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Differential outcomes training improves face recognition memory in children and in adults with Down syndrome

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ABSTRACT

Previous studies have demonstrated that the differential outcomes procedure (DOP), which involves paring a unique reward with a specific stimulus, enhances discriminative learning and memory performance in several populations. The present study aimed to further investigate whether this procedure would improve face recognition memory in 5- and 7-year-old children (Experiment 1) and adults with Down syndrome (Experiment 2). In a delayed matching-to-sample task, participants had to select the previously shown face (sample stimulus) among six alternatives faces (comparison stimuli) in four different delays (1, 5, 10, or 15 s). Participants were tested in two conditions: differential, where each sample stimulus was paired with a specific outcome; and non-differential outcomes, where reinforcers were administered randomly. The results showed a significantly better face recognition in the differential outcomes condition relative to the non-differential in both experiments. Implications for memory training programs and future research are discussed.

The differential outcomes procedure (DOP) refers to the increase in performance and terminal accuracy seen in conditional discrimination tasks when each of the stimuli-response associations to be learned is followed by a unique outcome. The DOP was first described by Trapold (1970) using rats as experimental subjects. Trapold showed that rats were able to learn faster to discriminate between a tone and a click when each correct stimulus-response association was followed by a specific outcome (e.g., tone-right lever-sucrose vs. click-left lever-food pellets), as compared with a condition where the same reinforcer was administered for both S-R associations. Since this first demonstration, the ubiquity of the phenomenon has been demonstrated in a variety of species and procedures (see Goeters, Blakely, & Poling, 1992; Urcuioli, 2005, for a review). Some of the key findings with humans participants are enhanced learning of symbolic relations in children (e.g., Estévez & Fuentes, 2003; Estévez, Fuentes, Marí-Beffa, González, & Álvarez, 2001; Maki, Overmier, Delos, & Gutman, 1995), adults (Estévez et al., 2007; Miller, Waugh, & Chambers, 2002; Mok & Overmier, 2007), adults with Prader–Willi syndrome (Joseph, Overmier, & Thompson, 1997) and children and adults with Down syndrome (Estévez, Overmier, Fuentes, & González, 2003).

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In addition to the benefits of the DOP observed with conditional discrimination learning, there is an increasing amount of evidence suggesting positive effects with memory tasks as well (see López-Crespo & Estévez, 2013, for a review). For instance, studies conducted on animals showed the potential of the DOP to alleviate short-term memory problems associated with aging or brain-damage. Concretely, the DOP has been found to improve memory performance of aged rats (Savage, Pitkin, & Careri, 1999) and pyrithiamine treated rats–an animal model of Wernicke–Korsakoff syndrome (Savage & Langlais, 1995). Similar results have been reported with humans. Hochhalter, Sweeney, Bakke, Holub, and Overmier (2000) employed a face Delayed Matching to Sample (DMTS) task in people with alcohol dementia. They reported improved memory performance in the differential outcomes condition, relative to the non-differential, in three of the participants. This finding has been replicated in larger samples of older adults (López-Crespo, Plaza, Fuentes, & Estévez, 2009), and people with Alzheimer's disease (Plaza, López-Crespo, Antúnez, Fuentes, & Estévez, 2012). Finally, two other studies have extended the finding of better performance in a delayed face recognition task with the DOP to a sample of young adults (Plaza, Estévez, López-Crespo, & Fuentes, 2011) and sleep-deprived adults with transient memory deficits (Martella, Plaza, Estévez, Castillo, & Fuentes, 2012).

