1.93	0.02	0.03	0.07

[a]Means based on the Snodgrass transformation: (New - Old) ÷ (New - 1) [b]5-yrs (6-change condition); 8-yrs (2-change-R).

$p < .001$, $R^2 = .12$, and, for free recall, $F(1, 81) = 8.60$, $MSe = 4.08$, $p < .01$, $R^2 = .11$.

On correct responses to once-seen items on picture recognition, no effects were statistically significant; both age groups performed similarly regardless of Experimental condition, all $ps > .05$. This outcome serves as an effective control group for the differences in performance found between experiments on measures proportion of hits for exposure items and for false alarms. The probability of correctly circling twice-seen items was higher for children exposed to fragpix using the ascending method of limits (Experiment 3: $M = 0.94$, $SD = 0.01$) than for those who saw the fragpix at a single level of fragmentation (Experiment 4: $M = 0.83$, $SD = 0.02$), $F(1, 81) = 1054.19$ (yep, that's right!), $MSe = .0003$, $p < .001$, $R^2 = .93$. Perhaps, at some cognitive level of processing, the repeated presentations of fragmented images serves as a repetition priming for memory of the final image.

When performance on correct rejection of distracter pictures (p/false alarms) was examined as a function of Age and Experiment, both main effects were reliable and the two factors interacted, although all three effects accounted for only a small proportion of variability ($Rs^2 < .08$). Figure 16 presents the interaction which illustrates that all ages responded in a similar manner except for 5-year-olds in Experiment 3, who had a reliably higher number of incorrect

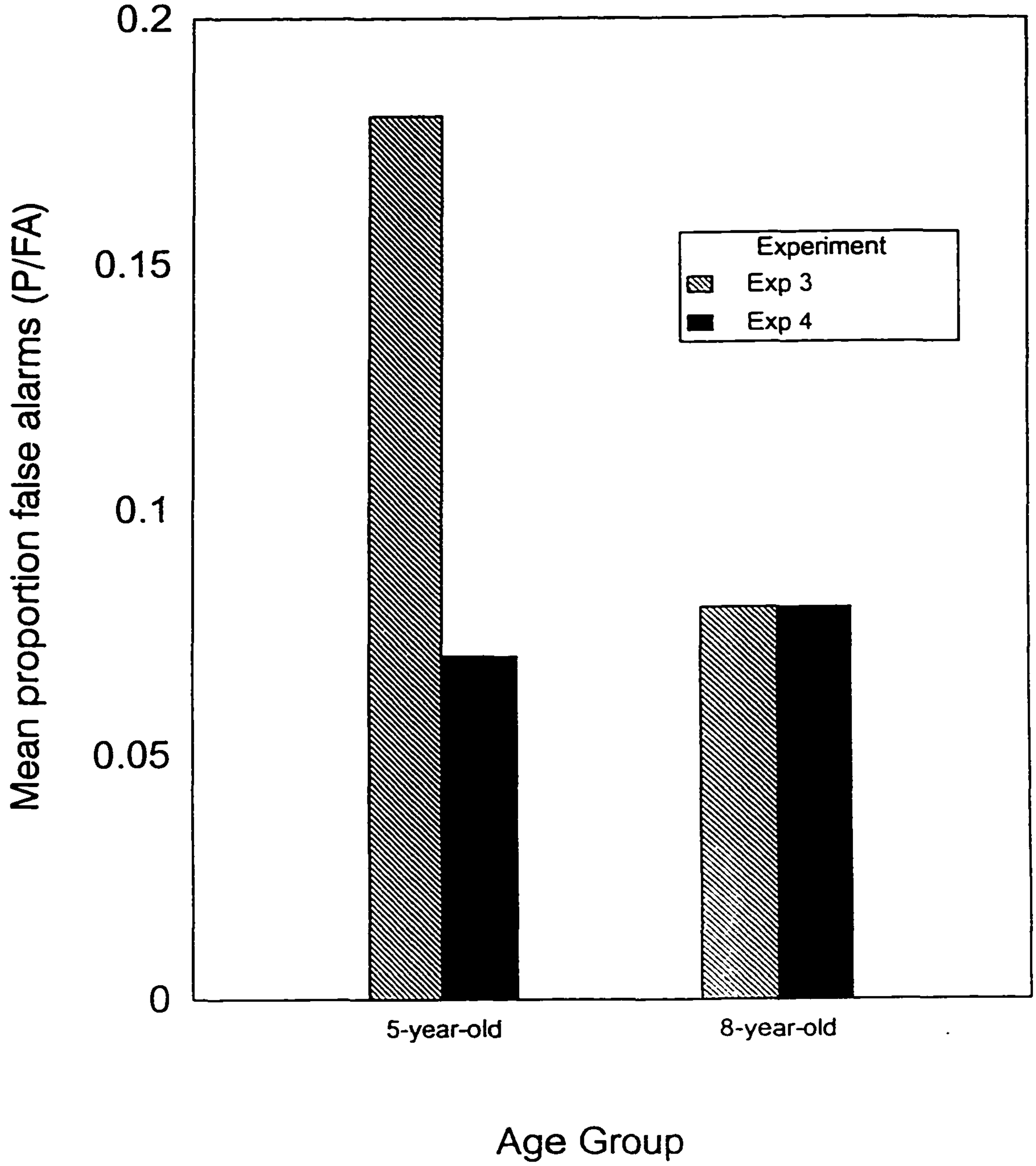

Figure 16. Mean proportion of false alarms (P/FA) on picture recognition for 5-year-olds and 8-year-olds in Experiments 3 and 4.

responses than any other children, $F(1, 81) = 5.68$, $MSe = .010$, $p < .02$, $R^2 = .06$. This outcome suggests a differential effect of exposure condition. Distinguishing pictures that had never been seen, which, nevertheless, bore either perceptual (belt/watchband) or categorical (lion/tiger) resemblances to pictures that had been seen, was a more conceptually based task than recognition of previously seen pictures. This task produced age differences independently in Experiments 3 and 4, where children were more likely to make errors on perceptually similar pictures than on categorically similar ones.

In summary, age differences for the magnitude of priming were found on picture identification, considered primarily a data-driven task, and on free recall, a conceptually driven task, and on some measures of picture recognition which is considered to rely on both data-driven and conceptually driven processes. Two implications of these findings warrant additional consideration. First, these findings suggest that the tasks themselves are not process-pure. It is not untenable, for example, to consider that a perceptually based task could activate both data-driven and conceptually driven processes during encoding. Second, because a frank dissociation in performance was not evident among memorial tasks from opposing ends of the processing continuum, transfer appropriate processing might be a reasonable theoretical explanation for what is happening in the data. The cognitive processes recruited during encoding are discussed first.

Perceptual and Conceptual Contributions to Encoding

Biederman and Cooper (1991) examined responses to incomplete pictures similar to the fragpix used in the current studies, and proposed that two steps were involved in the cognitive processing of these pictures. The first step involves the data-driven task of perceptual closure, which allows the person to mentally complete the image. Experiment 3 of the current study revealed support for this phenomenon based on the lack of any advantage on direct or indirect measures of memory from seeing the completed picture following its identification in a fragmented state.

Step two, a conceptually based process, follows the process of closure. The person matches the completed picture with stored mental representations of related images to select the label needed to name the picture. If both of these processes are activated with adults, as Biederman and Cooper suggest, then finding developmental differences among younger-aged children on a similar task is not only feasible but should be anticipated. In Experiments 3 and 4, age differences were evident on tests of picture identification, free recall, and identification of distracter pictures. This suggests that both data-driven and conceptually driven influences on cognitive processing may have been recruited for each task, rather than the task being process-specific.

The identification of fragmented pictures is primarily a perceptual task, in that the surface properties of the stimulus facilitate data-driven processes for encoding. This was supported in Experiment 4 when manipulations of perceptual attributes of the stimulus facilitated performance for picture identification while having minimal influence on retention tests. A notable exception to this dissociation was the finding that the optimum condition for 5-year-olds (a systematic, multi-change condition) reduced age differences for performance on tests of free recall and for recognition of picture distracters. Comparable to 8-year-olds and adults, a moderately fragmented stimulus facilitated recall more than a nearly complete or very incomplete picture, an outcome not found with the other 5-year-olds.

Because little environmental support is present to facilitate response, free recall is assumed to be primarily a conceptually driven task. The processes involved in recall are deliberate and explicit, but data-driven processes may also contribute to performance (Jacoby, 1983). This was most evident during recall when children's "self-talk" revealed their attempts to draw on perceptual components of the stimulus to facilitate memory ("that curly squiggle thing was a pig's tail; it's the pig!" Katie, age 3.6 years). As noted above, an optimum presentation of the stimulus during exposure enhanced performance for that specific group of 5-year-olds on free recall as well as on picture identification.

Picture recognition, such as the task used in the current study, is believed to reflect activation of both data-driven and conceptually driven processes. The surface attributes associated with visual stimuli promote high levels of response accuracy on picture recognition tests relative to other tests of explicit recall. In addition, the child, who rarely ever viewed the completed fragpic, must match the real picture on the template to one of several options of visually similar mental representations of that image (bear? cow? horse?). It is this explicit process that accesses conceptual processing. In both Experiments 3 and 4, ceiling effects obscured conclusions regarding developmental differences in distinguishing between Old and New pictures. The repeatedly viewed pictures reinforced data-driven processing sufficiently to promote equal recognition by both ages, and appeared to be particularly facilitative when viewed with the method of ascending degrees of fragmentation rather than at a single level of exposure. In contrast, the ability to distinguish between perceptually similar, but never-viewed distracter pictures, showed age-related differences. It is likely that conceptually driven processing was predominant for this measure of picture recognition.

Perceptual fluency was considered earlier in Chapter 1 of this paper as a plausible explanation for the effect of prior exposure on performance. As proposed by Jacoby and Dallas (1981), perceptual fluency reflects the increased indentifiability of a concept or idea as a result of its prior exposure. A reasonable assumption has been that fluency is a function of data-driven process at encoding. Consequently, the more similar perceptual characteristics of the stimulus are for study and test, the greater role fluency is expected to play in mediating memorial processes during retrieval.

In the present study, it is very likely that perceptual fluency facilitated memorial performance for the picture identification and recognition tests. In fact, responses were consistently superior for previously presented items than for New items on direct and indirect tests. A perceptual fluency hypothesis accounts for this outcome with picture identification tests but does not explain the related finding for free recall. When fluency effects were examined more specifically by contrasting performance on different forms of picture tests, for example, fragmented pictures and picture recognition, the expected similarity in perceptual fluency effects across tasks failed to emerge (Snodgrass & Hirshman, 1994; Snodgrass, Hirshman, & Fan, 1996). Perceptual fluency cannot, on its own, account for the enhanced effect of prior exposure on performance.

Masson and MacLeod (1992, 1996) demonstrated that such improved performance is not exclusively a function of data-driven processes. In terms of the two-step process for encoding described above, perceptual fluency contributes to performance by facilitating interpretive encoding and assisting in the creation of a context-sensitive interpretation of the stimulus. Masson and MacLeod proposed, as well, that it has a role in the enhancement of contextual aspects of the stimulus; conscious judgements by the subject access perceptual and conceptual components of the original stimulus to aid recall. Thus, even in free recall tests, twice-seen items are remembered more readily than items presented only once. Although perceptual fluency, with its isolated focus on the surface features of the stimulus, appears to be insufficient in accounting for performance across multiple tests, a modified version of transfer appropriate processing may be a more viable option.

<u>A Theoretical Account: Modification of Transfer-Appropriate Processing</u>

The principal tenet of transfer appropriate processing is that memorial performance will vary directly as a function of the similarity between processing operations incurred between study and test. This suggests that if stimulus attributes facilitate interpretive and/or contextual encoding (as opposed to <u>only</u> sensory or perceptual encoding), then performance will be enhanced on tests designed to access conceptually driven processes. Further, it will be immaterial whether the task is a direct or indirect test of memory. One of the previous difficulties with this theory has been its inability to adequately explain dissociations between and among direct and indirect tests of memory.

Masson and MacLeod (1992) proposed a modification of transfer appropriate processing. While accepting the theory in principle, they hypothesize that both data-driven and conceptually driven processes are evoked during encoding to produce a context-dependent interpretation of the stimulus. Similar to the proposal by Biederman and Cooper (1991), Masson and MacLeod posit a two-step encoding process that begins with an interpretation of surface features of the stimulus, and is followed by an elaboration of these features. Interpretive encoding operations respond to the perceptual or physical nature of the stimulus and construct an interpretation from it that is context-sensitive. When the interpretation has been constructed, the second processing step occurs, a conceptually based elaboration of surface and/or semantic aspects of the stimulus using the just-established interpretation of the stimulus to relate it to existing knowledge. Even the fact of constructing this interpretation suggests a conceptual process.

