The Effects of Maltreatment and Neuroendocrine Regulation on Memory Performance

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Abstract

This investigation examined basic memory processes, cortisol, and dissociation in maltreated children. School-aged children, 143 maltreated and 174 nonmaltreated, were administered the California Verbal Learning Test – Children (Delis, Kramer, Kaplan, & Ober, 1994) in a week-long camp setting, daily morning cortisol levels were assessed throughout the duration of camp, and behavioral symptoms were evaluated. Maltreatment and cortisol regulation were not related to short- or long-delay recall or recognition memory. However, children experiencing neglect/emotional maltreatment and low cortisol evinced heightened false recognition memory. Dissociative symptoms were higher in maltreated children; however, high dissociation was related to recognition inaccuracy only among nonmaltreated children. Results highlight the interplay between maltreatment and hypocortisolism in children's recognition memory errors.

Do maltreated children's basic memory processes operate in ways that are fundamentally different from those of nonmaltreated children? Despite the importance that answers to this question hold for advancing research, clinical, and socio-legal issues in the field of child maltreatment (Howe, 2000; Howe, Goodman, & Cicchetti, 2008; Howe, Toth, & Cicchetti, 2006; Toth & Cicchetti, 1998), there has been a paucity of studies, most of which have been published in recent years, that have examined basic memory processes in maltreated children (Howe, Cicchetti, & Toth, 2006).

Child Maltreatment and Memory

There are a number of reasons why the experience of child maltreatment might be expected to alter basic memory processes (Howe, Toth, & Cicchetti, 2006). Child abuse and neglect are stressful and threatening experiences that may bring about physiological changes in the neural mechanisms related to memory storage (Bremner & Narayan, 1998; Cicchetti, Rogosch, Gunnar, & Toth, in press; Howe, Cicchetti, & Toth, 2006). Moreover, a number of the socioemotional sequelae of child maltreatment, including the development of insecure, often disorganized, attachment relationships and deviations in symbolic and representational abilities (Cicchetti & Toth, 2005), may affect the processing of memories in abused and neglected children (Lynch & Cicchetti, 1998; Pollak, Cicchetti, & Klorman, 1998; Rieder & Cicchetti, 1989). In addition, it is conceivable that failures in caregiving may lead maltreated children either to defensively distort memories or to dissociate their memories of their abusive and neglectful experiences (Cicchetti & Valentino, 2006). Finally, maltreated children are at heightened risk for the development of trauma-related psychopathology, including Post-Traumatic Stress Disorder (PTSD) and dissociation, that may contribute to deficits in memory performance (Cicchetti & Toth, 2005; Howe, Toth, & Cicchetti, 2006).

The majority of the investigations on the effects of maltreatment experiences on memory have focused on examinations of adults who retrospectively report having been abused during their childhoods, adults with PTSD, nonmaltreated children participating in analog experiments, or individuals with relatively acute and/or routine stressors involving treatment for accidental injuries or visits to physicians' offices (Howe, 2000; Toth & Cicchetti, 1998). Among the studies of memory in adults who report having been maltreated, several investigations have used the Deese-Roediger-McDermott (DRM) paradigm (Deese, 1959; Roediger-McDermott, 1995) to examine false memories in adults who report having been maltreated in childhood and in adults who did not experience maltreatment (for a review, see Howe, Toth, & Cicchetti, 2006). Each of these investigations found that adults who report histories of maltreatment evinced a higher frequency of false recognition memory errors (i.e., inaccurately recognizing words not previously presented as heard**)** than did nonmaltreated comparison individuals.

Despite the fact that there have been relatively few studies of basic memory processes in maltreated children conducted to date, a review of the extant literature reveals that the experience of child abuse and neglect does not appear to exert any special effects on memory that fundamentally change the operation of memory from that observed in nonmaltreated children (Howe, Toth, & Cicchetti, 2006). For example, no differences have been found in investigations of maltreated children's memory for eyewitnessed events or in their degree of susceptibility to misinformation and suggestion, unless accompanying comorbid psychopathology is present (Eisen, Goodman, Qin, & Davis, 2002; Eisen, Goodman, Qin, Davis, & Crayton, 2007; Howe, Toth, & Cicchetti, 2006).

In an investigation of true and false recall memory in maltreated children, Howe, Cicchetti, Toth, and Cerrito (2004) examined the memory performances of maltreated and nonmaltreated children on the DRM task. The same pattern of results was found regardless of

maltreatment status. Consistent with the normative literature on false memory (Brainerd & Reyna, 2005), both maltreated and nonmaltreated children exhibited false recognition memories and memory inaccuracies with age at the same rate. Similarly, Porter, Lawson, and Bigler (2005) found no significant differences in memory function between sexually abused and nonabused children, despite elevations in psychopathology and diminished performance on measures of attention and executive function for the abused group. Additionally, Beers and DeBellis (2002) did not find any between group differences in basic memory processes for maltreated children and adolescents with PTSD and normative comparison youth. Overall, because these investigations focused on group differences, studies that examine within group differences might yield different results. Not all maltreated individuals are equally affected by their traumatic experiences (Cicchetti & Toth, 2005). Thus, investigations of basic memory processes in children who have experienced sexual and physical abuse, neglect, and emotional maltreatment are warranted.

Toward this end, a depth-of-processing incidental recall task was used to examine self-relevant information among maltreated children and the relation between maltreatment and false recall on dissociation (Valentino, Cicchetti, Rogosch, & Toth, 2008b). Abused, neglected, and nonmaltreated children all demonstrated better recall for words when words were encoded under self-referent conditions rather than under structural conditions. These results suggest that self-representations serve as an organizing schema for memory and may be used to facilitate recall (cf. Howe, 1998, 2000). Consistent with prior research (Howe et al., 2004), differences were not found among abused, neglected, or nonmaltreated children in the occurrence or total amount of false recall errors. Maltreated children were not rendered more or less susceptible to false recall errors (cf. Howe et al., 2004).

Notably, however, the younger group of neglected children demonstrated a greater proportion of negative false recall errors and less positive recall than did the younger abused children, suggesting a greater vulnerability for memory inaccuracy among neglected children. Among the older group, both abused and neglected children demonstrated less positive false recall than did the nonmaltreated children. Negative self-schemas were associated with increased dissociation among the abused children, whereas positive self-schemas were related to increased dissociation for the neglected children. In addition to addressing the role of dissociation on memory, it also is important to attend to possible neurobiological influences.

HPA Axis Functioning and Memory

Child abuse and neglect are stressful and threatening experiences that create adaptational challenges (Cicchetti & Rogosch, 2001a; DeBellis, 2001; Hart, Gunnar, & Cicchetti, 1996). One of the physiological systems that has evolved in mammals to help direct and sustain cognitive, emotional, and behavioral activity in response to threat and stress is the hypothalamic-pituitary-adrenal (HPA) axis. Basal levels of cortisol, usually referred to as the "stress hormone," are necessary for normal neurobiological growth and for the support of the metabolic activity necessary to sustain general functioning (McEwen, 1998). Among its many influences, cortisol affects the central neural processes that are implicated in cognition, emotion, and memory (Gunnar & Vazquez, 2006).

