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Visual recognition memory enhancement in children through differential outcomes

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ABSTRACT

Objective: The use of differential outcomes has been shown to enhance discriminative learning and face recognition in children and adults. In this study, we further investigated whether the differential outcome procedure (DOP) would also be effective in improving recognition memory for a wide range of stimuli with varying visual complexity (familiar objects, abstract stimuli, and complex scenes) in 5- and 7-year-old children.
Method: Participants viewed a sample stimulus and, after a short (5 s) or a long (15 s) delay, they had to identify the previously seen stimulus among four choice alternatives. In the differential outcomes condition, each sample stimulus was paired with a specific outcome; whereas in the non-differential conditions outcomes were administered randomly. In Experiment 2, we replicated Experiment 1 but in addition we asked participants to perform an articulatory suppression task to prevent verbal rehearsal.
Results: Children showed a greater overall visual delayed recognition when differential outcomes were arranged in both experiments. The type of stimulus being used modulated this effect; a beneficial effect of the differential outcomes training was evident with abstract objects in Experiment 1 and with both, abstract objects and scenes in Experiment 2.

1. Introduction

It is now well established in the literature (see Urcuoli, 2005 for a review) that animals and humans are able to learn better (higher accuracy and/or increased rate of acquisition) a conditional discrimination task (e.g., I should get the umbrella if it is cloudy or sun glasses if it is a sunny day) when a differential outcomes procedure (DOP) is employed. That is, when each discriminative stimulus–response association is always followed by a particular outcome, as compared to a condition where reinforcers are administered randomly (non-differential outcomes condition). This effect has been termed the differential outcomes effect (DOE, Trapold, 1970; Trapold & Overmier, 1972).

Shepp (1962, 1964) was the first to suggest that specific outcomes might play a role in human learning. He showed that consistent response–reinforcer relationships could be arranged to interfere with learning. Later on, Maki, Overmier, Delos, and Gutman (1995) investigated the value of the DOP to improve discriminative learning, and reported that children aged from 4 years and 6 months to 5 years and 5 months learned a conditional discrimination task better when differential outcomes were arranged. Since the first reports of the DOE in humans, there has been an escalating interest in the DOP due to its potential as an intervention tool to enhance discriminative learning particularly in people with learning deficits. For instance, the DOP has been shown to be effective in improving discriminative learning of children and adults with mental retardation (Janssen & Guess, 1978; Malanga & Poling, 1992; Saunders & Sailor, 1979), adults with Prader–Willi syndrome (Joseph, Overmier, & Thompson, 1997), children and adults with Down syndrome (Estévez, Overmier, Fuentes, & González, 2003) and prematurely born children (Martínez et al., 2012). The potential usefulness of this procedure as an intervention tool has been recently expanded to other cognitive processes such as short-term/working memory (Hochhalter, Sweeney, Bakke, Holub, & Overmier, 2000; López-Crespo, Daza, & Méndez-López, 2012; López-Crespo, Plaza, Fuentes, & Estévez, 2009; Martella, Plaza, Estévez, Castillo, & Fuentes, 2012; Martínez et al., 2012; Plaza, Estévez, López-Crespo, & Fuentes, 2011; Plaza, López-Crespo, Antúnez, Fuentes, & Estévez, 2012). Hochhalter et al. (2000) were the first to employ the DOP in a delayed face recognition task in four patients with alcohol dementia. Three out of the four patients exhibited better memory for faces at the 5 second delay in the differential outcomes condition relative to the non-differential outcomes condition although only two of them showed this effect at the longer delays (10 and 25 s). The finding of improved

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memory with the DOP was replicated in a later study by López-Crespo et al. (2009) with a larger sample of older adults. Lopez-Crespo and colleagues employed a delayed face recognition task with two delays (5 and 30 s), and found an age-dependent differential outcomes effect. That is, in the non-differential condition, older adults' performance dropped with increasing delay intervals. Importantly, in the differential outcomes condition older adults' performance was overall better, relative to the non-differential outcomes condition, and remained stable across delay intervals. The authors concluded that the DOP could be used to prevent or ameliorate memory decline with aging. This was confirmed in a recent study with Alzheimer's disease patients (Plaza et al., 2012).

All together, the results obtained in the aforementioned studies indicate that, the DOP seems to be effective in improving memory for faces in populations with age- or brain-damaged related memory impairments. Evidence suggests that short-term/working memory plays a crucial role in the development of language and the overall capacity of children to learn (Alloway, Gathercole, Willis, & Adams, 2004; Dollaghan, Campbell, Needleman, & Dunlosky, 1997; Weismer et al., 2000). Consequently, the DOP could be used in school settings to enhance children's overall academic performance. However, before this procedure can be implemented in the school context more research is needed to explore whether it is a suitable tool to enhanced children's recognition memory in general using other stimuli than faces. In the present study we wondered whether the DOP would also enhance visual recognition memory function in typically developing children. Furthermore, because the DOE has been mainly observed with face recognition memory tasks and faces are processed differently by the visual system due to their inherent social and biological significance (Farah, 1996), we wanted also to test whether the DOE in recognition memory would be observed with other stimuli with varying visual complexity. There is a general agreement that greater visual complexity taxes working memory by placing additional demands on resources (Alvarez & Cavanagh, 2004). Finally, two recent studies have explored children's long-term memory conditional discriminative learning under differential and non-differentials outcomes (Martínez, Estévez, Fuentes, & Overmier, 2009; Martínez, Flores, González-Salinas, Fuentes, & Estévez, 2013). The results showed a long-persistence of learning in 5- and 7-year-old children when specific outcomes were arranged independently of (1) the way of providing consequences (children receive a reinforcer following a correct choice; a reinforcer was removed after an incorrect choice; or the combination of both), and (2) the type of reinforcers being used (secondary and primary reinforcers vs. primary reinforcers alone). Thus, these two age groups seem to be suitable to explore the DOP effects on visual recognition memory.