Performance on indirect and direct tests of memory reflects support from both types of encoding operations, although the degree of support may vary as function of type of test. Indirect tests of memory, such as picture identification, that involve only the initial representation of the stimulus, reenact those processes used in the interpretive encoding of the fragmented picture. Because this process does not require deliberate awareness, this reenactment is typically perceived as being automatic, or without conscious awareness. The elaborative processes used during encoding may or may not be recruited during indirect tests of memory. If they are, for example when the child tries to relate a fragment of the picture with some other association ("those are stripes and animals have stripes and zebras and tigers have stripes; that's a tiger, I saw it before" Joshua, age 4 years), elaboration plays a secondary role to the initial process of relating that particular fragment to the study experience. Indirect tests are sensitive to aspects of the conceptual context in which the stimulus is encoded because the initial interpretive encoding was context-dependent.

Performance on tests of direct memory are also supported by both types of encoding operations. Surface and contextual information encoded during study can be explicitly called upon at test even when the context for study and test are very different, as it was for free recall of fragmented pictures. How well does this revised processing model fit the data from the current study when fragmented pictures are used as a stimulus?

Snodgrass and Feenan (1990) initially rejected transfer appropriate processing as an explanatory account for optimum transfer from a moderately fragmented picture during study to a very fragmented test stimulus. This position was reconsidered in Snodgrass and Hirshman (1994) under the assumption that, although the level of fragmentation of the stimulus differed in its presentation from study to test, the mechanism of perceptual closure was evoked regardless of the procedural condition. Specifically, when a moderately fragmented picture is named during the exposure phase as a function of perceptual closure, item-specific learning occurs for that picture. When the same picture is presented in its more fragmented version at test, and then subsequently named, perceptual closure is still evoked. Perceptual learning has facilitated the experience of perceptual closure for the stimulus in its more fragmented form.

Support for similarity in processing across study and test, despite variations in exposure conditions, was evident when comparing Experiments 3 and 4 of the current study. Children in Experiment 3 were exposed to the fragmented stimulus in ascending degrees of completion, while children in Experiment 4 were exposed to fragpix at fixed levels of fragmentation. A comparison of same-aged subjects found no statistical difference for the magnitude of priming between these diverse exposure conditions on tests of picture identification, free recall, or picture recognition.

The proposal by Biederman and Cooper (1991) and Masson and MacLeod (1992) that data-driven and conceptually driven processes are evoked during encoding could also account for the persistence of age differences in performance in the current experiments. Despite the varied range in ages from 3 to 8 years, the children likely processed surface features of the stimulus in a similar manner. Older children, in addition, would be able to re-enact the contextual or elaborative component of the encoding process more efficiently and effectively than younger children, resulting in superior performance on almost all tasks. This process likely accounts for the larger magnitude of priming found for older children on such diverse tasks as picture identification and free recall.

The modified version of transfer appropriate processing can also account for the pattern of dissociations observed among tests in the current study. Manipulations of the physical attributes of the stimulus had larger effects, that is accounted for a greater proportion of variability, on tests that most closely matched the original presentation of the stimulus than those that did not. To illustrate, on the picture identification test 10 to 25% of the variability could be accounted for by experimental manipulations such as order of stimulus presentation. In contrast, for free recall, the proportion of variability accounted for was negligible, $\underline{R}^2$s < .03, while the picture recognition test, where the only similarity between study and test was that stimuli in both conditions were visual, accounted for slightly more of the effect, .05 to .08 of the total variability.

Having adopted the modification of transfer appropriate processing as the model that best accounts for the data of this study, a final consideration was to speculate about the nature of memory systems involved in the cognitive processing. Tulving and Schacter (1990) proposed that many indirect memory tests, including perceptual identification tests, are driven by a perceptual representation system that is separate from episodic memory. This perceptual system responds to the form and structure of stimuli rather than their meaning. Such a system is plausible when there are dissociations among direct and indirect tests, particularly when developmental invariance is expressed on tests of implicit memory. In the current study, this pattern of test dissociation and age invariance was not evident. Tulving (1991) expanded his thesis of a separate perceptual memory system by introducing the concept of codetermination, which states that performance on certain memory tasks may be determined by the joint function of more than one memory system. Thus performance on the free recall test or recognition of distracter pictures would reflect the simultaneous participation of the perceptual representation system and episodic memory.

Given the mutual occurrence of interpretative and elaborative encoding operations, and the recruitment of both processes during memorial tasks, this researcher rejects the concept of separate memory systems. In concert with Masson and MacLeod (1992) and Snodgrass, Hirshman, and Fan (1996), support is offered toward the hypothesis that perceptual and contextual information is stored in, and reactivated from, the same memory store.

Snodgrass and her colleagues are currently examining this proposal in the form of an episodic trace hypothesis. Their recent study (1996) demonstrated that, for adults, surface similarity effects were larger for recognition memory than for identification of fragmented pictures. This outcome is not predicted by perceptual fluency but can be accounted for by the interactive function of sensory and conceptual stores from episodic memory. Although it might appear that the results of this dissertation conflict with findings for adults, this study was not designed specifically to examine their hypothesis. It is not implausible that the episodic trace hypothesis might be valid for young children, but would reflect age-related differences in the function of these integrated processes.

<u>Recommendations and Future Directions</u>

Four recommendations for changes in this study are immediately evident, one focusing on increasing the number of age groups examined, and three involving technical considerations of the design. A fifth recommendation follows from the first four. The first suggestion augments the finding for developmental differences in the magnitude of priming on indirect and direct memory tests. It would be of interest to extend the developmental component of this study to include two more age groups, a young adolescent group (e.g., 12-year-olds) and an adult group. Age-related differences, particularly on the perceptual identification tests, may continue to be expressed into adulthood; alternately, performance might plateau and approach adult levels at age twelve.

In addition, although a facilitative effect for priming with a moderately fragmented stimulus was demonstrated with 8-year-olds, the effect was marginal on some measures. The inclusion of two older age groups would permit further exploration of this manipulation of the prime. Age-associated changes in priming and in the strength of this effect on different tasks might offer more insight to the influences of sensory and contextual influences on episodic memory.

In reviewing the design for this study, Experiments 3 and 4 demonstrated that the cued recall test was of limited usefulness, and the recommendation is to eliminate it altogether. Compared to the other three tests, it is most likely to be contaminated by subjective bias. In addition, the picture recognition task could be improved. Its presentation following the other three tests inflated the possibility for unintentional repetition priming effects and ceiling effects. Parkin (1993), Russo et al. (1995), and Snodgrass, Hirshman, and Fan (1996) have demonstrated the value of making more direct comparisons between tests of picture recognition and identification of fragmented pictures. Examining outcome as an endorsement of modified transfer appropriate processing would be improved with viable information from tests that measure both perceptual and conceptually based processes.

The inclusion of distracter pictures on the recognition test was initially more of an afterthought rather than a deliberate manipulation. In retrospect, a more careful selection and analysis of distracter pairs would be of interest in examining the strength of the data and conceptually driven processes. This task was not subject to ceiling effects and it appeared to access more conceptually driven processes than traditional forms of recognition tests, at least among younger-aged subjects. In particular, the distracters should be chosen to permit a more careful investigation of the differential influence of perceptually similar versus categorically similar items on age.

Finally, along with the inclusion of a broader range of ages, a tightening of methodology for direct tests of memory, and a more careful selection of distracter pictures, attention could be directed toward manipulating the initial presentation of fragmented pictures for a further examination of episodic memory hypothesis. It would be of interest to explore whether children' performance replicates Snodgrass and Hirshman (1994) and their associates (1996), or whether there is a differential impact of developmental change on episodic memory. Not earth shattering, not world peace (yet) but curious nevertheless.

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Footnotes

[1]I have discovered that this moment can be very palpable with young children. Intently watching the screen, there is suddenly a quick intake of breath and then the correct answer is given. This occurs regardless of whether the child has been silent or has been chatting and making guesses during the portrayal of the ascending levels.

[2]Weighted contrasts used for trend analysis on Age (k = 4) Linear: -2 -1 0 3; Quadratic: 3.072 -1.214 -3.5 1.642.

[3]Formulas used for computation of A"

$$A'' = \frac{3 + h_1 - f_1 - f_1/h_1}{4} \quad \text{for } h_1 \leq (1 - f_1)$$

$$A'' = \frac{3 + h_1 - f_1 - (1 - h_1)/(1 - f_1)}{4} \quad \text{for } h_1 > (1 - f_1)$$

[4]Formulas used for computation of B''_D

$$B''_D = \frac{[(1 - H)(1 - FA) - HFA]}{[(1 - H)(1 - FA) + HFA]}$$

Appendix A

ORIGINAL PICTURE SETS

8-A	8-B	9-A	9-B
BANANA	AXE	BICYCLE	ARM
BED	BABY CARRIAGE	BIRD	BEAR
BUS	CLOCK	COMB	BROOM
DRUM	EAR	CUP	HAT
ELEPHANT	FISH	EYE	IRON
GLOVE	FOOTBALL	GUITAR	LOCK
KEY	GRAPES	HAMMER	PEAR
MOUNTAIN	HELICOPTER	KITE	RECORD PLAYER
REFRIGERATOR	MUSHROOM	LAMP	SANDWICH
ROLLING PIN	PANTS	MONKEY	SCISSORS
SQUIRREL	PIG	PUMPKIN	SNAKE
SUITCASE	POT	RABBIT	SNOWMAN
SWAN	SLED	SHOE	SOFA/COUCH
TELEVISION	TIE	TOASTER	TRUCK
WHISTLE	TIGER	TREE	WATCH

MODIFIED PICTURE SETS

10-A	10-B	11-A	11-B
BANANA	BABY CARRIAGE	BICYCLE	BEAR
BED	CLOCK	BIRD	BROOM
BUS	FISH	COMB	HAT
ELEPHANT	HELICOPTER	CUP	IRON
KEY	MUSHROOM	HAMMER	SCISSORS
REFRIGERATOR	PIG	KITE	SNOWMAN
SQUIRREL	POT	LAMP	SOFA/COUCH
SWAN	SLED	RABBIT	TRUCK
TELEVISION	TIGER	SHOE	WATCH

MODIFIED PICTURE SETS (REVISED)

10-A	10-B	12-A	12-B
BANANA	BABY CARRIAGE	BICYCLE	ARM
BED	CLOCK	BIRD	BEAR
BUS	FISH	CUP	HAT
ELEPHANT	HELICOPTER	GUITAR	SANDWICH
KEY	MUSHROOM	HAMMER	SCISSORS
REFRIGERATOR	PIG	LAMP	SNOWMAN
SQUIRREL	POT	RABBIT	SOFA/COUCH
SWAN	SLED	PUMPKIN	TRUCK
TELEVISION	TIGER	TREE	WATCH

Appendix B

Experiment 3

Rationale for Exclusion of 24 Children from Study

Reason for Exclusion	Gender	Age (years)
Insufficient command of English (n = 3)	Female	3
	Male	3
	Female	5
Disability in cognitive processing (n = 3)	Male	5
	Male	5
	Male	5
Refused to participate (n = 4)	Female	3
	Female	4
	Female	4
	Male	4
Refused to complete testing (n = 2)	Male	5
	Male	5
Too many disruptions during testing (n = 1)	Male	4
Absent during test days (n = 2)	Male	5
	Female	5
Data replaced to counter-balance picture sets in 5-year-old age group (n = 9)	Males (n = 6)	
	Females (n = 3)	

Total number of available subjects excluded from study N = 24

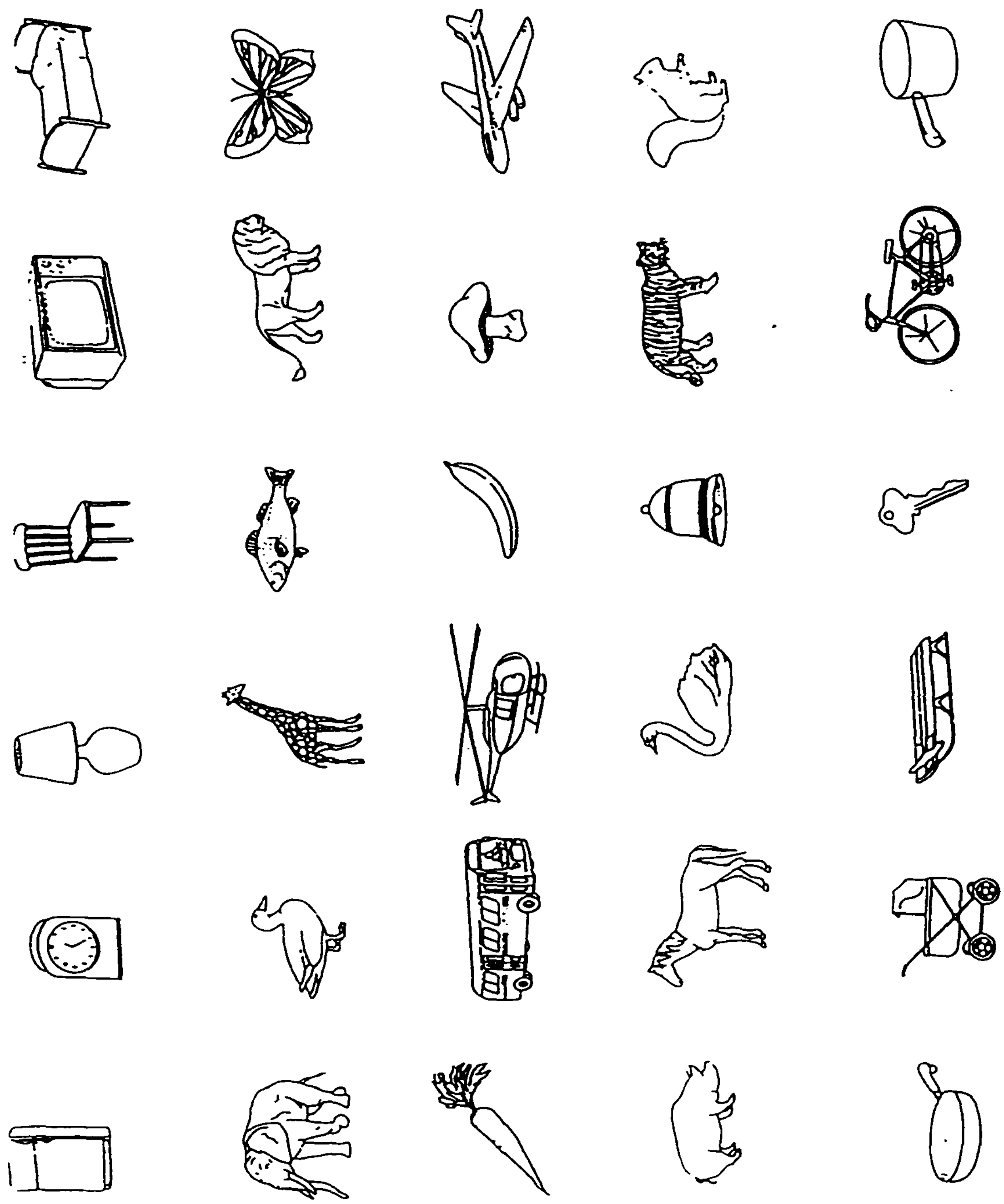
Appendix C

Sample of Picture Recognition Test (Experiments 3 and 4)