Brief elevations in cortisol following acute stressors enhance the individual's ability to manage stressful experiences competently, both physiologically and behaviorally (Lopez, Akil, & Watson, 1999; Vazquez, 1998). However, chronic hyperactivity of the HPA axis may eventuate in a number of negative biological and psychological outcomes, including the loss of hippocampal neurons and impaired affective and cognitive functioning (Sapolsky, 1992, 1996). Although studies of the effects of stress on HPA functioning in humans are less well controlled than are

those conducted with animals, hippocampal atrophy is associated with prolonged exposure to glucocorticoids, a class of steroid hormone that includes cortisol. Furthermore, chronic exposure to elevated levels of glucocorticoids is accompanied by cognitive problems, including impairment of declarative memory and visual episodic memory (for reviews, see Heffelfinger & Newcomer, 2001, and Howe, Toth, & Cicchetti, 2006).

Additionally, there is a phenomenon known as hypocortisolism in which individuals who have experienced chronic stress, such as ongoing maltreatment, may exhibit reduced adrenocortical secretion, reduced adrenocortical reactivity, or enhanced negative feedback inhibition of the HPA axis (Gunnar & Vazquez, 2001; Heim, Ebert, & Hellhammer, 2000; Miller, Chan, & Zhou, 2007). This flattening of the diurnal decrease in cortisol predicts heightened risk of impairment in cardiovascular and immune system functioning (Heim, Newport, Mletzko, Miller, & Nemeroff, 2008). Since it is firmly established that the glucocorticoid cortisol affects aspects of brain function such as visual episodic memory, just as is the case with hypercortisolism, hypocortisolism also may exert negative impacts upon brain development and cognitive functioning. To the best of our knowledge, to date there have been no studies conducted on the association between memory performance and hypocortisolism, either in maltreated or nonmaltreated children.

Studies cohere in the conclusion that the HPA axis of maltreated children is often characterized by regulatory difficulties (Tarullo & Gunnar, 2006). Although studies have not revealed differences in cortisol regulation between maltreated and nonmaltreated children, differences have emerged when maltreatment subtype is examined. For example, children who have been extensively maltreated (i.e., experienced sexual and physical abuse, plus neglect and/or emotional abuse) have been found to exhibit substantial elevations in morning cortisol levels (Cicchetti & Rogosch, 2001a); children in the multiple abuse (sexual and physical) group also have been shown to display elevations in cortisol levels in both the morning and afternoon (Cicchetti & Rogosch, 2001a). In contrast, maltreated children who have been physically abused, in the absence of sexual abuse, have been shown to exhibit low levels of cortisol. Thus, not all maltreated children exhibit the same patterns of cortisol regulation (Cicchetti, 2002). Hypercortisolism and hypocortisolism are likely outcomes of HPA axis dysregulation, while some maltreated children display what appears to be normal cortisol regulation (Cicchetti & Rogosch, 2001a; Tarullo & Gunnar, 2006).

Animal models of the impact of early caregiving adversity have predominantly focused on increased reactivity of the HPA axis on outcome (Heim, Owen, Plotsky, & Nemeroff, 1997; Sanchez, Ladd, & Plotsky, 2001; Sanchez, Noble, Lyon, Plotsky, Davis, Nemeroff, et al., 2005). However, as the research has been extended to human and non-human primates, it has become increasingly clear that a more accurate prediction is that the HPA axis will likely exhibit evidence of *dysregulation* and that this dysregulation may involve both hyper- and hypo- functioning (Heim, Plotsky, & Nemeroff, 2004; McEwen, 2000). Although not yet fully understood, a number of factors have been shown to affect whether elevated or suppressed cortisol occurs. The HPA axis tends to dysregulate in response to prolonged hyperactivation; thus, in response to chronic stressors, first hyper- and later hypo-activity of the axis may be noted (for review see Miller et al., 2007). Accordingly, hypercortisolism is more likely to occur as a result of acute stress and a shorter time since the onset of stress/maltreatment, whereas hypocortisolism is likely the result of a long-term process of chronic stress and a later time since the onset of stress/maltreatment.

Very few studies have examined stress and memory in normative samples of children

(Bremner & Narayan, 1998, 2001; Howe, Toth, & Cicchetti, 2006). The only investigation that has examined cortisol and memory in maltreated children conducted to date is that of Eisen and colleagues (Eisen et al., 2007). In the Eisen et al. (2007) study, maltreated and nonmaltreated comparison children's memory and suggestibility were assessed for an invasive medical procedure that had been administered to them as part of a child abuse and neglect investigation. At the conclusion of the medical examination, older (as compared to younger) children and those who possessed higher cognitive functioning exhibited fewer memory inaccuracies and less suggestibility in their responses to experimenter questions that focused on the recollection of events that were associated with the medical procedures that had been administered. For children low in dissociative symptomatology, higher levels of cortisol reactivity, assessed approximately 20 minutes after the medical procedures, were found to be related to fewer errors of omission to specific questions about the medical examination and to fewer errors of commission to the experimenter's misleading questions.

In contrast, for children who reported high levels of dissociative symptoms, higher levels of cortisol reactivity were related to more errors of omission to specific questions about the medical procedure and to more errors of commission to misleading questions of the experimenter. Although the initial findings of the Eisen et al. (2007) study are suggestive, limitations in the method of cortisol sampling, lack of cortisol collection for a sizable portion of the sample, and the very specific episodic memory assessment indicate that further research on cortisol, memory, and dissociation in maltreated children is necessary.

An interesting finding that emerged was that children who had experienced sexual and/or physical abuse evinced greater memory accuracy than did those who had experienced child neglect. Specifically, the sexually and/or physically abused children were less suggestible than were the neglected children when confronted with misleading questions about the medical examination, exhibited fewer errors of omission to questions about abuse-related incidents, and provided more correct answers in response to open-ended questions about the medical procedures. It may be the case that abuse contributes to greater vigilance and monitoring of experience and consequently to greater precision in memory encoding and retrieval.

In summary, because child maltreatment experiences do not affect all abused and neglected individuals in the same fashion *(known as multifinality – see Cicchetti & Rogosch, 1996)*, there are likely to be within group differences in memory performance among children with varying maltreatment subtypes. The chronic stress of maltreatment suggests that the cortisol dysregulation characteristic of many maltreated children may be a potential risk for recognition memory inaccuracies in these youngsters. Furthermore, neglected children may be more susceptible to recognition memory errors than are abused children (Eisen et al., 2007; Valentino et al., 2008b). Finally, dissociation appears to be either related to, or an independent contributor to, recognition memory inaccuracies.

In the present paper, we report the results of an investigation that examines the relation among neuroendocrine regulation, memory, and dissociative symptoms in maltreated children. We expect the memory performance of maltreated children to differ in relation to varying levels of cortisol regulation. Specifically, we examine the extent to which maltreated children's basic recognition memory processes differ from those of a group of demographically comparable nonmaltreated children. We then investigate the relation between these basic memory processes and individual differences in neuroendocrine functioning and dissociation in maltreated and nonmaltreated children.