In Experiment 1, we employed a visual recognition task with two delay intervals (5 and 15 s), three visual complexity conditions (familiar objects, abstract stimuli and complex visual scenes), and two outcomes conditions (differential and non-differential) in two groups of children (5- and 7-years-old). Previous studies have shown that performance on delayed-matching-to-sample tasks improves with age, with 5-year-old children showing worse performance regardless of the reinforcer condition, common reinforcers (Chelonis, Daniels-Shaw, Blake, & Paule, 2000) or differential outcomes condition (Martínez et al., 2009, 2013). Thus, we expect to find a worst overall recognition memory performance in this age group relative to the older group. In addition, we hypothesize that children will show a better memory-based performance in the differential outcomes condition relative to the non-differential outcomes condition. It has also been reported a modulation of the DOE by task difficulty (e.g., Estévez, Fuentes, Mari-Beffa, González, & Álvarez, 2001; Estévez et al., 2007; Martínez et al., 2012; Plaza et al., 2011). Namely, when task is very easy there is no benefit of using specific outcomes, however, the effect is observed when a difficult or more demanding task is used. In line with this, we also expect that the DOE will be bigger in magnitude for both age groups in conditions with a greater visual complexity (abstract stimuli and complex visual scenes), and thus with a greater working memory load. In Experiment 2, we replicated the same task used in Experiment 1, and in addition asked participants to perform an articulatory suppression task to ensure that participants were not using verbal rehearsal, and we were loading visual working memory.

2. Experiment 1

2.1. Method

2.1.1. Participants

Twenty-nine typically developing children (15 boys and 14 girls), who ranged in age from 4 years and 4 months to 7 years and 10 months, were recruited from a public school (C.E.I.P. Jose Diaz Diaz) in Almeria, Spain. Participants were divided in two groups; younger children (from 4 years and 4 months to 5 years and 11 months; $N = 16$, $\text{Mean}_{\text{age}} = 5$ years, $SD = 0.54$) and older children (from 6 years to 7 years and 10 months; $N = 13$, $M_{\text{age}} = 6.6$ years, $SD = 0.52$). All the children had Spanish as their mother-tongue, normal or corrected-to-normal vision, and did not have a history of learning difficulties. The study was approved by the University of Almeria's Ethics Committee, and parents gave written consent for their children to participate in the study.

2.1.2. Stimuli and materials

The stimuli consisted of abstract objects (yellow, two-dimensional geometric figures from the RehaCom computerized cognitive training program), colored scenes (Viktor Shvaiko's paintings) and line drawings of familiar objects from the Snodgrass and Vanderwart object pictorial set (Snodgrass & Vanderwart, 1980) presented on a white background. The stimuli measured approximately 5×6.5 cm, and were displayed either individually at the center of the screen (sample stimulus), or in a 2×2 grid (comparison stimuli). The E-prime program (Schenider, Eschman & Zuccolotto, 2002a,b) controlled the presentation of the stimuli as well as data collection. To display the stimuli we used a touch screen (12.1″ TFT-LCD WXGA monitor) located on a child-sized table.

Six hedonic outcomes (candies, lollypops, chocolates, pencils, collectable cards and stickers) were used as primary reinforcers. Both, younger and older children rated all prizes as highly desirable. Pictures of these prizes served as immediate secondary reinforcers. They measured 6.5×7 cm, and were presented individually, after a correct choice, at the center of the screen. Primary reinforces were not visible to children throughout the duration of the task. At the end of their participation all the children received at least two hedonic outcomes (food and toy) along with verbal appraisal.

In addition, the Peabody Picture Vocabulary Test (PPVT), and the Automated Working Memory Assessment (AWMA, Alloway, 2007) were administered prior to the memory task. The PPVT is a test of receptive vocabulary that provides a quick estimate of verbal ability and scholastic aptitude. Children have to match pictures to words. The test lasts for approximately 15 min. The AWMA is a computerized working memory assessment battery that contains tests of visuospatial and verbal short-term and working memory. We employed the short form that lasts for approximately 25 min and consists of the following tests: listening recall (verbal working memory), digit recall (verbal short-term memory), dot matrix (visuospatial short-term memory), and spatial recall (visuospatial working memory). The AWMA has been validated to the Spanish language.

2.1.3. Procedure

The study consisted of several phases. First, the experimenter assessed participants to determine their mental age and their working memory skills using the PPVT and the AWMA. All participants had AWMA scores within the average to high range. Also, the PPVT's scores suggested that all the children had a mental age equal to, or higher than, their chronological age (see Table 1).