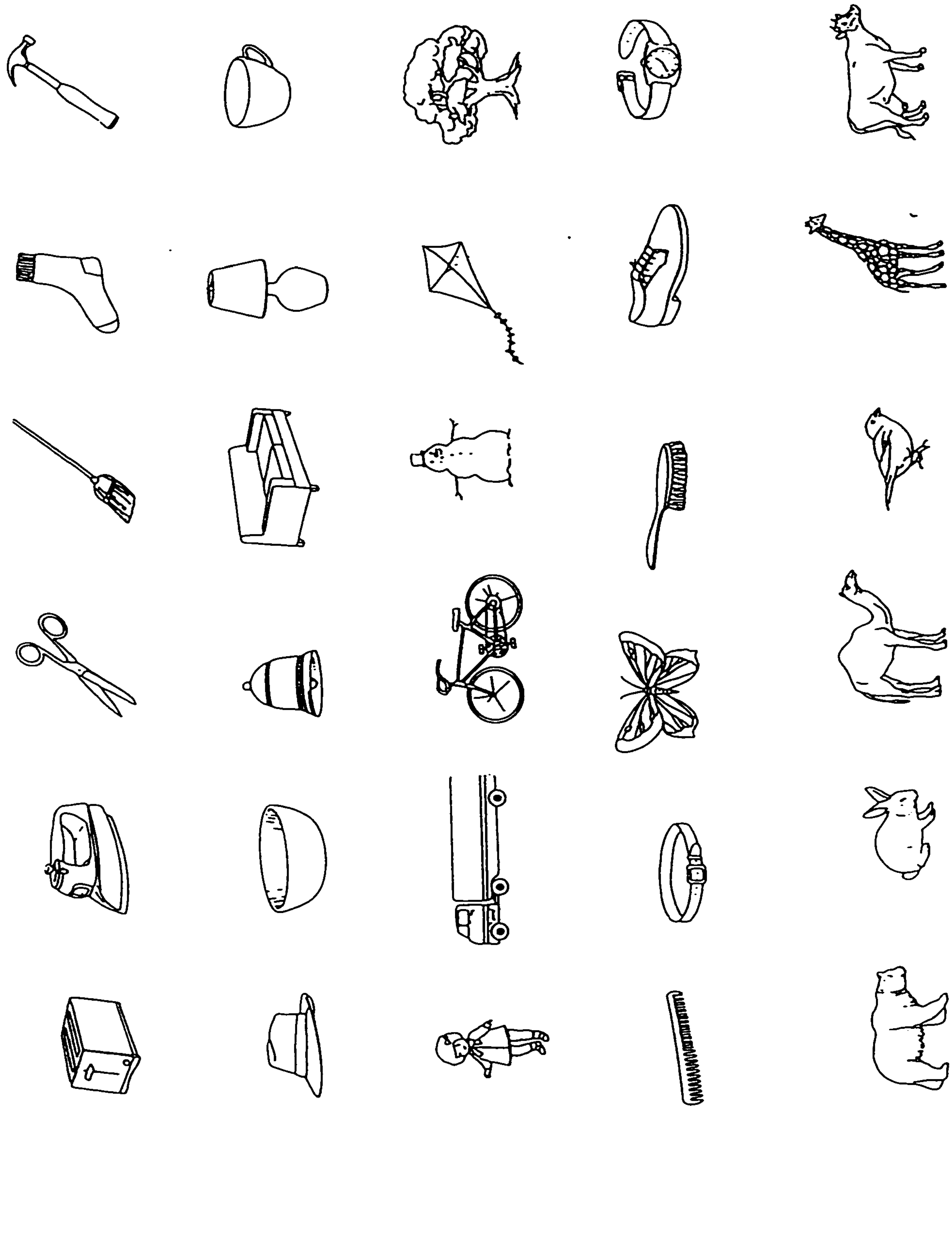
Stimulus set: PicSet 10

Stimulus set: PicSet 11

Stimulus set: PicSet 10



Stimulus set: PicSet 11



Appendix D

Experiment 3

Samples of Test Response Sheets

RESPONSE SHEET (10)

CODE #________________ SCHOOL____________________
TEST DATE______________________ BIRTHDATE_________________
TEST CONDITION__________________ PIXSET_________________

FRAGPIX MEANS

FRAGPIX:	TRAINING	_______	OLD	_______	NEW	_______
FREE RECALL:	OLD	_______	NEW	_______		
CUED RECALL:	OLD	_______	NEW	_______		
RECOGNITION:	TRAINING	_______	NEW	_______	DIST	_______

RECALL

FREE RECALL		CUED RECALL	
ITEM	LEVEL/CONDITION	ITEM	LEVEL/CONDITION
1.		1.	
2.		2.	
3.		3.	
4.		4.	
5.		5.	
6.		6.	
7.		7.	
8.		8.	
9.		9.	
10.		10.	
11.		11.	
12.		12.	
13.		13.	
14.		14.	
15.		15.	
16.		16.	
17.		17.	
18.		18.	

TOTAL # RECALLED PER LEVEL

OLD _____ NEW ______ OLD _____ NEW ______

RECOGNITION

							OLD	NEW	DST
A.	-FRYPAN	BUGGY	SLED	KEY	-BIKE	POT	____	____	____
B.	FRIDGE	CLOCK	-LAMP	-CHAIR	TV	BED	____	____	____
C.	ELEPH	-DUCK	GIRAF	FISH	-LION	BTFLY	____	____	____
D.	-CARROT	BUS	HELIC	BNANA	MUSHR	-PLANE	____	____	____
E.	PIG	-HORSE	SWAN	BELL	TIGER	SQRRL	____	____	____

RESPONSE SHEET (11)

CODE # ______________ SCHOOL ___________________
TEST DATE ___________________ BIRTHDATE ________________
TEST CONDITION ________________ PIXSET ________________

FRAGPIX MEANS

FRAGPIX:	TRAINING	_______	OLD	_______	NEW	_______
FREE RECALL:	OLD	_______	NEW	_______		
CUED RECALL:	OLD	_______	NEW	_______		
RECOGNITION:	TRAINING	_______	NEW	_______	DIST	_______

RECALL

FREE RECALL ITEM	LEVEL/CONDITION	CUED RECALL ITEM	LEVEL/CONDITION
1.		1.	
2.		2.	
3.		3.	
4.		4.	
5.		5.	
6.		6.	
7.		7.	
8.		8.	
9.		9.	
10.		10.	
11.		11.	
12.		12.	
13.		13.	
14.		14.	
15.		15.	
16.		16.	
17.		17.	
18.		18.	

TOTAL # RECALLED PER LEVEL

OLD _____ NEW ______ OLD _____ NEW ______

RECOGNITION

							OLD	NEW	DST
A.	BEAR	RABBT	-CAMEL	BIRD	GIRF	-COW	____	____	____
B.	-TOSTR	IRON	SCSRS	BROOM	-SOCK	HAMR	____	____	____
C.	HAT	-BOWL	BELL	SOFA	LAMP	CUP	____	____	____
D.	-DOLL	TRUCK	BIKE	SNOMN	KITE	-TREE	____	____	____
E.	COMB	-BELT	BTFLY	-BRSH	SHOE	WATH	____	____	____

Appendix E

Data Trial Runs (N = 30) for Number of Changes In Level of Fragmentation During Random Condition

<u>Data</u>

4	5	4	5	5	4	8	6	7	5	3	6	6	6	5
5	6	5	7	6	7	4	6	8	5	4	6	7	4	4

<u>Descriptive Statistics</u>

Number of changes in in 30 runs:	24
Mean number of changes:	5.43
Standard deviation:	1.278
Range:	3 - 8

Appendix F

Experiment 4

Samples of Test Response Sheets

RESPONSE SHEET (10-5)

CODE # ________________ SCHOOL ____________________

TEST DATE ____________________ BIRTHDATE ________________

TEST CONDITION __________________ PIXSET ________________

FRAGPIX MEANS

LEVEL 7	LEVEL 5	LEVEL 3	OLD/SAVINGS	NEW
______	______	______	______	______

CORRECT (Exposure)

7 ___ 5 ___ 3 ___

RECALL

FREE RECALL ITEM	LEVEL/CONDITION	CUED RECALL ITEM	LEVEL/CONDITION
1.		1.	
2.		2.	
3.		3.	
4.		4.	
5.		5.	
6.		6.	
7.		7.	
8.		8.	
9.		9.	
10.		10.	
11.		11.	
12.		12.	
13.		13.	
14.		14.	

TOTAL # RECALLED PER LEVEL

L-7	L-5	L-3	NEW	L-7	L-5	L-3	NEW
___	___	___	___	___	___	___	___

RECOGNITION

						L-7	L-5	L-3	NEW	DST
A.-FRYPN	BUGGY	SLED	KEY	-BIKE	POT	___	___	___	___	___
B. FRDGE	CLOCK	-LAMP	-CHAIR	TV	BED	___	___	___	___	___
C. ELEPH	-DUCK	GIRAF	FISH	-LION	BTFL	___	___	___	___	___
D.-CRROT	BUS	HELIC	BNANA	MUSHR	-PLAN	___	___	___	___	___
E. PIG	-HORSE	SWAN	BELL	TIGER	SQRL	___	___	___	___	___
					TOTAL	___	___	___	___	___

RESPONSE SHEET (10-8)

CODE #________________ SCHOOL______________________

TEST DATE______________________ BIRTHDATE_________________

TEST CONDITION__________________ PIXSET_________________

FRAGPIX MEANS

LEVEL 7	LEVEL 4	LEVEL 2	OLD/SAVINGS	NEW
________	________	________	________	________

CORRECT (Exposure)

7 ___ 4 ___ 2 ___

RECALL

FREE RECALL ITEM	LEVEL/CONDITION	CUED RECALL ITEM	LEVEL/CONDITION
1.		1.	
2.		2.	
3.		3.	
4.		4.	
5.		5.	
6.		6.	
7.		7.	
8.		8.	
9.		9.	
10.		10.	
11.		11.	
12.		12.	
13.		13.	
14.		14.	

TOTAL # RECALLED PER LEVEL

L-7	L-4	L-2	NEW	L-7	L-4	L-2	NEW
___	___	___	___	___	___	___	___

RECOGNITION

							L-7	L-4	L-2	NEW	DST
A.	-FRYPN	BUGGY	SLED	KEY	-BIKE	POT	___	___	___	___	___
B.	FRDGE	CLOCK	-LAMP	-CHAIR	TV	BED	___	___	___	___	___
C.	ELEPH	-DUCK	GIRAF	FISH	-LION	BTFL	___	___	___	___	___
D.	-CRROT	BUS	HELIC	BNANA	MUSHR	-PLAN	___	___	___	___	___
E.	PIG	-HORSE	SWAN	BELL	TIGER	SQRL	___	___	___	___	___
						TOTAL	___	___	___	___	___

Appendix G

Sample of Summary Letters Sent to Parents or Guardians of Child Participants

Department of Psychology
UNIVERSITY OF VICTORIA
PO BOX 3050, MS 7525
VICTORIA, BC, CANADA V8W 3P5
TELEPHONE (604) 721-7525, FAX (604) 721-8929
EMAIL ADDRESS: PSYCBIT@UVVM.UVIC.CA

March 1995

Dear Parents,

Your child recently participated in a study carried out with 3, 4, 5, and 8-year-old children at day cares and elementary schools in the Victoria region. The following is a preliminary summary of the project outcome:

FACTORS THAT INFLUENCE THE DEVELOPMENT OF PRIMING IN CHILDREN

Priming refers to the effect of prior exposure to information on subsequent learning. An important component of priming is that learning takes place without the person being aware that s/he had been exposed to the material to be learned. Priming has been demonstrated to occur at all ages, even in babies as young as six months of age. It has been assumed, however, that the amount of priming that happens with a 3-year-old is the same as with an 8-year-old or an adult. Although priming is currently a major topic in cognitive psychology, few studies have been carried out with children. My study examined 3, 4, 5, and 8 year-olds individually on a variety of measures.

