What Causes 3-year olds’ Difficulty on the Dimensional Change Card Sorting Task?

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Author Notes

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Abstract

Fifty-six children aged 3;01 to 4;11 years were tested with the standard DCCS task (Frye, Zelazo & Palfai, 1995) where children have to switch from one sorting dimension (e.g. colour) to another (e.g. shape), and with 3 variations of this task. The aim was to explore different factors (extra-dimensional vs. reversal shift and presence of visual clash between target and test cards) that may account for 3 year olds’ executive problems on this task. The only difficult task was the standard DCCS task with a visual clash and an extra-dimensional shift (mean of 3.55 out of 5 cards sorted correctly). The 3 new variations were all much easier (means of 4.6 or higher out of 5 cards sorted correctly). The difficulty with the DCCS task was particularly pronounced for 3-year olds when the task was presented first (mean of 0.50 correct) whereas when it followed one or more of the other tasks then children’s mean number correct was 4.0 or above. Implications of this finding are discussed for the theory that younger children suffer from an inability to inhibit a predominant sorting strategy and the cognitive complexity and control theory postulating limitations in understanding higher order rules, negative priming of the initially ignored dimension, and children’s difficulty in understanding that the change in the task consists in a redescription of the original cards.
What Causes 3-year olds’ Difficulty on the Dimensional Change Card Sorting Task?

One frequently used task to assess young children’s self control abilities is the Dimensional Change Card Sorting Task (DCCS task; Frye, Zelazo & Palfai, 1995). In the standard version children are given two target cards, for instance a black cat and a red snake. The test cards (red cats and black snakes) match one target card on one dimension and the other target card on the other dimension. In the pre-switch phase the children are told a pair of rules which specify how to sort the test cards according to a particular dimension, e.g. the colour rules: "We are playing a colour game. In this game all the red cards go here (point to red snake target) but all the black cards go there (point to black cat target)". After sorting 5 consecutive cards (usually correctly) the rules are changed to the shape rules. This is called the post-switch phase in which the children are told: "Now we are playing another game. We are playing the shape game. This time all the cats go here (point) and all the snakes go there (point)". They are then given 5 test trials without feedback. The typical results are that the 3-year olds have no difficulties when sorting the cards according to one dimension. Their difficulties emerge in the post-switch phase when the rules change from one sorting dimension to the other. The majority of 4- and 5- year olds can switch between the rules and sort the cards correctly.

The difficulties experienced by three-year olds can be explained in terms of deficits in executive function (e.g. Duncan, 1986; Welsh & Pennington, 1988). The term "executive function" refers to those processes that are responsible for action control (e.g. planning, inhibition, co-ordination and control of action sequences). Such processes are necessary to maintain a mentally specified goal and to bring it to fruition against distracting alternatives. Executive functions are not required for all actions but only for certain types of problems. Norman and Shallice (1986) distinguished between two levels of control. At the level of
contention scheduling the control takes place by low level mutual inhibition and activation. This control is automatic and ensures coherent execution of action sequences. However there are certain tasks (e.g. those involving planning/decision making, trouble shooting, novel/ill learned action sequences, overcoming strong habitual response tendencies or temptation) for which a higher level of control is required, which is provided by the supervisory attentional system (SAS). The typical executive function tasks that pose a severe problem for children at the age of 3 years are characterised by the need to exert executive inhibition of an interfering response tendency (Carlson, et al. 1997; Carlson & Moses, in press; Perner, Stummer & Lang, 1999). Executive inhibition is needed when automatic inhibition through high activation of the desired action schema fails. For example, this is the case when concentration on the desired schema not only strengthens activation of the desired but also of the interfering schema. On the DCCS task the children build up an action schema in order to sort the cards according to the pre-switch rules (e.g. colour). After the rule switch this schema interferes with sorting the cards by the new (post-switch) rules (shape). In order to sort the cards correctly in the post-switch phase the children have to inhibit the interfering old action schema.

