

Differential Outcomes Effect in Four-year-old Children

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To date, very few studies have demonstrated the benefit of the differential outcomes procedure in human learning. In one of these studies (Maki, Overmier, Delos, and Gutman, 1995) there was evidence that normal children, ranging in age from 4 years and 6 months to 5 years and 5 months, performed better on a symbolic matching-to-sample task when they received differential outcomes following their correct responses. However, they only found facilitative effects of the differential outcomes methodology in 4-year-old children when the last eight trials were analyzed. In the present study, we used a similar task to that used by Maki et al. (1995) but we included a new phase for additional training. Participants, children ranging in age from 4 years to 4 years and 6 months, showed a better terminal accuracy and a faster learning of the task across the different phases when differential outcomes were arranged. These data indicated that additional training is not necessary to find the differential outcomes effect in 4-year-old children.

The differential outcomes effect (hereafter DOE) refers specifically to the increase in speed of acquisition or terminal accuracy that occurs in a conditional discrimination training when each discriminative stimulus-response sequence is always followed by a particular outcome. Trapold (1970) provided an early demonstration of this phenomenon. He exposed rats to a discrimination problem that required a response to one lever (e.g., the right lever) in the presence of one stimulus (e.g., a tone), and a response to a second lever (e.g., the left lever) in the presence of another stimulus (e.g., a click). Trapold observed an increased rate of acquisition and a greater accuracy when the correct choice of the right lever was followed by pellets and the correct choice of the left lever was followed by sucrose than when both correct responses produced the same reinforcer, for instance pellet.

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The DOE has been demonstrated with a considerable range of subjects (although it has been used mainly pigeons and rats) and with a variety of qualitatively and quantitatively different consequences (for a review, see Goeters, Blakely, & Poling, 1992). However, very few studies have focused on this effect in humans. As far as we know, the DOE has been found in four studies that examined acquisition of a two-choice successive conditional discrimination by children and adults with mental handicaps and by autistic children (Litt & Schreibman, 1981; Malanga & Poling, 1992; Saunders & Sailor, 1979; Shepp, 1962). Maki et al. (1995) and Estévez, Fuentes, Marí-Beffa, González, & Alvarez (2001) also found the DOE with normal children ranged in aged from 4 years and 6 months to 8 years and 6 months performing a conditional symbolic discrimination task. Furthermore, Estévez et al. (2001) demonstrated that when a task is simple and subjects can easily solve it, there is no benefit of using the differential outcomes procedure.

More recently, Joseph, Overmier, and Thompson (1997) found that adults with Prader-Willi syndrome learned concepts and complicated equivalence relations only when differential outcomes were used. And, Hochhalter, Sweeney, Bakke, Holub, and Overmier (2000) extended the research about the DOE in humans by studying people with alcohol-induced amnesia. Participants in this study showed a significantly better face recognition at delays when differential outcomes were arranged.

From these results, it appears reasonable to consider the use of the differential outcomes procedure as a technique for facilitating the memory and learning of conditional discriminations. However, given the scarce number of studies about the DOE in humans, further research is needed to isolate the conditions (e.g., type of task and range of age) and populations under which this effect does and does not occur. With respect to the range of age in which the DOE can be observed, Maki et al. (1995) found that children ranging in age from 4 years to 4 years and 5 months showed the same discriminative performance under differential and non-differential outcomes conditions. However, when they analyzed the last 8 trials of the task they observed a light increase in the performance of these children when differential outcomes were arranged. According to the authors these data indicated that additional training is necessary to observe the benefit of using the differential outcomes procedure in 4-year-old children.

Our primary purpose in the experiment reported here was to assess whether it is necessary more training than usual to find the DOE in 4-year-old children. To explore this hypothesis, we used a delayed symbolic matching-to-sample task similar to that used by Maki et al. (1995) and by Estévez et al. (2001) but now one more discriminative phase was included.

METHOD

Participants. Ten capable children (5 boys and 5 girls) were recruited from the school C.P. Lope de Vega in Almería, Spain. The participant ranged in age from 4 years to 4 years and 6 months. None had evidenced learning difficulties.

Setting and materials. Each participant sat next to the experimenter in a quiet room. A book containing the stimuli lay between them on a child-sized table. Stimuli, drawings measuring approximately 5 x 5 cm, were selected from the groups of symbols included in Microsoft Word95; these were on pages contained in a binder. Sample stimuli always appeared centered on the top half of the page and choice alternatives appeared on the bottom half of the page. The two comparisons or choice stimuli were centered equidistant from one another. For each trial, consisted of three pages, the sample page was followed by a blank page (ensured an approximate 2-second delay) and then by a page with the choices. Blank pages with the number of the trial written in the lower right corner separated trials. Figure 1 shows the stimuli sequence.