Using a computer program, each child attempted to identify a series of pictures presented in a fragmented form (TRAINing phase). The child was allowed to ask for as much information as needed in order to correctly name the picture. Testing involved identification of pictures seen in the study phase (OLD) intermixed with a series of new pictures (NEW). It was hypothesized that children would identify OLD pictures at a lower level (i.e., needing less perceptual information) than NEW pictures. Measures of priming, savings and transfer of learning were analyzed.

A. Some students had a shorter set of pictures to identify than others (18 pictures versus 30 pictures). The longer picture set had pictures that were more difficult to identify.

YOUR CHILD HAD THE LONGER SHORTER PICTURE SET.

B. CLOSURE: Some students, when they had correctly named the picture during the STUDY PHASE were then shown the full picture (Closure) to see if that helped them do better on the second set of pictures and on the memory test (TEST PHASE).

YOUR CHILD WAS IN THE CLOSURE NON-CLOSURE CONDITION

*Seeing the complete picture during the study phase did not make any difference in how a child performed during the test phase.

C. I wanted to know if boys and girls would perform differently

*There was no difference in performance between boys and girls.

-2-

D. PRIMING: I tested whether or not performance improved when the student saw the same pictures during the test that they had seen during study. Scores ranged from 1 to 8, with 8 being a score given when the student had to see the full picture before naming it. Better performance is represented by LOWER scores.

*All children identified OLD pictures more readily (required less additional information) than NEW pictures, and, the older a child was, the better they were at completing this task.

Your child's scores: TRAIN________ OLD_________ NEW_________.

E. AMOUNT OF PRIMING (PERCEPTUAL LEARNING): I examined how much perceptual learning occurred at each age group, measured by subtracting OLD scores from NEW scores.

*Four-year-olds demonstrated more perceptual learning than 3-year-olds, but 4-, 5-, and 8-year-olds all experienced about the same amount of perceptual learning.

Average PRIMING score: 0.89 Your child's score: _______

F. SAVINGS: I looked at how much learning occurred between the study (TRAIN) and test phase (OLD) with the old pictures, i.e., how much more readily could the child perform the same task at test.

*Every child showed some savings, but children who had the highest scores at training tended to demonstrate the greatest amount of savings.

*Four-year-olds demonstrated more savings than 3-year-olds, but 4-, 5-, and 8-year-olds all experienced about the same amount of savings.

Average SAVINGS score: 1.14 Your child's savings score: _______

G. TRANSFER OF LEARNING: I tested whether the score for the NEW pictures seen at test would be similar to the score achieved during the training phase. Was the child able to take concepts learned during training and apply them to a related, but not identical, situation.

*The majority of children scored similarly when exposed to pictures seen for the first time on the TRAINing and the TEST phase, thus only a small amount of transfer of learning was noted. 5-year-olds showed the greatest amount of transfer.

Average TRANSFER score: 0.15 Your child's score: _______

THANK YOU FOR ALLOWING YOUR CHILD TO PARTICIPATE IN MY STUDY IF YOU HAVE ANY QUESTIONS, PLEASE CONTACT ME BY LEAVING A MESSAGE AT MY OFFICE 721-6327

Valerie Gonzales

Valerie Gonzales, M Sc
Doctoral Candidate

Appendix H

Table 1

Means and Standard Deviations:

Raw Score Responses on Cued Recall Tests

Table 1-a

Means and Standard Deviations for Number of Fragpix Correctly Recalled for Cued Recall Test as a Function of Stimulus Change and Identification Condition.

Age Group: 5-year-olds

	Identification Condition[a]			
Change	Level 7	Level 5	Level 3	New
Random[b]				
M	0.30	0.20	0.45	1.05
SD	0.57	0.41	0.60	1.05
2-Change[c]				
M	0.58	0.17	0.58	1.00
SD	0.52	0.39	0.79	0.95
2-Change Reverse[c]				
M	0.58	0.67	0.58	0.83
SD	0.67	0.78	0.67	1.03
6-Change[b]				
M	0.10	0.30	0.30	1.30
SD	0.31	0.47	0.57	1.98

[a]Total possible for each level of priming stimulus (N = 3); Total possible for New (N = 9). [b]N = 20 for Stimulus Change condition. [c]N = 12 for Stimulus Change condition.

Table 1-b

Means and Standard Deviations for Number of Fragpix Correctly Recalled for Cued Recall Test as a Function of Stimulus Change and Identification Condition.

Age Group: 8-year-olds

	Identification Condition[a]			
Change[b]	Level 7	Level 4	Level 2	New
Random				
M	0.55	0.25	0.50	1.90
SD	0.60	0.44	0.69	0.97
2-Change				
M	0.70	0.20	0.20	1.70
SD	0.57	0.52	0.41	1.46
2-Change Reverse				
M	0.45	0.55	0.40	1.35
SD	0.60	0.83	0.60	1.23
6-Change				
M	0.75	0.30	0.50	1.30
SD	0.72	0.66	0.61	1.13

[a]Total possible for each level of priming stimulus (N = 3); Total possible for New (N = 9)

[b]N = 20 for each Stimulus Change condition.

Appendix I

Data sets for Experiments 2, 3 and 4

Experiment 2

Coding Variables

Group	1	Original Picture sets
	2	Modified Picture sets
Age (in months)		
Gender	1	Females
	2	Males
Close	1	No Show (Complete picture not shown)
	2	Show (Complete picture shown)
Pic	1	Picset 8
	2	Picset 9
	1	Picset 10
	2	Picset 11
Subset	1	Subset a
	2	Subset b

Column headings for Data

Train	Mean threshold of identification for fragpix shown during exposure phase
Old	Mean threshold of identification for previously seen fragpix shown during test
New	Mean threshold of identification for novel fragpix shown during test

Experiment 2

Data set

GROUP	AGE	GENDR	CLOSE	PIC	SUBSET	TRAIN	OLD	NEW
1	100	1	1	1	1	5	3.78	4.67
1	108	1	1	1	2	5	3.67	5.2
1	105	1	1	2	1	5.11	3.22	4.78
1	102	1	1	1	1	5	2.78	4.89
1	103	1	1	1	1	5.11	3.22	4.45
1	108	2	1	1	2	4.11	2	4
1	106	2	1	2	1	5.33	4	5.44
1	103	2	1	2	2	4.44	2.78	5
1	100	2	1	2	1	6.11	2.89	6
1	109	2	1	1	2	5	3.11	4.22
1	100	1	2	1	2	4.11	2.78	4.89
1	106	1	2	2	1	5.56	4.67	5.22
1	101	1	2	2	2	5.56	4.67	5.11
1	104	1	2	1	1	5.33	4.11	5
1	105	1	2	1	2	4.44	2.33	4.78
1	100	2	2	1	1	5.67	4	5.22
1	99	2	2	1	2	4.33	2.67	5.22
1	109	2	2	2	1	5.44	4.33	5.22
1	110	2	2	2	2	5.89	3.56	5.45
1	103	2	2	2	2	5.44	4.11	4.11
2	107	1	1	1	1	5.47	3.8	5.4
2	105	1	1	1	2	5.8	4	5.27
2	109	1	1	2	2	5.4	3.87	5.07
2	106	1	1	1	1	5	4.07	4.87
2	100	1	1	2	2	5.44	3.4	5.07
2	102	2	1	1	1	4.73	2.67	5.2
2	114	2	1	1	2	5.4	4.4	5.53
2	104	2	1	2	2	5.33	3.53	5.26
2	101	2	1	1	2	5.47	3	5.07
2	104	2	1	2	1	5.8	4.4	5.87
2	105	1	2	1	2	5.6	3.87	5.27
2	107	1	2	2	2	5.8	3.67	5.67
2	105	1	2	1	2	5.6	3.13	5.07
2	107	1	2	1	2	4.13	2.93	4.53
2	102	1	2	2	2	5	3.47	4.47
2	105	2	2	1	1	4.73	2.4	4.73
2	105	2	2	1	2	5.07	2.73	4.8
2	105	2	2	2	1	5.53	3.67	4.87
2	102	2	2	2	2	5.47	4.27	5.47
2	106	2	2	2	2	5.33	3.27	5.07

Experiment 3

Coding Variables

AGEG	1	3-year-olds
	2	4-year-olds
	3	5-year-olds
	4	8-year-olds
AGE (in months)		
GENDER	1	Females
	2	Males
CLOSE	1	No Show
	2	Show
PIC	1	Picset 10
	2	Picset 11
SUBSET	1	Subset a
	2	Subset b

Column headings for Data

TRAIN	Mean threshold of identification for fragpix shown during exposure phase
OLD	Mean threshold of identification for previously seen fragpix shown during test
NEW	Mean threshold of identification for novel fragpix shown during test
FRO	# of Old (twice-seen) fragpix recalled during free recall test
FRN	# of New (once-seen) fragpix recalled during free recall test
CRO	# of Old (twice-seen) fragpix recalled during cued recall test
CRN	# of New (once-seen) fragpix recalled during cued recall test

Experiment 3

Coding Variables (continued)

PRO	# of Old (twice-seen) fragpix correctly circled during picture recognition test
PRN	# of New (once-seen) fragpix correctly circled during picture recognition test
PRD	# of distracter (never-seen) fragpix correctly rejected (not circled) during picture recognition test
PHOLD	Probability of Hits for twice-seen pictures in picture recognition test
PHNEW	Probability of Hits for once-seen pictures in picture recognition test
PF	Probability of False alarms for never-seen pictures (distracters) in picture recognition
A2OLD	Values for conversion of picture recognition data to sensitivity measure: A" for Old items
A2NEW	Values for conversion of picture recognition data to sensitivity measure: A" for New items
BDOLD	Measure of response bias calculated from picture recognition data: B''_D for Old items
BDNEW	Measure of response bias calculated from picture recognition data: B''_D for New items

Experiment 3: Data Set

Participants 1 - 50

AGEG	AGE	GEND	CLOSE	PIC	SUBSET	TRAIN	OLD	NEW
1	37	1	1	1	1	7.11	5.44	6.44
1	40	1	1	1	2	6.67	5.78	6.89
1	43	1	1	2	1	7	6.44	6.56
1	42	1	1	2	2	7.22	6.11	6.89
1	43	1	1	2	1	7.33	6.44	7.11
1	41	1	1	1	2	7.11	6	6.89
1	42	2	1	1	1	7	6	6.67
1	43	2	1	2	2	7.56	6.33	6.78
1	42	2	1	2	1	7.56	6.67	7.45
1	46	2	1	1	2	7	5.78	6.89
1	46	2	1	2	1	7.33	6.78	7.33
1	41	2	1	1	2	6.44	4.89	6.33
1	45	1	2	1	1	7	5.89	7.33
1	38	1	2	1	1	7.33	6	7.11
1	39	1	2	1	2	7.56	6.44	7.33
1	46	1	2	2	1	7.89	6.56	7.33
1	46	1	2	2	2	6.67	5.67	6.22
1	44	1	2	2	2	6	5.22	6.55
1	34	2	2	1	1	6.89	5.78	6.45
1	38	2	2	2	1	7	6	6.67
1	43	2	2	2	1	7.33	5.89	6.78
1	44	2	2	2	2	7.33	5.56	6.55
1	46	2	2	1	1	6.22	4.89	6.11
1	46	2	2	1	2	7.11	5.78	7
2	54	1	1	1	1	6.78	5.22	6.67
2	57	1	1	1	2	6.33	4.56	6.33
2	56	1	1	2	1	6.33	4.78	5.78
2	58	1	1	2	2	6.11	4.44	5.78
2	53	1	1	1	2	6.22	4.89	6.11
2	51	1	1	2	1	6.33	3.44	6
2	54	2	1	1	1	6.67	5	6.67
2	54	2	1	1	2	6.67	4.67	6.33
2	56	2	1	2	1	6.33	5.44	6.67
2	58	2	1	1	1	6.33	4.78	5.56
2	55	2	1	1	2	5.33	4	5.89
2	54	2	1	2	1	6.33	6.11	6.56
2	57	1	2	1	1	5.78	3.11	6
2	53	1	2	1	2	6.33	4.56	6.33
2	52	1	2	2	1	6.22	5.67	6.44
2	53	1	2	2	2	6.67	5	6.44
2	54	1	2	2	2	7.11	5.67	6.78
2	51	1	2	2	2	6.67	5.89	6.44
2	54	2	2	1	1	6.55	4.89	5.78
2	56	2	2	1	2	6.55	3.89	6.33
2	52	2	2	2	1	6	5.22	6.55
2	56	2	2	2	2	6.56	5.45	6.11
2	55	2	2	1	2	6.33	4.56	5.67
2	53	2	2	2	2	6.45	5.11	6.67
3	71	1	1	1	1	5.22	4.11	5.22
3	71	1	1	1	2	5.78	4.89	5.78