This research is guided by the following hypotheses and research questions:

1) In accord with the extant literature, we expected that maltreated children's basic recall and recognition memory skills would not differ from those of nonmaltreated children.
2) We did not expect to find group mean differences between maltreated and comparison children in average morning cortisol levels; however, more extreme patterns of atypical cortisol regulation were expected in physically and/or sexually abused children.
3) We expected that maltreated children with either low morning cortisol or high morning cortisol, suggesting neuroendocrine dysregulation, would have more false recognition memory than nonmaltreated children. Based on the Eisen et al. (2007) and Valentino et al. (2008b) findings, we hypothesized that this relation would be particularly true for children who experienced physical neglect and/or emotional maltreatment but not physical and sexual abuse.
4) Finally, we expected that high levels of dissociation would be related to anticipated differences in memory performance based on maltreatment subtype and cortisol regulation patterns.

Method

Participants

The participants in this investigation included 317 children who attended a recreational summer camp program designed for school-aged low-income, maltreated (n = 143) and nonmaltreated (n = 174) children. Two cohorts of children from different camp years were aggregated for the current study. In addition to recreational activities, the annual summer camp program incorporated research assessments. The children on average were 9.17 years of age (SD = 2.43, range: 6-13), and 54.6% were boys. The racial/ethnic composition of the sample was diverse: 56.6% were black, 21.5% were white, 17.0% were Latino, and 1.9% were of other racial/ethnic backgrounds.

Parents of all maltreated and nonmaltreated children provided informed consent for their child's participation, as well as consent for examination of any Department of Human Services (DHS) records. Children in the maltreated group had been identified by the county DHS as having experienced child abuse and/or neglect, and the sample was representative of the children in families receiving services from the DHS. A recruitment liaison from DHS contacted eligible maltreating families, explained the study, and if parents were interested, then their names were released to the project team for recruitment. Comprehensive searches of DHS records were completed, and maltreatment information was coded utilizing operational criteria contained in the Barnett, Manly, and Cicchetti (1993) nosological system for child maltreatment. Children in the maltreated group were living in their family homes and not residing in foster care.

Consistent with national demographic characteristics of maltreating families (NIS-3; Sedlack & Broadhurst, 1996), the maltreated children were predominantly from low socioeconomic status families. Accordingly, a demographically comparable sample of nonmaltreated children was recruited from families receiving Temporary Assistance to Needy Families (TANF). A DHS recruitment liaison contacted eligible nonmaltreating families, described the project, and if interested, parents signed a release for their names to be given to the project for recruitment. DHS record searches were completed for these families to verify the absence of any record of child maltreatment. Trained research assistants also interviewed mothers of children recruited for the nonmaltreatment group to confirm a lack of DHS involvement and prior maltreatment experiences. Subsequently, record searches were conducted in the year following camp attendance to verify that all available information had been accessed. Only children from families without any history of documented or mother-reported abuse and/or

neglect were retained in the nonmaltreatment group. In addition, families who had received preventive services through DHS due to concerns over risk for maltreatment also were excluded from the nonmaltreated comparison group to reduce the potential for unidentified maltreatment existing within this group

Table 1 presents demographic information for families of children in the maltreated and nonmaltreated groups. The groups were comparable on a number of family characteristics. The maltreated and nonmaltreated groups did not differ in terms of total family income (including public assistance; t (305) = 1.45, p = .15), maternal marital status ($?^2$ (2) = 4.95, p = .08), or maternal education ($?^2$ (1) = 3.11, p = .08). Overall, the majority of families in both groups were headed by a single parent, and most mothers had a high school education or less. Family income was limited, and across the families, 73% were currently receiving public assistance.

Procedure

Children attended a week-long day camp program, participated in research assessments, and took part in a variety of recreational activities. The camp was not designed to provide a therapeutic intervention experience. After providing assent, children participated in various research assessments (see Cicchetti & Manly, 1990, for detailed descriptions of camp procedures). Children were administered the specific measures of interest in the current report, the California Verbal Learning Test - Children and the Peabody Picture Vocabulary Test-III, on different days during the camp week. At the end of each week, counselors who worked with the children rated them on behavioral symptomatology.

Measures

Maltreatment Classification System (MCS; Barnett, Manly, & Cicchetti, 1993). The MCS (Barnett et al., 1993) was used to delineate diverse features of maltreatment experienced by individual children. The MCS utilizes DHS records detailing investigations and findings involving maltreatment in identified families over time. Rather than relying on official designations and case dispositions, the MCS codes all available information from DHS records, making independent determinations of maltreatment experiences. Based on operational criteria, the MCS designates all of the subtypes of maltreatment children have experienced (i.e., neglect, emotional maltreatment, physical abuse, sexual abuse), the perpetrator(s) of the maltreatment, the severity of each subtype, frequency of occurrence, and the developmental periods of occurrence, allowing for determination of onset, recency, and chronicity.

In terms of the subtypes of maltreatment, *neglect* involves failure to provide for the child's basic physical needs for adequate food, clothing, shelter, and medical treatment. In addition to inadequate attention to physical needs, forms of this subtype include lack of supervision, moral-legal neglect, and educational neglect. *Emotional maltreatment* involves extreme thwarting of children's basic emotional needs for psychological safety and security, acceptance and self-esteem, and age-appropriate autonomy. Examples of emotional maltreatment of increasing severity include belittling and ridiculing the child, extreme negativity and hostility, exposure to severe marital violence, abandoning the child, and suicidal or homicidal threats. *Physical abuse* involves the non-accidental infliction of physical injury on the child (e.g., bruises, welts, burns, choking, broken bones). Injuries range from minor and temporary to permanently disfiguring. Finally, *sexual abuse* involves attempted or actual sexual contact between the child and caregiver for purposes of the caregiver's sexual satisfaction or financial benefit. Events range from exposure to pornography or adult sexual activity, to sexual touching and fondling, to forced intercourse with the child.

Coding of the DHS records was conducted by trained research assistants, doctoral students, and clinical psychologists. Coders were required to meet acceptable reliability with criterion standards before coding actual records for the study. Coders demonstrated acceptable reliability (weighted ?‘s with the criterion ranging from .86 to .98). Reliabilities for the presence/absence of maltreatment subtypes (?’s of .90 to 1.00) also were established. Other investigators have demonstrated that the MCS is reliable and valid in classifying maltreatment (Bolger et al., 1998; Dubowitz, Pitts, Litrownik, Cox, Runyan, & Black, 2005**;** English, Upadhyaya, Litrownik, Marshall, Runyan, Graham, et al., 2005; Manly, 2005; Smith & Thornberry, 1995).

Among the maltreated children, 79.7% had experienced neglect, 73.4% had experienced emotional maltreatment, 36.4% had experienced physical abuse, and 14.7% had experienced sexual abuse. Thus, neglect and emotional maltreatment had occurred frequently among most of the maltreated children, whereas lower prevalence rates were found for physical and sexual abuse. As is typical in maltreated populations (Bolger et al., 1998; Manly, Cicchetti, & Barnett, 1994; Manly, Kim, Rogosch, & Cicchetti, 2001), the majority of children had experienced multiple subtypes of maltreatment. Specifically, 68.5% of the maltreated children had experienced two or more maltreatment subtypes (M = 2.04, SD = .89), and 14 of the 15 possible combinations of the four maltreatment subtypes were observed in the sample. In order to consolidate groups for comparison purposes, we sought to differentiate children whose maltreatment experiences had involved physical and/or sexual abuse with or without neglect and emotional maltreatment (PA/SA, n = 61) from those who had not been physically or sexually abused but had been neglected and/or emotionally maltreated (PN/EM) (n = 82). Within the PA/SA group, 75.4% had been emotionally maltreated and 82.0% had been neglected. Comparable rates of emotional maltreatment (72.0%) and neglect (78.0%) were observed in the PN/EM group. Thus, what distinguished the PA/SA group from the PN/EM group was the presence of abuse.