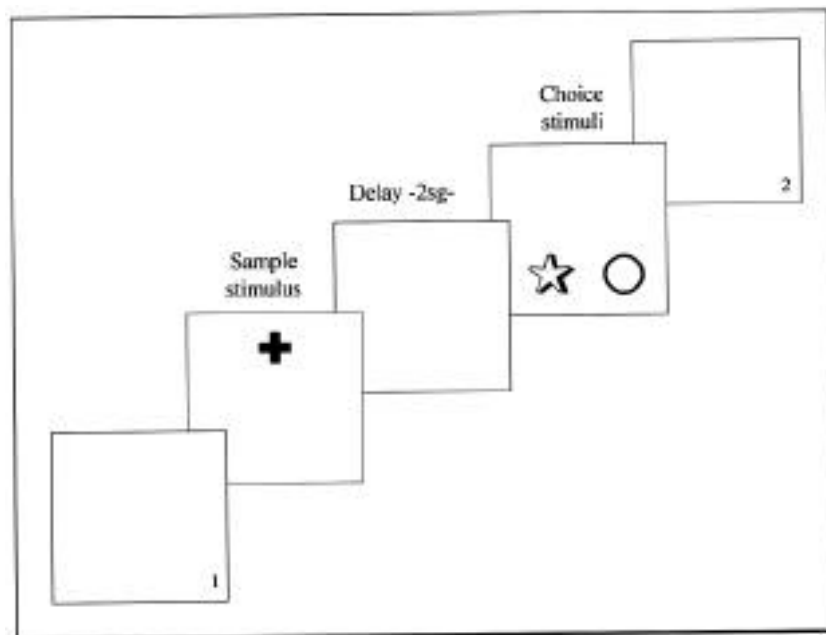


Figure 1. Stimuli sequence (from left to right) used in the study. Participants were required to point to the sample stimulus and then to the comparison stimulus that went with it.

Primary and secondary reinforcers were used as outcomes. Following a correct choice, children received either a red or a green token which they then placed in the corresponding red or green bowl. Food consisting of cookies, sweet candies, and triskis and gublines balls (two kinds of vegetable chips) were located in a red bin. Toys including crayons, stickers, masks, and globes were located in a green one. At the end of the session, participants exchanged red tokens for food and green tokens for toys. The bins were located behind the participants and out of their immediate sight.

Procedure. Participants were randomly assigned to one of the two experimental conditions, differential (DO) or non-differential (NDO). Participants in the differential outcomes condition received a red token following the correct choice of one comparison stimulus in response to the presentation of one designated sample stimulus and a green token following the correct choice of the other comparison stimulus in response to the presentation of the other sample stimulus. Those participants in the non-differential outcomes condition received random rewards of either red or green tokens for correct choices.

Each child participated in a single session lasting approximately 50 minutes. The task consisted of four phases: pre-training and three conditional discrimination phases which will be referred to as phase I, phase II and phase III. A separate binder held the stimuli for each phase. The first three phases were similar to those used by Maki et al. (1995): pretest (here, pre-training), conditional discrimination pretraining (here, phase I) and conditional discrimination training (here, phase II). The pre-training ensured the participant's ability to discriminate the stimuli to be used in the study. This phase included four identity trials and eight conditional discrimination trials. On the first identity trial, the child saw a page with a picture of a pair of glasses centered above the midline and two alternative comparison pictures, one of a pair of glasses and the other of a candle, below the midline. The experimenter explained that they were to play a memory game in which they had to guess which picture was associated with the sample stimulus. Then, participants were instructed to point to the sample stimulus (the pair of glasses) and to the choice alternative that "went with" the sample (the pair of glasses). Children were told that either a red or a green token followed a correct response, but it was not explained how the rewards were assigned. Incorrect choices led to an approximate 3-second intertrial interval and then the experimenter proceeded to the next trial without giving a token. On the first conditional discrimination trial, the participants were told that the game would change a little. The picture on the top of the page (the sample stimulus; a bell) would not look like either of the two pictures on the bottom of the page (the comparison stimuli; a pair of glasses and a candle). They had to guess which picture (the candle) was associated with the sample stimulus (the bell) and then remember which picture goes with each sample stimulus. All the participants met the criterion of at least 75% on the pre-training to participate in the experiment.

Three conditional discrimination phases (I, II and III) followed the pre-training. Each phase consisted of 32 conditional discrimination trials, randomized in blocks of eight trials. Each sample stimulus appeared 4 times per block and correct choice stimuli appeared an equal number of times on the right and left sides. In these three phases the same comparison stimuli were used, but the sample stimuli were different, thus requiring the learning of new symbolic relations. The specific stimuli used in each conditional discrimination phase are presented in Figure 2.