FRO	FRN	CRO	CRN	PRO	PRN	PRD
2	1	0	0	9	9	3
0	2	0	0	9	9	2
4	1	0	0	9	9	7
0	0	0	0	9	9	6
0	0	0	0	9	9	8
0	1	0	0			
0	0	0	0	9	9	7
4	2	0	0	9	8	2
2	0	2	2			
2	1	1	0	8	9	8
1	1	1	0	9	8	5
1	1	0	0	9	9	6
0	0	0	0	9	9	6
0	0	0	0	9	9	5
0	0	0	0	6	7	8
2	2	0	1			
0	0	0	0	9	8	8
0	0	0	0			
2	1	1	0			
0	1	0	0	9	9	9
0	0	0	0	9	8	6
1	2	2	1	8	8	8
1	1	1	2	9	8	8
4	2	2	1	9	9	9
1	1	0	1	9	9	9
3	0	3	1	9	9	8
2	2	0	0	9	8	6
4	0	3	0	9	8	7
5	2	1	1	9	9	9
4	1	2	2	9	9	6
0	0	0	0	9	9	9
2	2	2	0	9	8	3
1	4	0	0			
3	1	0	1	9	8	9
3	2	1	0	9	8	8
5	0	2	3	9	8	8
3	3	1	1	9	8	9

Experiment 3: Data Set

Participants 1 - 50

PHOLD	PHNEW	PF	A2OLD	A2NEW	BDOLD	BDNEW
0.944	0.944	0.667	0.778	0.778	-0.943	-0.943
0.944	0.944	0.778	0.729	0.729	-0.967	-0.967
0.944	0.944	0.222	0.913	0.913	-0.659	-0.659
0.944	0.944	0.333	0.882	0.882	-0.789	-0.789
0.944	0.944	0.111	0.943	0.943	-0.36	-0.36
0.944	0.944	0.944	0.5	0.5	-0.993	-0.993
0.944	0.944	0.222	0.913	0.913	-0.659	-0.659
0.944	0.889	0.778	0.729	0.653	-0.967	-0.931
0.944	0.944	0.056	0.958	0.958	0	0
0.889	0.944	0.111	0.913	0.943	0	-0.36
0.944	0.889	0.444	0.85	0.811	-0.863	-0.73
0.944	0.944	0.333	0.882	0.882	-0.789	-0.789
0.944	0.944	0.333	0.882	0.882	-0.789	-0.789
0.944	0.944	0.444	0.85	0.85	-0.863	-0.863
0.667	0.778	0.111	0.847	0.881	0.6	0.391
0.944	0.944	0.944	0.5	0.5	-0.993	-0.993
0.944	0.889	0.111	0.943	0.913	-0.36	0
0.944	0.944	0.944	0.5	0.5	-0.993	-0.993
0.944	0.944	0.944	0.5	0.5	-0.993	-0.993
0.944	0.944	0.056	0.958	0.958	0	0
0.944	0.889	0.333	0.882	0.847	-0.789	-0.6
0.889	0.889	0.111	0.913	0.913	0	0
0.944	0.889	0.111	0.943	0.913	-0.36	0
0.944	0.944	0.056	0.958	0.958	0	0
0.944	0.944	0.056	0.958	0.958	0	0
0.944	0.944	0.111	0.943	0.943	-0.36	-0.36
0.944	0.889	0.333	0.882	0.847	-0.789	-0.6
0.944	0.889	0.222	0.913	0.881	-0.659	-0.391
0.944	0.944	0.056	0.958	0.958	0	0
0.944	0.944	0.333	0.882	0.882	-0.789	-0.789
0.944	0.944	0.056	0.958	0.958	0	0
0.944	0.889	0.667	0.778	0.722	-0.943	-0.882
0.944	0.944	0.944	0.5	0.5	-0.993	-0.993
0.944	0.889	0.056	0.958	0.943	0	0.36
0.944	0.889	0.111	0.943	0.913	-0.36	0
0.944	0.889	0.111	0.943	0.913	-0.36	0
0.944	0.889	0.056	0.958	0.943	0	0.36

Experiment 3: Data Set

Participants 51 - 96

AGEG	AGE	GEND	CLOSE	PIC	SUBSET	TRAIN	OLD	NEW
3	63	1	1	2	1	5.56	3.56	5.56
3	69	1	1	2	2	6.11	3.67	5.56
3	64	1	1	1	1	5.67	4.11	4.78
3	70	1	1	2	2	5.67	4.78	5.22
3	69	2	1	1	1	5.89	4.22	5.33
3	70	2	1	1	2	5.33	4.11	5.56
3	66	2	1	2	1	6	4.67	5.89
3	63	2	1	2	2	6.89	5.22	6
3	67	2	1	1	1	6	4.22	4.78
3	65	2	1	1	2	5.33	2.67	5.45
3	72	1	2	1	1	6	4.45	4.45
3	68	1	2	1	2	6.11	4.56	5.78
3	63	1	2	2	1	6.33	5.11	5.33
3	66	1	2	2	2	6.11	3.78	5.44
3	71	1	2	2	1	5.44	3.22	4.78
3	70	1	2	1	2	5.33	4.11	4.78
3	65	2	2	1	1	5.89	3.78	5.45
3	64	2	2	1	2	5.56	3.89	5.67
3	63	2	2	2	1	5.89	5	6.45
3	63	2	2	2	2	6.78	5	5.78
3	66	2	2	1	2	6.11	3.44	5.56
3	72	2	2	2	2	5.67	4.67	5.44
4	100	1	1	1	1	5	3.78	4.67
4	108	1	1	1	2	5	3.67	5.22
4	105	1	1	2	1	5.11	3.22	4.78
4	109	1	1	2	2	4.89	3	5.44
4	101	1	1	1	1	5	2.78	4.89
4	97	1	1	2	1	5.22	3.89	5.22
4	113	2	1	1	1	5.67	3.89	4.67
4	108	2	1	1	2	4.11	2	4
4	106	2	1	2	1	5.33	4	5.44
4	103	2	1	2	2	4.45	2.78	5
4	100	2	1	2	1	6.11	2.89	6
4	109	2	1	1	2	5	3.11	4.22
4	100	1	2	1	2	4.11	2.78	4.89
4	106	1	2	2	1	5.56	4.67	5.22
4	101	1	2	2	2	5.56	4.67	5.11
4	104	1	2	1	1	5.33	4.11	5
4	105	1	2	1	2	4.45	2.33	4.78
4	113	1	2	2	2	5	3.67	4.56
4	100	2	2	1	1	5.67	4	5.22
4	99	2	2	1	2	4.33	2.67	5.22
4	109	2	2	2	1	5.44	4.33	5.22
4	110	2	2	2	2	5.89	3.56	5.44
4	97	2	2	1	1	4.11	2.56	3.78
4	103	2	2	2	2	5.44	4.11	4.11

Experiment 3: Data Set

Participants 51 - 96

FRO	FRN	CRO	CRN	PRO	PRN	PRD
4	4	1	0	9	9	9
2	1	3	1	9	8	9
5	3	0	1	8	6	8
1	3	2	2	9	9	9
1	3	3	1	8	9	5
5	1	1	1	9	9	9
2	2	1	1	8	7	9
2	0	1	0	9	8	9
2	0	1	0	9	7	4
4	5	1	1	9	9	6
3	1	1	1	9	9	9
4	2	1	0	9	9	9
4	1	2	1	9	4	8
3	1	0	0	9	9	9
3	0	1	1	9	9	5
2	2	1	3	9	9	8
3	1	1	1	9	9	5
0	3	0	1	9	9	9
3	0	1	1	9	9	5
7	3	0	2	9	9	9
5	3	0	2	9	9	8
5	0	1	1	9	9	9
8	1	0	1	9	8	8
4	3	2	0	9	9	9
2	3	5	2	9	9	9
4	3	1	1	9	9	8
5	2	1	1	9	9	9
6	2	0	1	9	9	9
6	2	0	1	9	9	9
4	0	3	0	9	8	9
6	2	0	0	9	9	8
7	2	0	3	9	8	9
5	3	1	1	9	9	9
3	1	2	2	9	8	8
6	1	2	2	9	9	9
7	2	0	3	9	8	9
7	4	1	1	9	9	9
4	1	3	2	9	8	8
7	4	0	0	9	9	9
3	2	2	2	9	8	9
5	5	1	1	9	9	9
6	6	3	1	9	8	9
5	2	2	2	9	8	8

Experiment 3: Data Set

Participants 51 - 96

PHOLD	PHNEW	PF	A2OLD	A2NEW	BDOLD	BDNEW
0.944	0.944	0.056	0.958	0.958	0	0
0.944	0.889	0.056	0.958	0.943	0	0.36
0.889	0.667	0.111	0.913	0.847	0	0.6
0.944	0.944	0.056	0.958	0.958	0	0
0.889	0.944	0.444	0.811	0.85	-0.73	-0.863
0.944	0.944	0.056	0.958	0.958	0	0
0.889	0.778	0.056	0.943	0.913	0.36	0.659
0.944	0.889	0.056	0.958	0.943	0	0.36
0.944	0.778	0.556	0.816	0.681	-0.91	-0.628
0.944	0.944	0.333	0.882	0.882	-0.789	-0.789
0.944	0.944	0.056	0.958	0.958	0	0
0.944	0.944	0.056	0.958	0.958	0	0
0.944	0.444	0.111	0.943	0.771	-0.36	0.818
0.944	0.944	0.056	0.958	0.958	0	0
0.944	0.944	0.444	0.85	0.85	-0.863	-0.863
0.944	0.944	0.111	0.943	0.943	-0.36	-0.36
0.944	0.944	0.444	0.85	0.85	-0.863	-0.863
0.944	0.944	0.056	0.958	0.958	0	0
0.944	0.944	0.444	0.85	0.85	-0.863	-0.863
0.944	0.944	0.056	0.958	0.958	0	0
0.944	0.944	0.111	0.943	0.943	-0.36	-0.36
0.944	0.944	0.056	0.958	0.958	0	0
0.944	0.889	0.111	0.943	0.913	-0.36	0
0.944	0.944	0.056	0.958	0.958	0	0
0.944	0.944	0.056	0.958	0.958	0	0
0.944	0.944	0.111	0.943	0.943	-0.36	-0.36
0.944	0.944	0.056	0.958	0.958	0	0
0.944	0.944	0.056	0.958	0.958	0	0
0.944	0.944	0.056	0.958	0.958	0	0
0.944	0.889	0.056	0.958	0.943	0	0.36
0.944	0.944	0.111	0.943	0.943	-0.36	-0.36
0.944	0.889	0.056	0.958	0.943	0	0.36
0.944	0.944	0.056	0.958	0.958	0	0
0.944	0.889	0.111	0.943	0.913	-0.36	0
0.944	0.944	0.056	0.958	0.958	0	0
0.944	0.889	0.056	0.958	0.943	0	0.36
0.944	0.944	0.056	0.958	0.958	0	0
0.944	0.889	0.111	0.943	0.913	-0.36	0
0.944	0.944	0.056	0.958	0.958	0	0
0.944	0.889	0.056	0.958	0.943	0	0.36
0.944	0.944	0.056	0.958	0.958	0	0
0.944	0.889	0.056	0.958	0.943	0	0.36
0.944	0.889	0.111	0.943	0.913	-0.36	0

Experiment 4

Coding Variables

AGEG	1	5-year-olds
	2	8-year-olds
AGE (in months)		
CHANGE	1	Random
	2	2-Change
	3	2-Change Reverse
	4	6-Change
GENDER	1	Females
	2	Males
PICS	1	Picset 10
	2	Picset 11

Column headings for Data

LV7	Mean threshold of identification at test for fragpix presented at Level 7 during exposure
LV5	Mean threshold of identification at test for fragpix presented at Level 5/4 during exposure
LV3	Mean threshold of identification at test for fragpix presented at Level 3/2 during exposure
OLD	Mean threshold of identification for fragpix presented at test averaged across the three priming levels (Levels 7, 5, & 3)
NEW	Mean threshold of identification for novel fragpix shown during test
FR7	# of fragpix presented at Level 7 during exposure recalled for free recall test
FR5	# of fragpix presented at Level 5/4 during exposure recalled for free recall test
FR3	# of fragpix presented at Level 3/2 during exposure recalled for free recall test
FRN	# of New (once-seen) fragpix recalled during free recall test

Experiment 4

Coding Variables (continued)