Salivary cortisol. The camp context provided a setting where a consistent collection of saliva samples could occur at uniform times across the camp week. Each day upon arrival to the camp at 9:00 a.m. trained research assistants obtained saliva samples from each child. The children had not consumed food or drink for at least 30 minutes before each saliva sample was obtained. Given the approximate 45-minute transportation time and the time spent being greeted by camp staff, children had been awake at least one hour prior to providing the morning saliva samples. Because cortisol levels are volatile and sharply rise and fall during the first hour after morning awakening (cf. Susman, Dockray, Dorn, Schiefelbein, Herwehe, & Heaton, 2007), the timing of morning samples likely occurred when relative stability in morning level was established, before gradually declining over the course of the day. Although we were not able to obtain daily wake-up times for children, there is no reason to suspect that wakening times systematically varied across groups.

Two different saliva collection procedures were used depending on the child’s cohort membership. In the first cohort involving 49.8% of the participants, Kool-Aid crystals were administered to stimulate saliva flow, mouthing of a sterile cotton dental role to soak up the saliva, with subsequent expressing of the saliva from the dental role into storage vial via a syringe at –80^{o}C. Cortisol assays were conducted at the University of Minnesota utilizing the Ciba Corning Magic Cortisol Kit. For the second cohort, children deposited saliva through a small straw directly into storage vials. The samples were analyzed at Pennsylvania State University using a high-sensitive enzyme immunoassay (Salimetrics, PA).

Because of the difference in assay method and variation in the distribution of assay results

in different cohorts, standardized scores were used to calibrate samples across cohorts. As is typical, high kurtosis and negative skew characterized the distributions of cortisol values each year. As a result, all values were transformed using log10. Within each year all log10 transformed values were converted to Z scores. The standardized scores thus allowed for relative comparability in cortisol levels across camp years (cf. Cicchetti & Rogosch, 2001a, 2001b). All morning values for each child were averaged to derive a mean morning cortisol variable. The two cohorts did not differ on demographic characteristics, cortisol levels, memory variables, or dissociation.

California Verbal Learning Test – Children (CVLT-C; Delis, Kramer, Kaplan, & Ober, 1994). The CVLT-C provides an assessment of strategies and processes involved in learning and recall of verbal material. The test is individually administered and normed for children aged 5 to 16. It is used to assist in the diagnosis and treatment of memory impairments. The CVLT-C provides indices of verbal learning and recall and recognition memory. The CVLT-C was developed and standardized on a representative sample of the U.S. population, and reliability and validity have been established (Delis et al., 1994). Completion time for the CVLT-C was approximately 50 minutes.

In the first five trials, children are read a list of 15 words from three non-affective semantic categories (i.e., things to wear; things to play with; fruits) and then are asked to recall as many words as they can. An interference trial of 15 new words is then presented. Children are then requested to freely recall the words from the original list and then are given a subsequent trial in which semantic cues to the words are presented to facilitate recall. A 20-minute delay involving a nonverbal activity occurred next. Children then are directed to recall the original word list, followed by another cued recall trial. Finally, children were presented with a serial list of 45 items and asked to determine whether each word was on the original list. In the current report, children are compared on their abilities in short-delay recall, long-delay recall, recognition memory, and false positive memory recognition. A discriminability index, comparable to d', which assesses children ability to distinguish target words from distractor words, also was evaluated. Age standardized scores for all memory variables were used. Finally, deficits in retrieval (low standard scores for long-delay recall and normal standard scores for discriminability) and encoding (low standards scores for both long-delay recall and discriminability) also were examined.

Peabody Picture Vocabulary Test – III (PPVT-III; Dunn & Dunn, 1997). The PPVT-III assesses children's receptive vocabulary abilities. The PPVT-III correlates with the Full Scale IQ of the Wechsler Intelligence Test for Children (WISC-III). The PPVT-III was completed in approximately 15 minutes.

Teacher Report Form (TRF; Achenbach, 1991) *and dissociation subscale*. Behavioral symptomatology was evaluated at the end of each week by camp counselors' completion of the TRF after approximately 35 hr of observation and interaction with the children. The camp counselors were unaware of maltreatment status and research hypotheses. The TRF is a widely used and validated instrument to assess behavioral disturbance from the perspective of teachers, and the measure was used in the present study, because camp counselors are able to observe similar behaviors to that of teachers. The TRF, containing 118 items rated for frequency, assesses a broad range of symptoms. In the present study, interrater reliability for total behavior problem scores, based on average intraclass correlations among pairs of raters, ranged from .78 to .87 (M = .82). Ogawa and colleagues (1987) developed a subscale to assess dissociative symptoms in childhood and adolescence based on 12 TRF items. The content of these items is similar to those

assessed by the *Child Dissociative Checklist* (Putnam, Helmers, & Trickett, 1993). The counselors' scores for the dissociation subscale items for each child were averaged to derive individual child scores for dissociative symptomatology.

Results

Maltreatment and cortisol dysregulation

Overall, as found in previous work (Cicchetti & Rogosch, 2001a, 2001b), maltreated and nonmaltreated children did not differ in their average level of morning cortisol, t (313) = 1.60, p = .11. Furthermore, no significant differences were found for the PA/SA, PN/EM, and nonmaltreated groups, F(2, 312) = 1.41, p = .24. (See Table 2). However, based on an interest in patterns of cortisol dysregulation (i.e., hypocortisolism; hypercortisolism) rather than solely on group mean levels, children were differentiated into three groups based on the sample's distribution of average morning cortisol scores: low morning cortisol (< - 1 *SD*), medium morning cortisol (> - 1 *SD* and < + 1 *SD*), and high morning cortisol (> + 1 *SD*). The proportion of children in the three cortisol groups differed between maltreated and nonmaltreated children, (^{2} (2, N = 315) = 6.59, p = .04. Group contrasts revealed that more maltreated children (19.7%) were in the low cortisol group compared to nonmaltreated children (10.4%), (^{2} (1, N = 315) = 5.43, p = .02, whereas the proportion in the high morning cortisol group did not differ between maltreated (14.8%) and nonmaltreated children (12.1%), (^{2} (1, N = 315) = 0.47, p = .49.

Maltreatment subtypes, cortisol dysregulation, and memory performance

Next, a series of ANCOVAs was conducted to examine maltreatment subtype groups and the three-level grouping of morning cortisol in relation to differences in memory processes, as indicated by standard scores from the CVLT-C, including short-delay recall, long-delay recall, recognition memory, false positive recognition memory, and the discriminability index. Subtype group means are presented in Table 2. Children's age and PPVT-III scores were used as covariates in all analyses. Initially, general memory processes, including short- and long-delay recall and recognition memory were examined. ANCOVAs for these variables did not result in any significant main or interactive effects (see Table 3).