<i>Sample stimulus</i>	<i>Choice stimuli</i>	<i>DO condition</i>	<i>NDO condition</i>
<i>Phase I</i>			
Γ	☆	Green chip	Green/red chip
	○	No Outcome	No Outcome
+	☆	No Outcome	No Outcome
	○	Red chip	Green/red chip
<i>Phase II</i>			
■	☆	Green chip	Green/red chip
	○	No Outcome	No Outcome
■	☆	No Outcome	No Outcome
	○	Red chip	Green/red chip
<i>Phase III</i>			
▲	☆	Green chip	Green/red chip
	○	No Outcome	No Outcome
△	☆	No Outcome	No Outcome
	○	Red chip	Green/red chip

Figure 2. Stimuli used in the three conditional discrimination phases (I, II, and III). When the experiment was completed, green chips were exchanged for toys and red chips were exchanged for food.

The experimenter controlled stimulus presentations, data collection, and outcome presentations. Reliability checks of the experimenter's scoring and reinforcement procedures were obtained. For reliability proposes an observer present in the experimental setting recorded the child's responses and the reinforcement procedure being used.

RESULTS

The reliability assessments revealed no disagreements between experimenter and observer on either response or training condition.

To determine whether participants showed greater terminal accuracy and learned the task faster when differential outcomes were arranged, data from the different phases were analyzed grouping the trials in 8 blocks of 4 trials each. Because the pattern of results was similar for boys and girls, data from this factor were collapsed for the statistical analyses. Figure 3 shows the percentage of correct responses in the three phases as a function of outcomes and blocks of trials. Data were analyzed through a mixed ANOVA with Outcomes as the between-subjects factor and Block of Trials (1, 2, 3, 4, 5, 6, 7 and 8) and Phases (I, II, and III) as the within-subjects factors.

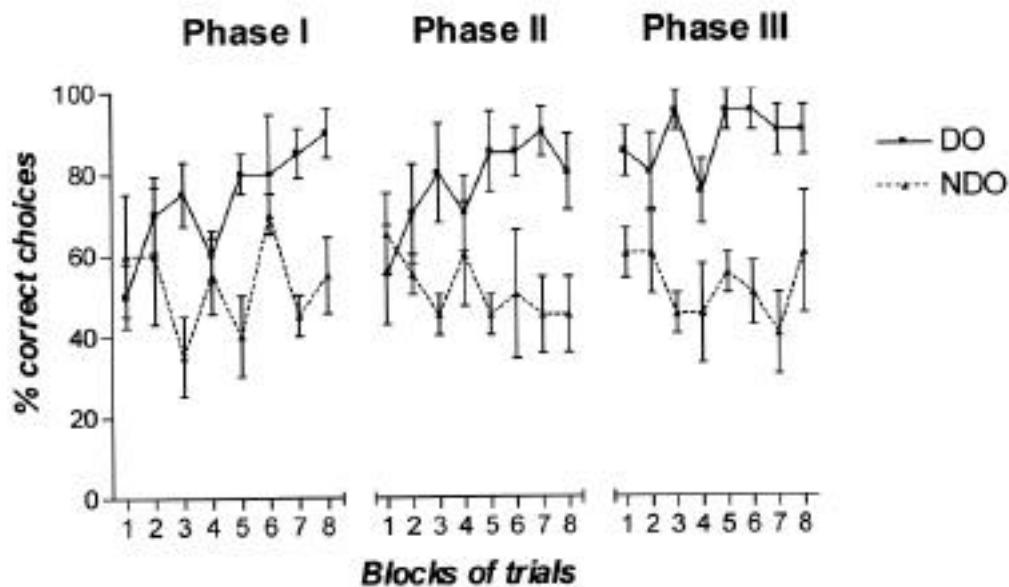


Figure 3. Mean percentages of correct choice responses as a function of blocks of trials (8 blocks of 4 trials each) and outcomes (D: differential and ND: non-differential) for conditional discrimination phases I, II, and III.

The results revealed significant main effect of Outcomes [$F(1,8)=95.61$, $p<0.01$]. That is, participants in the study typically performed the task better when they obtained differential outcomes after their correct responses than when they received non-differential outcomes (79% and 52% accuracy, respectively). There were also significant main effect of Phases [$F(2,16)=5.54$, $p<0.05$] indicating that the overall performance of children changed across the phases (63%, 64%, and 70% accuracy in phases I, II, and III respectively). In fact, children showed a higher performance in phase III than in phases I and II.

Importantly, the interaction Outcomes x Block of Trials was significant [$F(7,56)=3.63$, $p<0.01$]. Analysis of the interaction revealed a significant main effect of Block of Trials for children in the differential outcomes condition [$F(7,28)=3.95$, $p<0.01$], and not for those in the non-differential outcomes condition [$F(7,28)=1.26$, $p=0.31$]. These data suggest that children learned the conditional discrimination task only when differential outcomes were arranged.