CR7	# of fragpix presented at Level 7 during exposure recalled for cued recall test
CR5	# of fragpix presented at Level 5/4 during exposure recalled for cued recall test
CR3	# of fragpix presented at Level 3/2 during exposure recalled for cued recall test
CRN	# of New (once-seen) fragpix recalled during cued recall test
PR7	# of fragpix presented at Level 7 during exposure circled on picture recognition test
PR5	# of fragpix presented at Level 5/4 during exposure circled on picture recognition test
PR3	# of fragpix presented at Level 3/2 during exposure circled on picture recognition test
PRN	# of New (once-seen) fragpix correctly circled during picture recognition test
PRD	# of distracter (never-seen) fragpix correctly rejected (not circled) during picture recognition test
EX7	# of fragpix presented at Level 7 during exposure that were correctly identified
EX5	# of fragpix presented at Level 5/4 during exposure that were correctly identified
EX3	# of fragpix presented at Level 3/2 during exposure that were correctly identified
PH3	Probability of Hits on picture recognition for pictures presented at Level 3 during exposure
PH5	Probability of Hits on picture recognition for pictures presented at Level 5 during exposure
PH7	Probability of Hits on picture recognition for pictures presented at Level 7 during exposure
PHOLD	Averaged probability of Hits for pictures presented during at Levels 3, 5, 7

Experiment 4

Coding Variables (continued)

PHNEW	Probability of Hits for once-seen (New) pictures on picture recognition test
PF	Probability of False alarms for never-seen pictures (distracters) in picture recognition
A23	Values for conversion of picture recognition data to sensitivity measure: A" for items presented at Level 3 during exposure
A25	Values for conversion of picture recognition data to sensitivity measure: A" for items presented at Level 5 during exposure
A27	Values for conversion of picture recognition data to sensitivity measure: A" for items presented at Level 7 during exposure
BD3	Measure of response bias (B''_D) calculated from picture recognition for fragpix presented at Level 3 during exposure
BD5	Measure of response bias (B''_D) calculated from picture recognition for fragpix presented at Level 5 during exposure
BD7	Measure of response bias (B''_D) calculated from picture recognition for fragpix presented at Level 7 during exposure
BDOLD	Averaged value for response bias (B''_D) calculated for all pictures shown during exposure
BDNEW	Measure of response bias (B''_D) calculated for once-seen (New) pictures on picture recognition test
A2OLD	Averaged values for sensitivity measure: A" for twice-seen (Old) items presented during exposure on picture recognition test
A2NEW	Values for conversion of picture recognition data to sensitivity measure: A" for once-seen (New) items on picture recognition test

Experiment 4: Data Set

Participants 1 - 50

AGEG	AGE	CHANGE	GENDER	PICS	LV7	LV5	LV3	OLD
1	67	1	2	1	5	7	7	6.33
1	69	1	1	2	5	4.67	5.33	5
1	63	1	2	2	5.33	5.67	6.67	5.89
1	64	1	2	1	5	6.33	5.67	5.67
1	72	1	1	2	4.33	5.33	6.67	5.44
1	65	1	1	1	5	6.33	6.33	5.89
1	66	1	2	2	4	5	5.33	4.78
1	68	1	2	1	2	6.33	4.33	4.22
1	61	1	2	1	5.33	5.67	2	4.33
1	70	1	2	2	5.33	3.67	6.33	5.11
1	64	1	1	2	5	7	7	6.33
1	61	1	1	2	6	6.33	7.33	6.56
1	69	1	2	1	5.33	5.33	5.33	5.33
1	62	1	1	1	5.67	5	5.33	5.33
1	63	1	2	1	4.33	4.33	3.67	4.11
1	59	1	1	2	4.67	5.67	5.67	5.34
1	63	1	1	2	5.33	6.33	5.33	5.66
1	61	1	1	1	5.33	5.33	5.67	5.44
1	73	1	2	2	5	6.33	6.67	6
1	65	1	1	1	4.33	5.33	5.33	5
1	64	2	2	1	5	3.67	6.33	5
1	60	2	1	2	5.33	5.33	3.67	4.67
1	61	2	1	1	6	6.67	6.3	6.33
1	64	2	2	2	7	4.33	7	6.11
1	67	2	2	1	4.33	4	5	4.44
1	63	2	1	2	5	5.33	5.67	5.33
1	60	2	1	2	5.33	3.33	2.33	3.67
1	67	2	1	1	6	4.67	3.33	4.67
1	70	2	1	2	4	4.33	5	4.44
1	69	2	2	1	6	7	6.67	6.56
1	62	2	2	1	4	4	5	4.33
1	61	2	2	2	4	5.33	5	4.78
1	67	3	1	1	3	3.67	6	4.22
1	67	3	2	2	5.33	5	5.67	5.33
1	64	3	2	2	5	4.67	3	4.22
1	68	3	1	2	5.33	3.67	4	4.33
1	63	3	1	1	4.33	3.33	5.33	4.33
1	69	3	2	2	5	5	4.67	4.89
1	66	3	1	2	5.33	5.33	5	5.22
1	63	3	2	2	5	5.33	6.33	5.55
1	61	3	2	1	5.33	5.67	5	5.33
1	60	3	1	1	5.67	6.33	6.33	6.11
1	70	3	1	1	4.33	5.67	5	5
1	60	3	2	1	5.67	5.33	5.67	5.56
1	70	4	1	1	5.33	5	5	5.11
1	62	4	2	1	5.33	5.33	2.67	4.44
1	67	4	1	1	5	5	5	5
1	60	4	2	2	4	5	6	5
1	70	4	1	1	4.67	5.67	5	5.11
1	65	4	2	2	4.67	4.67	5.33	4.89

Experiment 4: Data Set

Participants 1 - 50

NEW	FR7	FR5	FR3	FRN	CR7	CR5	CR3	CRN
6.22	2	0	1	1	0	0	1	0
5.33	1	1	1	2	0	0	0	2
6.45	1	0	2	0	0	0	0	0
5.67	1	0	1	4	1	1	0	0
5	1	0	2	0	0	0	1	0
5.89	3	2	1	0	0	0	1	0
5	2	1	1	2	0	1	0	2
5.67	1	0	1	1	0	0	1	2
5.33	1	0	1	3	0	0	0	2
6.22	1	1	1	2	0	0	0	1
6.55	2	0	0	0	1	1	0	1
6.67	0	2	1	0	0	0	0	0
5.89	2	2	1	0	0	0	0	2
6	0	2	0	1	0	0	1	1
5.78	0	0	3	1	1	0	0	1
6.33	2	1	2	1	0	0	1	1
6.11	2	1	0	3	0	0	2	4
5.33	1	1	1	1	2	0	1	1
5.67	1	1	1	1	0	1	0	1
6.55	1	1	2	1	1	0	0	0
6.33	1	1	1	0	1	0	0	1
5.78	1	1	0	1	1	0	2	2
6.89	0	2	0	0	1	0	1	2
6.33	1	0	1	1	0	0	0	0
5.55	0	1	2	3	0	0	0	0
5.89	0	0	0	2	0	0	0	1
6.11	0	0	0	4	0	1	1	1
5.33	1	2	1	0	1	0	0	1
5.55	2	1	0	1	0	1	2	3
6.33	1	1	2	0	1	0	0	0
5.78	0	0	1	1	1	0	0	0
5.67	2	0	1	2	1	0	1	1
5.89	2	1	2	1	1	1	0	0
6.11	1	2	1	1	1	0	1	3
5.67	0	1	1	3	2	0	1	1
5.45	0	1	2	2	1	2	0	2
5.22	1	0	0	1	1	1	0	0
6.44	2	2	0	1	0	1	1	2
5.78	2	1	0	0	0	0	1	1
6.67	0	1	1	2	0	1	0	1
5.56	1	1	0	0	0	0	2	0
6.44	1	0	0	1	1	2	1	0
6.67	2	1	1	2	0	0	0	0
6.11	2	1	1	1	0	0	0	0
6.22	0	0	1	2	0	0	1	0
6.22	1	1	1	0	0	0	0	1
6.22	0	2	0	0	0	0	0	1
5.89	1	1	0	2	0	0	0	0
5.56	1	3	1	3	0	0	0	0
5.67	0	1	1	1	0	0	0	3

Experiment 4: Data Set

Participants 1 - 50

PIC7	PIC5	PIC3	PICN	PICD	EX7	EX5	EX3
3	3	3	9	9	3	0	0
3	1	3	7	9	3	0	0
3	3	3	8	9	3	0	0
3	3	3	9	6	3	0	0
3	3	3	7	9	3	1	0
3	3	3	5	8	3	0	0
3	3	3	8	7	3	1	0
					3	0	0
					3	3	0
3	3	3	9	7	3	2	0
3	2	3	8	9	3	0	0
3	3	3	9	8	3	0	0
3	3	3	8	9	3	1	0
3	2	3	8	9	3	1	0
3	3	3	9	8	3	1	1
3	3	3	8	9	2	0	0
3	3	3	9	9	3	1	0
3	3	3	9	8	3	0	0
3	3	3	9	4	3	1	0
3	3	3	9	9	3	1	1
3	2	3	9	7	3	1	0
3	2	3	9	9	3	1	0
3	3	3	9	9	3	0	0
3	3	3	9	6	2	2	0
2	3	3	6	8	3	1	0
3	3	3	8	9	3	0	1
3	3	3	9	8	3	2	0
3	3	3	7	8	3	2	0
3	3	3	6	9	3	3	1
3	3	3	8	7	3	1	0
3	3	3	7	8	3	1	0
3	3	3	8	9	3	2	0
3	3	3	9	9	3	2	0
3	3	3	8	9	3	2	0
3	3	3	8	7	3	2	1
3	3	2	9	8	3	2	0
2	3	2	8	9	3	3	0
3	3	2	8	9	3	1	0
3	3	2	7	8	3	2	0
3	3	3	9	8	3	2	0
3	3	3	9	6	3	1	0
3	3	3	9	8	3	0	0
3	3	3	9	9	3	2	0
3	3	3	7	8	3	0	0
3	3	2	7	7	3	3	1
3	3	3	8	9	3	1	0
3	3	3	9	7	3	2	0
3	3	3	7	9	3	1	0
3	3	2	8	9	3	2	0
3	3	3	9	9	3	1	0

Experiment 4: Data Set

Participants 1 - 50

BD3	BD5	BD7	BDOLD	BDNEW	A2OLD	A2NEW
0.545	0.545	0.545	0.545	0	0.928	0.958
0.545	0.943	0.545	0.677667	0.659	0.878	0.913
0.545	0.545	0.545	0.545	0.36	0.928	0.943
-0.429	-0.429	-0.429	-0.429	-0.789	0.813	0.882
0.545	0.545	0.545	0.545	0.659	0.928	0.913
0.231	0.231	0.231	0.231	0.73	0.897	0.811
-0.176	-0.176	-0.176	-0.176	-0.391	0.849	0.881
-0.977	-0.977	-0.977	-0.977	-0.993	-0.028	0.5
-0.977	-0.977	-0.977	-0.977	-0.993	-0.028	0.5
-0.176	-0.176	-0.176	-0.176	-0.659	0.849	0.913
0.545	0.789	0.545	0.626333	0.36	0.912667	0.943
0.231	0.231	0.231	0.231	-0.36	0.897	0.943
0.545	0.545	0.545	0.545	0.36	0.928	0.943
0.545	0.789	0.545	0.626333	0.36	0.912667	0.943
0.231	0.231	0.231	0.231	-0.36	0.897	0.943
0.545	0.545	0.545	0.545	0.36	0.928	0.943
0.545	0.545	0.545	0.545	0	0.928	0.958
0.231	0.231	0.231	0.231	-0.36	0.897	0.943
-0.724	-0.724	-0.724	-0.724	-0.91	0.726	0.816
0.545	0.545	0.545	0.545	0	0.928	0.958
-0.176	0.273	-0.176	-0.02633	-0.659	0.825333	0.913
0.545	0.789	0.545	0.626333	0	0.912667	0.958
0.545	0.545	0.545	0.545	0	0.928	0.958
-0.429	-0.429	-0.429	-0.429	-0.789	0.813	0.882
0.231	0.231	0.6	0.354	0.6	0.880333	0.847
0.545	0.545	0.545	0.545	0.36	0.928	0.943
0.231	0.231	0.231	0.231	-0.36	0.897	0.943
0.231	0.231	0.231	0.231	0.391	0.897	0.881
0.545	0.545	0.545	0.545	0.789	0.928	0.882
-0.176	-0.176	-0.176	-0.176	-0.391	0.849	0.881
0.231	0.231	0.231	0.231	0.391	0.897	0.881
0.545	0.545	0.545	0.545	0.36	0.928	0.943
0.545	0.545	0.545	0.545	0	0.928	0.958
0.545	0.545	0.545	0.545	0.36	0.928	0.943
-0.176	-0.176	-0.176	-0.176	-0.391	0.849	0.881
0.6	0.231	0.231	0.354	-0.36	0.880333	0.943
0.789	0.545	0.789	0.707667	0.36	0.897333	0.943
0.789	0.545	0.545	0.626333	0.36	0.912667	0.943
0.6	0.231	0.231	0.354	0.391	0.880333	0.881
0.231	0.231	0.231	0.231	-0.36	0.897	0.943
-0.429	-0.429	-0.429	-0.429	-0.789	0.813	0.882
0.231	0.231	0.231	0.231	-0.36	0.897	0.943
0.545	0.545	0.545	0.545	0	0.928	0.958
0.231	0.231	0.231	0.231	0.391	0.897	0.881
0.273	-0.176	-0.176	-0.02633	0	0.825333	0.817
0.545	0.545	0.545	0.545	0.36	0.928	0.943
-0.176	-0.176	-0.176	-0.176	-0.659	0.849	0.913
0.545	0.545	0.545	0.545	0.659	0.928	0.913
0.789	0.545	0.545	0.626333	0.36	0.912667	0.943
0.545	0.545	0.545	0.545	0	0.928	0.958