In contrast**,** significant effects were obtained for false positive recognition memory, as shown in Table 3. In the ANCOVA, a significant effect was obtained for cortisol level F(2,302) = 5.13, p = .01; however, this effect was clarified by a significant interaction between maltreatment subtype and cortisol level F(4,302) = 2.45, p = .05. Figure 1 depicts the interactive effect. To probe the interaction effect, separate ANCOVAs were conducted within each of the maltreatment subtype groups to examine the relation of cortisol level to false recognition memory. The effect of cortisol level was not significant in the analysis for nonmaltreated children, F(2,167) = 1.38, p = .46, or for the PA/SA group, F(2,55) = 1.97, p = .24. However, a significant effect was obtained for the PN/EM group, F(2,76) = 9.01, p < .001. Post hoc Tukey tests indicated that within the PN/EM group of children, the low cortisol group had significantly higher false recognition memory scores than the average and high cortisol groups.

The discriminability index, which measures a child's ability to distinguish between target words and distractors, taking into account a child's recognition memory ability in relation to the rate of false positives, also was evaluated. False recognition memory and the discriminability index were correlated (r = .49, p < .001). The results from the ANCOVA for the discriminability index mirrored those observed for false recognition memory. The effect of cortisol levels was significant, F(2,302) = 3.16, p = .04, and a marginally significant interaction effect between maltreatment subtype group and cortisol level was observed, F(4,302) = 2.28, p = .06. This interaction is depicted in Figure 2. The interaction effect was probed by examining the effect of

cortisol level on the discriminability index within each of the maltreatment subtype groups. No significant effect of cortisol level was found in the nonmaltreated group, $F(2,167) = 0.10$, $p = .91$, or the PA/SA group, $F(2,55) = 0.14$, $p = .87$, whereas a significant interaction was obtained for the PN/EM group, $F(2, 76) = 11.18$, $p < .001$. Post hoc Tukey tests indicated that among the PN/EM children, those with low morning cortisol group had significantly lower discriminability scores than children with medium level morning cortisol.

Additionally, the potential for retrieval and encoding deficits to influence these findings was evaluated. The overall rates of deficits in retrieval (10.4%) and in encoding (8.2%) in the sample were low. No significant differences between subtype groups were obtained for retrieval deficits, $?^2$ (2, $N = 317$) = .59, $p = .74$, or for encoding deficits, $?^2$ (2, $N = 317$) = 1.18, $p = .55$. Similarly, the cortisol groups also were not differentiated by the rate of retrieval deficits, $?^2$ (2, $N = 317$) = .87, $p = .65$, or encoding deficits, $?^2$ (2, $N = 317$) = .28, $p = .87$. Thus, retrieval and encoding deficits did not appear to be unique to particular subtype or cortisol level groups.

The differentiation in memory performance between the PA/SA and PN/EM groups was examined in further detail to determine if other aspects of child maltreatment would better explain the interaction effects of level of morning cortisol and subtype. Specifically, rather than subtype, various maltreatment features, including early onset of maltreatment in infancy and/or toddlerhood, chronicity based on number of developmental periods of maltreatment occurrence, recency of maltreatment, and the number of subtypes of maltreatment experienced were examined in the same ANCOVAS as utilized above. None of the interaction effects of the various maltreatment features and level of morning cortisol was significant, indicating that the subtype interactive effects provided the greatest explanatory power.

The influence of dissociative symptomatology

The influence of dissociative symptomatology on the findings also was examined. Initially, an ANOVA was conducted to examine potential differences in dissociation scores based on cortisol levels and subtype group. Neither the main effect of cortisol level, $F(2,303) = .42$, $p = .66$, nor the interaction of subtype group and cortisol level, $F(4,303) = .79$, $p = .53$, was significant. However, significant subtype differences were found, $F(2,303) = 7.37$, $p < .001$. Tukey post hoc tests indicated that children in both the PA/SA group (M = 3.53, SD = 3.05) and the PN/EM group ($M = 2.93$, $SD = 2.99$) had significantly higher dissociation scores on average than the nonmaltreated group ($M = 1.63$, $SD = 1.94$).

Next, given an interest in the effects of high levels of dissociative symptoms, children with dissociation symptoms greater than + 1 *SD* were categorized into a high dissociation group ($n = 51$), and all remaining children were categorized into a low dissociation group ($n = 260$). The dissociation level factor was then used in subsequent ANCOVAs along with subtype group to predict memory performance, with age and PPVT-R standard scores as covariates. The main and interaction effects for these analyses were all nonsignificant for short-term recall, long-term recall, and recognition memory. In contrast, findings emerged for false recognition memory and discriminability. For false recognition memory, a main effect was found for dissociation level, $F(1,311) = 4.37$, $p = .04$. However, this main effect was qualified by a significant interaction effect of dissociation level and subtype group, $F(2,311) = 4.16$, $p = .02$. To probe the interaction, follow-up analyses were conducted within each subtype group. Whereas no significant differences in false recognition were observed between children with high and low dissociation levels in the PN/EM, $F(1,75) = 1.53$, $p = .22$, or the PA/SA, $F(1,56) = 1.50$, $p = .23$, groups, among the nonmaltreated group, children with high levels of dissociative symptoms had higher false recognition scores ($M = .90$, $SD = 1.66$) than those with low levels of dissociation ($M = -.17$,

SD = 1.11), *F*(1,168) = 8.91, *p* = .003. Similar effects were found for discriminability, with a significant effect for the interaction of dissociation level and subtype group, *F*(2,303) = 3.29, *p* = .04. Again, no differences were found within the PN/EM or PA/SA based on dissociation level, whereas among nonmaltreated children, those with high dissociation had poorer discriminability scores (*M* = -1.20, *SD* = 1.89) than those with low dissociation scores, (*M* = -.13, *SD* = 1.31), *F*(1,168) = 6.27, *p* = .04). Finally, whether high dissociation was related to greater likelihood of retrieval or encoding deficits was examined; both ?^{2} tests were nonsignificant, *p*'s > .80. Further analyses examining subtype, dissociation level, and cortisol group were not feasible given restrictions in cell sizes. Overall, the findings suggest that dissociation contributes to higher inaccurate memory among nonmaltreated children, but does not influence false recognition or discriminability among PN/EM or PA/SA children. Thus, dissociation does not account for the attenuated memory performance of PN/EM children with low cortisol.

Discussion

Consistent with the extant literature, the findings from this investigation reveal that the experience of child maltreatment per se does not appear to adversely affect, nor does it enhance, basic memory for nontraumatic material (Howe, Cicchetti, & Toth, 2006; Howe, Toth, & Cicchetti, 2006). Specifically, in accord with our hypotheses, the basic recall and recognition memory abilities of maltreated children did not differ from that of the nonmaltreated comparison children. Likewise, an examination of the rate of deficits in encoding and retrieval memory processes revealed no between group differences. Conversely, when examining HPA axis functioning and memory, some interesting differences between maltreated and nonmaltreated comparison children do begin to emerge. As anticipated, differences were not found in the average morning basal cortisol of maltreated and nonmaltreated children. Notably, however, when different levels of cortisol regulation were examined, more maltreated children exhibited lower levels of basal cortisol than did nonmaltreated children.