The Outcomes x Phases interaction was also significant [$F(2,16)=5.93$, $p<0.05$]. The interaction analysis in terms of partial interactions showed a larger differential outcomes effect in Phase III compared to phases I and II [$F(1,8)=6.78$, $p<0.05$ and $F(1,8)=8.88$, $p<0.05$, respectively]. Moreover, there were no differences in the size of the effect between phases I and II [$F(1,8)=1.07$, $p=0.33$].

Interestingly, a one-way ANOVA on the first block of trials revealed a significant main effect of Outcomes in phase III [$F(1,8)=8.33$, $p<0.05$]. That is, children showed higher accuracy in the first trials of this phase when differential outcomes were arranged. However, participants had shown similar accuracies in the first block of trials in phases I and II [$F_s<1$].

DISCUSSION

The general focus of the present study was to extend the DOE methodology to children ranging in age from 4 years to 4 years and 6 months. In a previous study the benefit of the differential outcomes procedure was not observed in these children although it was suggested that might be obtained with additional training (Maki et al., 1995). To explore this hypothesis we used a similar task to that used by Maki et al. (1995) but we included an additional conditional discrimination phase. The results showed that participants in the differential outcomes condition performed significantly higher and learned the task faster than those in the non-differential outcomes condition. In fact, children in the latter condition showed a performance close to chance during all the discriminative phases indicating that they did not learn the discrimination task. However, despite of the results obtained by Maki et al. (1995), the effect was evident from the first phase of the task or phase I. These results replicate those obtained with older children (Estévez et al., 2001;

Maki et al., 1995) and they demonstrate that it is not necessary more training than usual to observe the DOE in 4-year-old children.

There is no obvious reason why the DOE was apparent in the present study but not in the Maki et al. (1995) study. The general procedure used in the experiment reported here was similar to that used by Maki et al. (1995) but we used secondary reinforcers and different primary reinforcers (toys vs. food instead of pieces of dried or fresh fruit vs. verbal phrase). Maybe this type of reinforcers increased the participant's motivation to correctly accomplish the task and, therefore, they paid more attention to it. This issue is currently a matter of further research in our laboratory.

One interesting observation in this experiment was that children trained with the differential outcomes procedure, and only they, showed better performance in the first four trials of phase III. This might have been because the same correct choice alternatives and reinforcers were used in this phase as in phases I and II with only the sample stimuli changing. That is, the comparison stimulus-outcome relations were maintained across the different phases. Recently, Estévez, Overmier, and Fuentes (in press) have demonstrated that initial discrimination training on the unique choice alternatives-outcomes associations facilitates the learning of a new conditional discrimination that share these elements. Moreover, the results indicated that both the unique sample-outcome associations and the unique choice-outcome associations are equally important contributing features of enhanced discriminative learning under differential outcomes procedures in humans.

So far, the conditions under which the DOE can be observed in humans are not well known. However, the present findings, as those found in previous studies (Estévez et al., 2001; Maki et al., 1995), indicate that the DOE can be used as an effective technique for training and teaching difficult conditional discriminations to normal children. More specifically, the data from this study demonstrated the usefulness of the differential outcomes procedure on the learning of a symbolic discrimination task by 4-year-old children and this, in turn, increases the scope of its future use in more applied settings.

RESUMEN

El efecto de consecuencias diferenciales en niños de cuatro años de edad. Hasta la fecha muy pocos estudios han demostrado en humanos la utilidad del procedimiento de consecuencias diferenciales en el aprendizaje discriminativo. En uno de estos estudios (Maki, Overmier, Delos y Gutman, 1995) los autores encontraron que un grupo de niños, con edades comprendidas entre 4 años y 6 meses y 5 años y 5 meses, realizaron mejor una tarea de igualación demorada a la muestra cuando tras sus respuestas correctas obtuvieron consecuencias diferenciales. Sin embargo, sólo se observó este efecto en niños de cuatro años de edad cuando se analizaron los últimos 8 ensayos de discriminación, sugiriéndose que para que dicho efecto fuese evidente sería necesario un mayor entrenamiento. Para explorar esta hipótesis en el presente estudio utilizamos una tarea similar a la de Maki et al. (1995) pero incluyendo una nueva fase. Los participantes, niños con

edades comprendidas entre 4 años y 4 años y 6 meses, mostraron desde la primera fase de la tarea una mejor ejecución y un aprendizaje más rápido cuando se administraron consecuencias diferenciales tras sus respuestas correctas. Estos datos indican que no es necesario un entrenamiento adicional para obtener el efecto de consecuencias diferenciales en niños de 4 años de edad.

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