Experiment 4: Data Set

Participants 1 - 50

PH3	PH5	PH7	PHOLD	PHNEW	PF	A23	A25	A27
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.333	0.833	0.666333	0.778	0.056	0.928	0.778	0.928
0.833	0.833	0.833	0.833	0.889	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.333	0.813	0.813	0.813
0.833	0.833	0.833	0.833	0.778	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.556	0.111	0.897	0.897	0.897
0.833	0.833	0.833	0.833	0.889	0.222	0.849	0.849	0.849
0.833	0.833	0.833	0.833	0.944	0.944	-0.028	-0.028	-0.028
0.833	0.833	0.833	0.833	0.944	0.944	-0.028	-0.028	-0.028
0.833	0.833	0.833	0.833	0.944	0.222	0.849	0.849	0.849
0.833	0.667	0.833	0.777667	0.889	0.056	0.928	0.882	0.928
0.833	0.833	0.833	0.833	0.944	0.111	0.897	0.897	0.897
0.833	0.833	0.833	0.833	0.889	0.056	0.928	0.928	0.928
0.833	0.667	0.833	0.777667	0.889	0.056	0.928	0.882	0.928
0.833	0.833	0.833	0.833	0.944	0.111	0.897	0.897	0.897
0.833	0.833	0.833	0.833	0.889	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.111	0.897	0.897	0.897
0.833	0.833	0.833	0.833	0.944	0.556	0.726	0.726	0.726
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.667	0.833	0.777667	0.944	0.222	0.849	0.778	0.849
0.833	0.667	0.833	0.777667	0.944	0.056	0.928	0.882	0.928
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.333	0.813	0.813	0.813
0.833	0.833	0.667	0.777667	0.667	0.111	0.897	0.897	0.847
0.833	0.833	0.833	0.833	0.889	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.111	0.897	0.897	0.897
0.833	0.833	0.833	0.833	0.778	0.111	0.897	0.897	0.897
0.833	0.833	0.833	0.833	0.667	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.889	0.222	0.849	0.849	0.849
0.833	0.833	0.833	0.833	0.778	0.111	0.897	0.897	0.897
0.833	0.833	0.833	0.833	0.889	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.889	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.889	0.222	0.849	0.849	0.849
0.667	0.833	0.833	0.777667	0.944	0.111	0.847	0.897	0.897
0.667	0.833	0.667	0.722333	0.889	0.056	0.882	0.928	0.882
0.667	0.833	0.833	0.777667	0.889	0.056	0.882	0.928	0.928
0.667	0.833	0.833	0.777667	0.778	0.111	0.847	0.897	0.897
0.833	0.833	0.833	0.833	0.944	0.111	0.897	0.897	0.897
0.833	0.833	0.833	0.833	0.944	0.333	0.813	0.813	0.813
0.833	0.833	0.833	0.833	0.944	0.111	0.897	0.897	0.897
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.778	0.111	0.897	0.897	0.897
0.667	0.833	0.833	0.777667	0.778	0.222	0.778	0.849	0.849
0.833	0.833	0.833	0.833	0.889	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.222	0.849	0.849	0.849
0.833	0.833	0.833	0.833	0.778	0.056	0.928	0.928	0.928
0.667	0.833	0.833	0.777667	0.889	0.056	0.882	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928

Experiment 4: Data Set

Participants 51 - 100

AGEG	AGE	CHANGE	GENDER	PICS	LV7	LV5	LV3	OLD
1	60	4	1	2	5.67	5.67	5.33	5.56
1	64	4	1	2	4	4.33	6	4.78
1	61	4	1	1	5.33	5.33	4.33	5
1	67	4	2	1	5.33	3	5	4.44
1	63	4	1	1	4	4.67	3.33	4
1	62	4	2	1	4	4.33	2.33	3.55
1	67	4	1	1	2.67	4	3.67	3.45
1	70	4	1	2	5	4.33	4	4.44
1	67	4	2	2	4	4.33	6	4.78
1	71	4	2	1	4.67	3.33	3.67	3.89
1	62	4	2	1	3.33	2.67	4.67	3.56
1	66	4	2	2	6.33	2.33	5.33	4.67
1	72	4	1	2	5.33	3	4.67	4.33
1	65	4	1	2	5.33	3.67	5	4.67
2	97	1	1	1	4	5.67	3.67	4.45
2	99	1	1	2	4.67	6	6	5.56
2	97	1	1	1	4	4.33	4.33	4.22
2	95	1	1	1	4	4.33	3.67	4
2	103	1	1	2	5	4.33	6.33	5.22
2	113	1	2	1	3.67	2.33	2.67	2.89
2	92	1	2	2	5	3.33	4.33	4.22
2	111	1	1	2	5	3.67	4.67	4.44
2	102	1	1	2	5	3.67	6.33	5
2	101	1	1	2	4.67	4.33	3.67	4.22
2	100	1	2	2	3.33	3.67	3.67	3.56
2	99	1	1	1	4	4	3.67	3.89
2	99	1	2	1	4.33	5.67	3	4.33
2	98	1	2	2	6	2.67	5.67	4.78
2	102	1	1	1	3	5	4	4
2	104	1	1	1	3.67	6	3	4.22
2	112	1	1	2	4.67	4	3	3.89
2	95	1	2	2	4.67	4	4.67	4.45
2	96	1	2	1	3.67	2.33	2.67	2.89
2	101	1	2	2	4.33	3	4	3.78
2	98	2	2	2	4	3.67	5.67	4.44
2	100	2	1	2	4	4.67	5	4.56
2	108	2	2	2	4.33	3.67	3.67	3.89
2	102	2	1	2	3.33	2	5	3.44
2	106	2	2	2	4	4	3	3.67
2	98	2	1	1	4	2.67	4	3.56
2	98	2	2	1	5	3.33	3	3.78
2	107	2	2	1	5	5	3.67	4.55
2	114	2	2	2	3	4	4.67	3.89
2	98	2	1	2	2	4.67	2.33	3
2	95	2	2	2	3.67	2.33	5	3.67
2	97	2	2	1	3.33	3.33	4	3.55
2	100	2	2	1	3.67	3.33	2.33	3.11
2	103	2	1	1	3.67	3.33	3	3.33
2	101	2	1	2	4	3.33	2	3.11
2	100	2	1	1	3	2.33	3	2.78
2	95	2	1	1	5.33	4.33	5.33	5

Experiment 4: Data Set

Participants 51 - 100

NEW	FR7	FR5	FR3	FRN	CR7	CR5	CR3	CRN
6.11	1	1	1	2	0	1	1	2
5.67	3	1	3	1	0	1	0	3
5.56	2	3	2	1	0	0	0	2
5.78	2	1	1	0	0	1	0	1
5.44	0	2	0	2	0	1	0	1
6.22	1	1	3	1	0	0	0	2
6.22	1	2	0	2	0	0	0	2
5.56	0	2	1	1	0	0	0	2
5.78	0	1	1	1	0	0	1	2
5.55	0	1	2	5	1	1	0	0
4.67	1	3	1	2	1	0	0	0
6.22	2	1	1	3	0	0	1	1
5.78	1	1	2	3	0	1	0	1
5.89	0	1	0	2	0	0	2	2
6.11	0	1	2	2	0	0	0	3
5.33	1	3	3	1	1	0	0	3
4	2	0	1	2	0	1	2	1
5.89	2	2	0	2	1	0	2	3
6	1	2	1	2	1	0	0	3
5	1	1	1	3	2	0	0	2
4.89	2	3	1	0	0	0	0	1
4.78	2	2	1	2	0	0	1	2
5.67	1	1	1	1	1	1	0	2
5.44	1	2	1	4	1	1	0	2
4.33	1	3	1	1	1	0	1	2
4.78	1	3	2	2	0	0	0	2
5.33	0	0	0	1	0	0	0	1
5.33	2	1	1	0	0	0	1	3
5.11	3	1	1	2	0	0	1	0
5.11	2	3	1	2	1	0	1	1
4.89	1	2	2	3	1	1	0	0
6	2	2	0	1	0	0	0	2
5.22	3	1	3	0	0	0	0	3
4.89	1	1	2	3	1	1	1	2
5.22	3	2	1	4	0	0	0	2
5.33	1	1	2	2	0	0	1	2
5.67	2	2	2	0	1	0	0	6
5.22	2	3	2	2	0	0	0	1
5.11	1	2	2	3	0	0	1	1
4.55	1	0	2	3	0	0	0	1
5.11	3	1	3	3	0	0	0	1
5.33	2	1	1	1	0	0	0	1
5.33	2	0	2	2	1	0	0	3
4.33	2	2	1	3	1	0	0	2
4.78	1	0	2	5	1	2	0	2
4	1	1	3	2	1	0	0	1
4.44	0	2	3	2	1	0	0	1
4.44	1	2	3	4	2	1	0	0
4.22	1	1	1	4	1	0	1	3
4.22	1	3	3	5	1	0	0	2
5.67	1	1	2	4	1	0	1	1

Experiment 4: Data Set

Participants 51 - 100

PIC7	PIC5	PIC3	PICN	PICD	EX7	EX5	EX3
3	3	3	9	9	3	0	0
3	3	3	9	9	3	1	0
3	3	3	9	9	3	2	0
3	3	3	9	8	3	3	0
3	3	3	9	9	3	2	0
3	3	3	8	8	3	2	1
3	3	3	9	9	3	2	1
3	3	3	9	9	3	2	0
3	3	3	9	9	3	2	0
3	3	3	8	9	3	2	0
3	3	3	7	8	3	3	1
3	3	3	9	9	3	2	0
3	3	3	9	9	3	3	0
3	2	3	9	8	3	2	0
3	3	3	9	8	3	0	0
3	3	3	9	9	3	0	0
3	3	3	8	9	3	1	0
3	3	3	9	8	3	1	0
3	3	2	9	9	3	1	0
3	3	3	9	8	3	3	0
3	3	3	8	9	3	1	0
3	3	3	8	9	3	0	0
3	3	3	8	9	3	0	0
3	3	3	9	9	3	1	0
3	3	3	9	9	3	2	0
3	3	3	9	8	3	1	0
3	3	3	9	9	3	2	0
3	3	3	9	9	3	1	0
3	3	3	8	9	3	0	0
3	3	3	9	9	3	0	0
3	3	3	9	9	3	2	0
3	3	3	8	9	3	1	0
3	3	3	8	9	3	1	1
3	3	3	9	9	3	1	0
3	3	3	9	8	3	1	0
3	3	3	9	9	3	3	0
3	3	3	9	9	3	1	0
3	3	3	8	9	3	2	0
3	3	3	9	9	3	2	1
3	3	3	8	9	3	2	0
3	3	3	9	7	3	3	0
3	3	3	9	9	3	0	0
3	3	3	7	9	3	2	0
3	3	3	8	9	3	2	0
3	3	3	9	9	3	1	0
3	3	3	9	9	3	2	0
3	3	3	9	9	3	2	0
3	3	3	9	9	3	2	0
3	3	3	9	9	3	2	0
3	3	3	9	9	3	2	0

Experiment 4: Data Set

Participants 51 - 100

PH3	PH5	PH7	PHOLD	PHNEW	PF	A23	A25	A27
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.111	0.897	0.897	0.897
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.889	0.111	0.897	0.897	0.897
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.889	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.778	0.111	0.897	0.897	0.897
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.667	0.833	0.777667	0.944	0.111	0.897	0.847	0.897
0.833	0.833	0.833	0.833	0.944	0.111	0.897	0.897	0.897
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.889	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.111	0.897	0.897	0.897
0.667	0.833	0.833	0.777667	0.944	0.056	0.882	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.111	0.897	0.897	0.897
0.833	0.833	0.833	0.833	0.889	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.889	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.889	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.111	0.897	0.897	0.897
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.889	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.889	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.889	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.111	0.897	0.897	0.897
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.889	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.889	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.222	0.849	0.849	0.849
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.778	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.889	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928