Our hypothesis that low morning cortisol would result in increased false recognition memory in maltreated children was supported; however, our hypothesis that maltreated children who exhibited high morning cortisol levels would display increases in false recognition memory was not confirmed. More specifically, in the present study the expectation that the subgroup of maltreated children with low cortisol who had experienced PN/EM would exhibit increased false recognition memory and poorer discriminability was confirmed. These results are in keeping with those reported in two prior investigations of false memory in maltreated children (Eisen et al., 2007; Valentino et al., 2008b). In both of these investigations, children who had experienced physical neglect and often co-occurring emotional maltreatment evinced increased levels of memory inaccuracy compared to children who experienced physical abuse and/or sexual abuse.

Furthermore, an in-depth examination of additional maltreatment classification system variables that could have influenced the results obtained included an investigation of the potential contribution of age of onset of maltreatment, the number of developmental periods during which a child experienced maltreatment, the recency of maltreatment, and the distinct number of subtypes of maltreatment that occurred. None of these factors were found to interact significantly with morning levels of cortisol. Thus, the significant interaction effect of physical neglect/emotional maltreatment and low levels of morning cortisol resulted in the clearest identification of a subgroup of maltreated children with elevated recognition inaccuracy.

To the best of our knowledge, the finding that low basal levels of cortisol are associated with impairments in false recognition memory in neglected/emotionally maltreated children is the first demonstration that a form of cortisol dysregulation known as hypocortisolism can exert

negative effects on memory. Conversely, we did not find an association between high basal levels of cortisol and increased false recognition memory. The absence of differences for high basal cortisol may be related to the co-occurrence of psychopathology, specifically dissociation. The only previous investigation to examine memory processes and cortisol in maltreated children and adolescents (Eisen et al., 2007) found that among children with high levels of dissociative symptomatology, high cortisol reactivity to a stressful medical examination was associated with memory impairment (i.e., increased suggestibility); however, for children with low levels of dissociation, high cortisol reactivity was not found to relate to suggestibility of memory. Thus, it appears that high levels of dissociation moderated the relation between cortisol reactivity and suggestibility. Unfortunately, due to sample size restrictions, the Eisen et al. study could not examine the possible effects of maltreatment subtype on cortisol reactivity.

In the current investigation, maltreated children in the physically and/or sexually abused and the physically neglected and/or emotionally maltreated groups had greater levels of dissociative symptoms than did the nonmaltreated comparison children. Cortisol level alone or in interaction with subtype did not predict dissociation symptoms. Similar to the results obtained by Eisen et al. (2007), we found that high dissociation was related to higher false recognition memory; however, in contrast, and contrary to our expectations, in our investigation these results held true only for the nonmaltreated comparison group of children with high dissociative symptoms. We did not find any relation between high dissociation and higher false recognition memory for the physically and/or sexually abused or the physically neglected/emotionally maltreated groups. It should be kept in mind that the Eisen et al. (2007) study focused on cortisol reactivity (and not basal levels as we did) and assessed an affectively-laden form of memory (suggestibility in response to a medical exam as opposed to inaccuracies in basic recognition memory).

Our findings suggest that there may be two different risk profiles associated with false recognition memory. For the subgroup of nonmaltreated children, increased levels of dissociative symptoms appear to be the contributor to false recognition memory. In contrast, increased dissociative symptomatology was not related to false recognition memory in the physically neglected/emotionally maltreated subgroup of children; rather, low levels of basal cortisol were found to be associated with false recognition memory. Among children in the physically and/or sexually abused group, there does not appear to be a risk profile for recognition memory inaccuracy. Specifically, neither increased dissociation, nor cortisol level were associated with false recognition memory for these children.

Because the HPA-axis has been demonstrated to down-regulate in response to chronic stressors, the presence of hypocortisolism suggests that HPA-axis dysregulation has been operating for a prolonged period of time. Just as has been found in empirical studies of hypercortisolism and memory (McEwen & Stellar, 1993; Sapolsky, 1996), the HPA-axis dysregulation characteristic of hypocortisolism also may be related to neurobiological sequelae and memory impairments.

Neuroimaging studies conducted with maltreated individuals have revealed that the hippocampus, the major brain structure that subserves memory, evinces structural decreases in volume among adults (Bremner, Vythilingam, Vermetten, Southwick, McGlasha, Nazeer, et al., 2003). However, cross-sectional and short-term longitudinal studies of maltreated children and adolescents with PTSD have not found evidence of structural hippocampal impairments (DeBellis, 2001, 2005). Although stress-induced hypercortisolism has often been invoked as a potential neurobiological mechanism underlying the development of hippocampal damage, it is

conceivable that hypocortisolism also may be a likely indicator of hippocampal damage given that the HPA axis of individuals with hypercortisolism over time would tend to down-regulate in response to prolonged hyperactivation.

It is instructive to consider why it was the subgroup of physically neglected/emotionally maltreated children with low levels of cortisol who exhibited the increased false recognition memory impairments, whereas the physically and/or sexually abused children with low levels of cortisol, who also had levels of neglect and emotional maltreatment comparable to the PN/EM group, did not reveal increases in false recognition memory. It is possible that the more distinct incidents of trauma experienced by physically and/or sexually abused children may contribute to enhanced attention and greater vigilance to environmental stimuli. In turn**,** this hypervigilance may counteract the negative effects of hypocortisolism upon memory. The lack of predictability associated with when physical and/or sexual abuse occurs may engender hypervigilance to aggression in these children, even when abusive events are not taking place (Pollak, Cicchetti, Klorman, & Brumaghim, 1997; Rieder & Cicchetti, 1989; Teisl & Cicchetti, 2008). The prior experience of anger and trauma may impel physically and sexually abused children to engage in a more careful monitoring of each context they experience (cf. Pollak & Kistler, 2002; Pollak, Vardi, Putzer, Bechner, & Curtin, 2005; Shackman, Shackman, & Pollak, 2007). Moreover, the chronic nature of neglect most likely involves general rather than discrete memories. Although further investigation is necessary, it may be that a memory system organized around over-general memories is more prone to impaired memory performance in the context of hypocortisolism.

The fact that maltreated children who have not experienced physical or sexual abuse exhibit memory impairments in conjunction with hypocortisolism is quite interesting. In fact, various subgroups of maltreated children display increases in false recognition and recall memory under mother-referent and self-referent conditions (Valentino, Cicchetti, Rogosch, & Toth, 2008a, 2008b). Why have differences not been found in other forms of basic memory? Why has hypercortisolism not resulted in memory difficulties in maltreated children? Alternatively, does hypercortisolism initiate the pathway from hyper- to hypocortisolism to structural neurobiological changes in the hippocampus that alter basic memory processes?