All together, the results obtained in the aforementioned studies support the potential of the DOP to improve memory for faces in a variety of conditions. However, more research with other relevant populations, such as Down syndrome (DS), is needed before this technique may be implemented as an intervention/education tool in school and health care settings. DS results from anormalities of chromosome 21 (in particular Trisomy 21), and it is considered the most common genetic form of intellectual disability (McGrother & Marshall, 1990; Sherman, Allen, Bean, & Freeman, 2007). Among these intellectual disabilities, the study of the working memory capacities in DS has received an important amount of attention. Although, initially it was thought that visuospatial working memory was relatively spared in DS (e.g., Jarrold & Baddeley, 1997, 2001; Lanfranchi, Cornoldi, & Vianello, 2004; Laws, 2002; Marcell & Weeks, 1988; Wang & Bellugi, 1994), more recent studies suggest deficits in several aspects of visuospatial working memory in this population (e.g., Carreti, Lanfranchi, & Mammarella, 2013; Lanfranchi, Carretti, Spanò, & Cornoldi, 2009; Visu-Petra, Benga, Tincas, & Miclea, 2007). Specifically, task complexity seems to be a crucial factor. Thus, when participants with DS were shown a complex visual pattern in a DMTS (as part of the Cambridge Neuropsychological Test Automated Battery, CANTB), they performed worse than the control group matched on mental age (Visu-Petra et al., 2007). The evidence with face processing is also relatively scarce, and studies have mostly focused on emotional face processing. Studies have reported impaired recognition of neutral expressions (e.g., Hippolyte, Barisnikov, Van der Linden, & Detraux, 2009), anger, surprise and fear (e.g., Kasari, Freeman, & Hughes, 2001; Porter, Coltheart, & Langdon, 2007; Williams, Wishart, Pitcairn, & Willis, 2005; Wishart & Pitcairn, 2000). Overall, people with DS seem to show tendency toward positive evaluation of facial expressions (Kasari et al., 2001). Few researchers have investigated facial identity recognition in DS, and the results are not consistent. While some studies reported no significant differences between DS adults and control participants on a simultaneous face identity-matching task (e.g., Hippolyte, Barisnikov, & Van der Linden, 2008; Hippolyte et al., 2009); a more recent study (Fernández-Alcaraz, Rueda, García-Andrés, & Carvajal, 2010) showed worse performance on a face discrimination task in adults with DS as compared to a control group.

In the present study we aimed at testing the efficacy of the DOP to improve delayed recognition of faces in typically developing children, and in a sample of adults with DS. Based on the findings of impaired delayed recognition of complex visual patterns (Visu-Petra et al., 2007) and impaired recognition of identities (e.g., Fernández-Alcaraz et al., 2010) or facial expressions (e.g., Hippolyte et al., 2009; Kasari et al., 2001; Porter et al., 2007; Williams et al., 2005), we hypothesized that people with DS would show worse performance in a face DMTS as compared to a mental-age matched control group. We also expected that the overall performance of both groups, children and DS, would be improved in the differential outcomes condition relative to the non-differential outcomes condition.

1. Experiment 1: DOP in typically developing children

1.1. Method

1.1.1. Participants

Forty-six typically developing children (23 girls and 23 boys), ranging in age from 4 years and 2 months to 8 years and 11 months participated in the present study. They were assigned to two groups according to age: younger children (from 4 years and 2 months to 5 years and 11 months; $N = 15$, $\text{Mean}_{\text{age}} = 5.2$ years, $SD = 0.50$) and older children (from 6 years and 3 months to 7 years and 11 months; $N = 31$, $\text{Mean}_{\text{age}} = 6.8$ years, $SD = 0.49$). All of them were Hispanic, recruited from a public school (C.E.I.P. Lope de Vega) in Almería (Spain), had Spanish as their mother-tongue and normal or corrected-to-normal vision. The study was approved by the University of Almeria's Ethics Committee, and we obtained written informed consent from the parents and oral consent to participate from the children.

1.1.2. Stimuli and materials

Each participant sat next to the experimenter in a quiet room. The stimuli consisted of 18 photographs of neutral male faces taken from a front perspective presented on a white background on a touch screen (12,1″ TFT LCD WXGA monitor) located on a child-size table. Photographs were selected from Kristen Kennedy' Normed Faces available at: http://agingmind.utdallas.edu/facedb/view/normed-faces-by-kristen-kennedy (Kennedy, Hope, & Raz, 2009). They were grouped