Experiment 4: Data Set

Participants 51 - 100

BD3	BD5	BD7	BDOLD	BDNEW	A2OLD	A2NEW
0.545	0.545	0.545	0.545	0	0.928	0.958
0.545	0.545	0.545	0.545	0	0.928	0.958
0.545	0.545	0.545	0.545	0	0.928	0.958
0.231	0.231	0.231	0.231	-0.36	0.897	0.943
0.545	0.545	0.545	0.545	0	0.928	0.958
0.231	0.231	0.231	0.231	0	0.897	0.913
0.545	0.545	0.545	0.545	0	0.928	0.958
0.545	0.545	0.545	0.545	0	0.928	0.958
0.545	0.545	0.545	0.545	0	0.928	0.958
0.545	0.545	0.545	0.545	0.36	0.928	0.943
0.231	0.231	0.231	0.231	0.391	0.897	0.881
0.545	0.545	0.545	0.545	0	0.928	0.958
0.545	0.545	0.545	0.545	0	0.928	0.958
0.231	0.6	0.231	0.354	-0.36	0.880333	0.943
0.231	0.231	0.231	0.231	-0.36	0.897	0.943
0.545	0.545	0.545	0.545	0	0.928	0.958
0.545	0.545	0.545	0.545	0.36	0.928	0.943
0.231	0.231	0.231	0.231	-0.36	0.897	0.943
0.789	0.545	0.545	0.626333	0	0.912667	0.958
0.231	0.231	0.231	0.231	-0.36	0.897	0.943
0.545	0.545	0.545	0.545	0.36	0.928	0.943
0.545	0.545	0.545	0.545	0.36	0.928	0.943
0.545	0.545	0.545	0.545	0.36	0.928	0.943
0.545	0.545	0.545	0.545	0	0.928	0.958
0.545	0.545	0.545	0.545	0	0.928	0.958
0.231	0.231	0.231	0.231	-0.36	0.897	0.943
0.545	0.545	0.545	0.545	0	0.928	0.958
0.545	0.545	0.545	0.545	0	0.928	0.958
0.545	0.545	0.545	0.545	0.36	0.928	0.943
0.545	0.545	0.545	0.545	0	0.928	0.958
0.545	0.545	0.545	0.545	0	0.928	0.958
0.545	0.545	0.545	0.545	0.36	0.928	0.943
0.545	0.545	0.545	0.545	0.36	0.928	0.943
0.545	0.545	0.545	0.545	0	0.928	0.958
0.231	0.231	0.231	0.231	-0.36	0.897	0.943
0.545	0.545	0.545	0.545	0	0.928	0.958
0.545	0.545	0.545	0.545	0	0.928	0.958
0.545	0.545	0.545	0.545	0.36	0.928	0.943
0.545	0.545	0.545	0.545	0	0.928	0.958
0.545	0.545	0.545	0.545	0.36	0.928	0.943
-0.176	-0.176	-0.176	-0.176	-0.659	0.849	0.913
0.545	0.545	0.545	0.545	0	0.928	0.958
0.545	0.545	0.545	0.545	0.659	0.928	0.913
0.545	0.545	0.545	0.545	0.36	0.928	0.943
0.545	0.545	0.545	0.545	0	0.928	0.958
0.545	0.545	0.545	0.545	0	0.928	0.958
0.545	0.545	0.545	0.545	0	0.928	0.958
0.545	0.545	0.545	0.545	0	0.928	0.958
0.545	0.545	0.545	0.545	0	0.928	0.958
0.545	0.545	0.545	0.545	0	0.928	0.958
0.545	0.545	0.545	0.545	0	0.928	0.958

Experiment 4: Data Set

Participants 101 - 144

AGEG	AGE	CHANGE	GENDER	PICS	LV7	LV5	LV3	OLD
2	111	2	2	2	2.67	3.33	4.67	3.56
2	92	2	1	1	5	2.67	2	3.22
2	104	2	1	1	4.33	5	4.33	4.55
2	95	3	2	1	3.67	4.67	3.67	4
2	109	3	2	1	4	2.67	3.33	3.33
2	103	3	2	1	4.67	1.33	3	3
2	104	3	2	2	5.33	4.33	3.67	4.44
2	104	3	1	2	3	2.33	2.33	2.56
2	96	3	2	2	2.67	3.67	4	3.44
2	98	3	1	1	4.33	3.67	6.33	4.78
2	98	3	1	1	4	3	3.67	3.56
2	105	3	1	2	4.33	3.67	4.33	4.11
2	99	3	1	1	3.67	1	4.33	3
2	104	3	2	1	2.33	2.33	3.67	2.78
2	104	3	2	1	3.67	2.67	2.67	3
2	99	3	1	2	4.33	2	4.33	3.55
2	98	3	1	1	5.67	1.67	5	4.11
2	95	3	1	1	2.33	5	4.67	4
2	105	3	2	2	4.33	5	3	4.11
2	102	3	2	2	2.67	2.67	5	3.45
2	99	3	2	2	4.33	3.33	2	3.22
2	103	3	1	2	5.33	4.33	5.33	5
2	110	3	1	2	5.67	2.67	3	3.78
2	103	4	2	1	3	4	5.33	4.11
2	102	4	2	1	3.33	3.67	2.33	3.11
2	95	4	1	2	2.67	4	5.67	4.11
2	105	4	1	1	4	3	3.33	3.44
2	109	4	2	2	2.33	4.67	6	4.33
2	97	4	1	2	5.33	5.67	4.67	5.22
2	97	4	2	2	4.67	5	6	5.22
2	94	4	2	2	3.33	4.67	4.67	4.22
2	97	4	1	2	4	4	2	3.33
2	97	4	1	2	4.33	4.33	6	4.78
2	100	4	2	1	1	3.67	4.33	3
2	96	4	1	1	3.67	4.33	4	4
2	106	4	1	2	5	3.67	3.67	4.11
2	110	4	1	2	3.33	3.67	4	3.67
2	110	4	1	1	3.67	1.33	2.67	2.56
2	101	4	2	2	4.33	5	5.67	5
2	100	4	2	1	5.67	1.67	5.67	4.33
2	106	4	2	1	4	4	3.67	3.89
2	101	4	1	1	3.67	2.33	2.33	2.78
2	105	4	2	1	3.67	1.67	4.33	3.22

Experiment 4: Data Set

Participants 101 - 144

NEW	FR7	FR5	FR3	FRN	CR7	CR5	CR3	CRN
5.33	1	1	0	3	1	0	0	4
5.44	0	1	2	3	1	1	0	0
6	2	2	3	1	1	0	0	0
6.11	2	3	2	1	0	0	0	2
4.67	2	2	2	0	0	0	0	4
4.55	1	1	2	2	1	1	0	0
6	1	3	0	3	1	0	0	1
4.44	2	3	3	1	1	0	0	1
4.67	0	2	1	2	1	0	2	0
5.11	1	0	2	2	1	0	1	1
4.67	1	3	2	3	0	0	0	2
5.67	0	1	2	2	2	1	0	3
5	2	2	0	2	0	1	0	1
4.89	1	2	2	2	0	0	0	0
5.11	1	1	1	3	0	1	1	1
5.33	2	2	1	3	0	0	1	0
5.67	2	3	2	5	0	0	1	0
5.55	2	0	2	1	1	2	0	3
5.44	2	0	2	1	0	3	0	2
5	2	1	1	2	0	1	1	2
5.33	1	2	2	5	0	1	0	0
6.11	1	3	1	1	0	0	1	1
4.67	1	2	2	3	1	0	0	3
4.89	0	0	2	2	1	0	1	0
4.33	1	3	1	2	1	0	1	0
5.22	2	0	2	2	0	0	1	1
4.55	2	2	1	4	0	0	1	1
5.89	1	0	1	1	2	0	0	2
5.33	0	2	2	1	1	0	0	2
5.78	0	0	0	4	2	2	1	2
5.33	1	1	1	2	2	0	1	1
5	0	1	2	1	1	0	0	5
5.33	2	1	0	1	0	1	2	1
5.67	3	2	1	1	0	2	0	1
5.22	2	1	3	3	0	0	0	1
5.45	2	2	1	1	1	1	0	1
4.78	0	2	1	2	1	0	1	1
5.11	2	1	2	6	0	0	0	0
5.44	1	3	0	3	1	0	0	1
6.11	3	1	1	2	0	0	0	0
4.89	0	1	1	1	0	0	1	2
5.33	0	2	1	1	1	0	0	2
3.78	2	2	1	2	1	0	0	2

Experiment 4: Data Set

Participants 101 - 144

PIC7	PIC5	PIC3	PICN	PICD	EX7	EX5	EX3
3	3	3	9	9	3	2	0
3	3	3	8	9	3	3	0
3	3	3	9	9	3	1	0
3	3	3	9	9	3	1	1
3	3	3	8	9	3	2	0
3	3	3	8	9	3	2	0
3	3	3	9	9	3	2	0
3	3	3	9	7	3	2	0
3	3	3	9	9	3	1	0
3	3	3	9	8	3	2	0
3	3	3	9	9	3	2	0
3	3	2	9	9	3	1	0
3	3	3	9	9	3	0	0
3	3	3	8	9	3	2	0
3	3	3	9	9	3	1	0
3	3	3	9	9	3	3	0
3	3	3	8	9	3	2	0
3	3	3	9	6	3	1	0
3	3	3	8	9	3	2	0
3	3	3	8	9	3	3	0
3	3	2	9	9	3	2	0
3	3	3	9	9	3	0	0
3	3	3	9	9	3	1	0
2	2	3	7	8	3	1	0
3	3	3	9	9	3	1	0
3	3	3	8	9	3	2	0
3	3	3	8	9	3	1	0
3	3	3	9	9	3	2	0
3	3	3	9	9	3	0	1
3	3	3	9	9	3	0	0
3	3	3	9	8	3	1	0
3	3	3	9	9	3	3	0
3	3	3	8	8	3	1	0
3	3	3	8	9	3	1	1
3	3	3	7	9	3	2	0
3	3	3	9	9	3	1	0
3	3	3	8	9	3	1	1
3	3	3	9	9	3	2	0
3	3	3	8	9	3	2	0
3	3	3	8	9	3	1	1
3	3	3	9	9	3	2	0
3	3	3	9	9	3	2	1
3	3	3	8	9	3	3	0

Experiment 4: Data Set

Participants 101 - 144

PH3	PH5	PH7	PHOLD	PHNEW	PF	A23	A25	A27
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.889	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.889	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.889	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.222	0.849	0.849	0.849
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.111	0.897	0.897	0.897
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.667	0.833	0.833	0.777667	0.944	0.056	0.882	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.889	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.889	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.333	0.813	0.813	0.813
0.833	0.833	0.833	0.833	0.889	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.889	0.056	0.928	0.928	0.928
0.667	0.833	0.833	0.777667	0.944	0.056	0.882	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.667	0.667	0.722333	0.778	0.111	0.897	0.847	0.847
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.889	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.889	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.111	0.897	0.897	0.897
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.889	0.111	0.897	0.897	0.897
0.833	0.833	0.833	0.833	0.889	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.778	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.889	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.889	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.889	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.944	0.056	0.928	0.928	0.928
0.833	0.833	0.833	0.833	0.889	0.056	0.928	0.928	0.928

Experiment 4: Data Set

Participants 101 - 144

BD3	BD5	BD7	BDOLD	BDNEW	A2OLD	A2NEW
0.545	0.545	0.545	0.545	0	0.928	0.958
0.545	0.545	0.545	0.545	0.36	0.928	0.943
0.545	0.545	0.545	0.545	0	0.928	0.958
0.545	0.545	0.545	0.545	0	0.928	0.958
0.545	0.545	0.545	0.545	0.36	0.928	0.943
0.545	0.545	0.545	0.545	0.36	0.928	0.943
0.545	0.545	0.545	0.545	0	0.928	0.958
-0.176	-0.176	-0.176	-0.176	-0.659	0.849	0.913
0.545	0.545	0.545	0.545	0	0.928	0.958
0.231	0.231	0.231	0.231	-0.36	0.897	0.943
0.545	0.545	0.545	0.545	0	0.928	0.958
0.789	0.545	0.545	0.626333	0	0.912667	0.958
0.545	0.545	0.545	0.545	0	0.928	0.958
0.545	0.545	0.545	0.545	0.36	0.928	0.943
0.545	0.545	0.545	0.545	0	0.928	0.958
0.545	0.545	0.545	0.545	0	0.928	0.958
0.545	0.545	0.545	0.545	0.36	0.928	0.943
-0.429	-0.429	-0.429	-0.429	-0.789	0.813	0.882
0.545	0.545	0.545	0.545	0.36	0.928	0.943
0.545	0.545	0.545	0.545	0.36	0.928	0.943
0.789	0.545	0.545	0.626333	0	0.912667	0.958
0.545	0.545	0.545	0.545	0	0.928	0.958
0.545	0.545	0.545	0.545	0	0.928	0.958
0.231	0.6	0.6	0.477	0.391	0.863667	0.881
0.545	0.545	0.545	0.545	0	0.928	0.958
0.545	0.545	0.545	0.545	0.36	0.928	0.943
0.545	0.545	0.545	0.545	0.36	0.928	0.943
0.545	0.545	0.545	0.545	0	0.928	0.958
0.545	0.545	0.545	0.545	0	0.928	0.958
0.545	0.545	0.545	0.545	0	0.928	0.958
0.231	0.231	0.231	0.231	-0.36	0.897	0.943
0.545	0.545	0.545	0.545	0	0.928	0.958
0.231	0.231	0.231	0.231	0	0.897	0.913
0.545	0.545	0.545	0.545	0.36	0.928	0.943
0.545	0.545	0.545	0.545	0.659	0.928	0.913
0.545	0.545	0.545	0.545	0	0.928	0.958
0.545	0.545	0.545	0.545	0.36	0.928	0.943
0.545	0.545	0.545	0.545	0	0.928	0.958
0.545	0.545	0.545	0.545	0.36	0.928	0.943
0.545	0.545	0.545	0.545	0.36	0.928	0.943
0.545	0.545	0.545	0.545	0	0.928	0.958
0.545	0.545	0.545	0.545	0	0.928	0.958
0.545	0.545	0.545	0.545	0.36	0.928	0.943