In order to address these challenging questions in a manner that is commensurate with the complexity of the issues noted, future investigations must be conducted that strive to identify other factors that may exert mediating or moderating effects on false recall and recognition memory. It will be important to conduct prospective longitudinal investigations that repeatedly assess HPA-axis functioning and various forms of basic memory, utilizing diverse memory paradigms. The incorporation of molecular genetic techniques into these studies also could help to elucidate, for example, how variants of glucocorticoid receptor genes and corticotrophin receptor hormone genes, and variations in catechol-o-methyl-transferase (COMT) genes may serve as moderators of the relation among maltreatment, HPA-axis functioning, and memory. Ideally, subgroups of maltreated children who have either hyper- or hypocortisolism should also receive periodic structural and functional neuroimaging assessments. Such multiple levels of analysis research programs have the potential to provide answers to key questions that the field of memory and trauma must address.

The findings of this investigation contribute to the extant literature by highlighting the interplay between neglect/emotional maltreatment and hypocortisolism in relation to false recognition memory. In view of the current findings related to subtype of maltreatment, it is important to note that physically neglected and emotionally maltreated children have been accorded less attention than physically and sexually abused children in research conducted to date

on basic memory processes in maltreated children. Although the emphasis on investigating memory in physically and sexually abused children is understandable given that these forms of maltreatment are particularly heinous forms of child maltreatment, it was the physically neglected and emotionally maltreated children who exhibited the impairments in false recognition memory. Thus, future research on memory processes in maltreated children should include groups of physically neglected and emotionally maltreated children (cf. Eisen et al., 2007; Valentino et al., 2008a, b).

Similarly, forensic work typically is more focused on physical and sexual abuse cases. These children, even the subgroup with low cortisol, do not appear to have a greater likelihood of false recognition memory; however, the less studied physically neglected and emotionally maltreated children do show evidence of increases in false recognition memory. The findings of the current investigation urge caution in prematurely assuming that the memories of neglected children are less affected than are those of children who have experienced physical or sexual abuse.

It is important to acknowledge that the findings of the current investigation may not generalize to maltreated children who do not come to the attention of child protective agencies. A potential limitation of the current study is the difficulty in being able to identify sufficient numbers of children who were abused but not neglected/emotionally maltreated, in order to have distinct group comparisons. However, the co-occurrence of these forms of maltreatment is typical in this population, and an exclusive focus on children who were only abused would result in poor generalizability to the larger maltreated population. Nevertheless, it does not seem likely that the memory performance of the atypical group of children who are exclusively physically and/or sexually abused would be markedly different from those who also have had neglect and/or emotional maltreatment experiences.

The current investigation also possesses implications for intervention. It is imperative that children who have been neglected or emotionally maltreated be afforded access to services commensurate with those more commonly provided to children who have been physically or sexually abused. Because neglected/emotionally maltreated children may evidence perturbations in memory associated with their experiences, the provision of narrative therapies that assist them in developing a cohesive life story in the context of neglect and emotional maltreatment may be particularly useful (Fivush, Bohanek, Robertson, & Duke, 2004). Such therapeutic approaches ultimately may prevent the coalescence of the negative self-representations frequently associated with experiences of maltreatment (Toth, Cicchetti, Macfie, Rogosch, & Maughan, 2000; Toth, Maughan, Manly, Spagnola, & Cicchetti, 2002).

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Table 1. Family Demographic Features.

	Nonmaltreated *M* (*SD*) or %	Maltreated *M* (*SD*) or %
Marital Status		
Never Married	35.7%	28.2%
Married/ Living Together	42.1%	38.7%
No Longer Married	22.2%	33.1%
Maternal Education		
High School or Less	52.0%	62.0%
Total Family Income		
$1000's including public assistance	24.81 (12.37)	22.86 (10.90)

Table 2. Morning Cortisol and *California Verbal Learning Test – Children* (CVLT-C) Standard Scores for Maltreatment Subtype Groups.

	Nonmaltreated *M* (*SD*)	PN/EM *M* (*SD*)	PA/SA *M* (*SD*)
Morning Cortisol Z-Score	.07 (.98)	-.14 (.82)	-.05 (1.27)
CVLT-C Standard Scores			
Short Delay Free Recall	-.05 (.90)	.12 (.91)	-.05 (1.30)
Long Delay Free Recall	-.59 (1.07)	-.77 (1.15)	-.64 (1.19)
Recognition Memory	-.23 (1.04)	-.38 (1.29)	-.20 (1.13)
False Positive Recognition	-.07 (1.21)	.01 (.92)	.27 (1.24)
Discriminability Index	-.24 (1.41)	-.37 (1.16)	-.55 (1.43)

Note: PN/EM = Physical Neglect and/or Emotional Maltreatment only; PA/SA = Physical Abuse and/or Sexual Abuse.

Table 3.
Analyses of covariance with maltreatment subtype group and morning cortisol level for CVLT-C memory indices.

Source	*df*	*F*	?^{2}	*p*
Short Delay-Free Recall Standard Score				
Age	1	1.22	.004	.27
PPVT-R Standard Score	1	6.60	.021	.01
Maltreatment Subtype Group	2	0.56	.004	.57
Level of Morning Cortisol	2	1.40	.009	.25
Subtype X Cortisol Level	4	0.21	.003	.93
Error	302			
Long Delay-Free Recall Standard Score				
Age	1	0.43	.001	.51
PPVT-R Standard Score	1	7.17	.023	.01
Maltreatment Subtype Group	2	1.91	.013	.15
Level of Morning Cortisol	2	2.44	.016	.09
Subtype X Cortisol Level	4	0.93	.012	.45
Error	302			

Recognition Memory Standard Score				
Age	1	2.30	.008	.13
PPVT-R Standard Score	1	0.06	.000	.89
Maltreatment Subtype Group	2	1.81	.012	.17
Level of Morning Cortisol	2	0.16	.001	.85
Subtype X Cortisol Level	4	1.52	.020	.20
Error	302			
False Positive Recognition Standard Score				
Age	1	0.12	.000	.73
PPVT-R Standard Score	1	20.50	.064	.000
Maltreatment Subtype Group	2	1.17	.008	.31
Level of Morning Cortisol	2	5.13	.033	.01
Subtype X Cortisol Level	4	2.45	.031	.05
Error	302			
Discriminability Index Standard Score				
Age	1	0.65	.002	.42
PPVT-R Standard Score	1	14.48	.046	.000
Maltreatment Subtype Group	2	1.96	.013	.14
Level of Morning Cortisol	2	3.16	.021	.04
Subtype X Cortisol Level	4	2.28	.029	.06
Error	302			

Figure Captions:

Figure 1. Interaction of maltreatment subtype group and level of morning cortisol for CVLT-C false recognition memory.

Figure 2. Interaction of maltreatment subtype group and level of morning cortisol for the CVLT-C discriminability index.

Figure 1

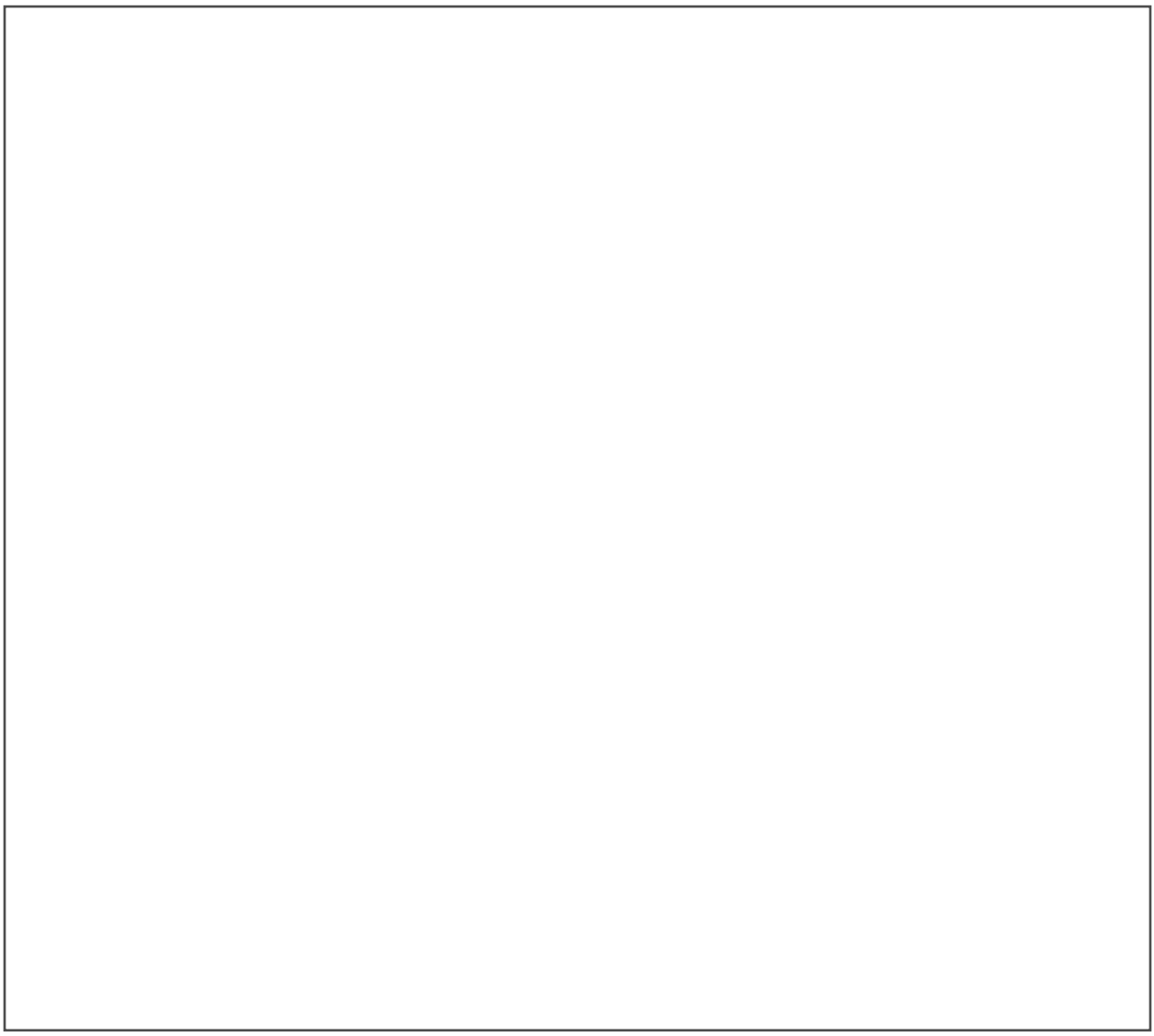
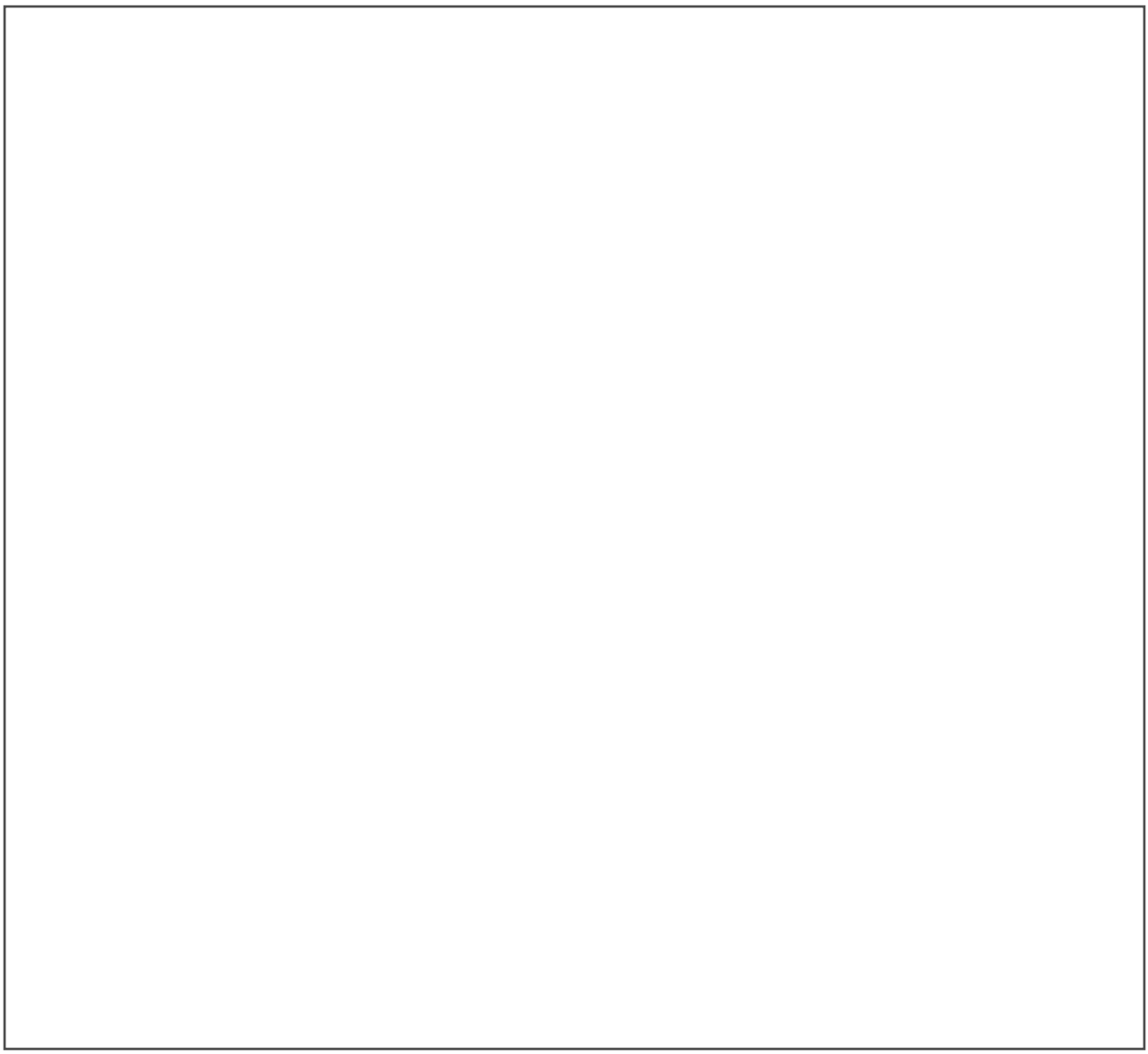


Figure 2



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