Zelazo and Frye (1997) suggested that children’s control problems are a consequence of the cognitive complexity (Cognitive Complexity and Control Theory; CCC-Theory) posed by the executive function tasks in terms of embedded conditional action rules. Tasks on which children have difficulties are characterised by a tree structure in which the tasks are analysed by conditional relations from different antecedents ($a_i$) to consequences ($c_j$) that change according to setting conditions ($s_k$).

IF $s_1$ THEN

IF $a_1$ THEN $c_1$ Rule A

IF $a_2$ THEN $c_2$ Rule B
IF $s_2$ THEN

IF $a_1$ THEN $c_2$ \hspace{1cm} \text{Rule C}

IF $a_2$ THEN $c_1$ \hspace{1cm} \text{Rule D}

Different first order rules connect the antecedents ($a_1$ and $a_2$) with the consequences ($c_1$ and $c_2$). For example, rule A indicates that consequent 1 ($c_1$) should follow antecedent 1 ($a_1$), rule B indicates that consequent 2 ($c_2$) should follow antecedent 2 ($a_2$), rule C connects $a_1$ to $c_2$ and rule D connects $a_2$ to $c_1$. Each of these rules is controlled by a higher order rule (E) that can be used to select between rules A, B, C and D. In order to use E one has to consider the setting conditions ($s_1$ and $s_2$) and the antecedents ($a_1$ and $a_2$) to be sure which consequence will follow ($c_1$ or $c_2$). With age children improve in selecting the correct rules. On the DCCS task, in one setting ($s_1$ sort by colour) the red cats ($a_1$) go into the box marked with a red snake target ($c_1$) and the black snakes ($a_2$) into the box with the black cat target ($c_2$), whereas under the other setting ($s_2$ sort by shape) the red cats ($a_1$) go into the box marked with a black cat target ($c_2$) and the black snakes ($a_2$) into the box with the red snake target ($c_1$).

However, several other features of the DCCS task could be responsible for children’s difficulties. One such feature is the fact that the switch in rule is a switch in dimension which requires the test cards to be described differently: first by colour and then by shape. This renaming of the same test card might confuse the children. Another feature is the direct visual clash between test and target cards. Before the rules switch from colour to shape the children pay attention to only the relevant dimension of the target cards (colour). The visual cue from the targets provides support for sorting the cards correctly. After the switch of dimensions the visual support from the target cards becomes a problem because the target card now displays the formerly relevant and now misleading/wrong visual cue, i.e., there is a visual clash between the picture of the black cat on the target card and the red cat on the test card when it needs to be sorted by shape.
The aim of the study was to manipulate these features independently. The switch in dimensions was avoided by using a "reversal shift" (instead of an extra-dimensional shift from colour to shape). There is some evidence (Owen et al., 1991; 1992) that patients with either frontal lobe damage or Parkinson's disease show impaired performance on attentional set-shifting tests only when the previous irrelevant dimension has to be focused on the following trial (extra-dimensional shift). However, both groups have no difficulties when stimuli vary in only one dimension and the previous wrong stimulus is correct in the next trial (reversal shift). Moreover, children with autism, who are known for their executive problems, show specific impairment on extra-dimensional shift but not on reversal shift (Hughes, Robinson & Russell, 1994). This type of shift is comparable to our reversal shift-variation of the standard DCCS task where the test and target cards are all of the same colour (e.g. black). The children have to sort the cats to the cat target and the snakes to the snake target in the pre-switch phase (normal game) and in the post-switch phase they should put all cats to the snakes and all snakes to the cats (reversed game). This kind of shift requires no re-description of the test cards.

The second manipulation was to avoid the visual clash by replacing the target cards by target puppets (e.g. Donald and Mickey). Inspired by Hughes' (1998) "teddy task" the rules for sorting the cards are described in terms of preference of the puppets (pre-switch: e.g. Donald likes red things and Mickey black things; post-switch: Donald likes snakes and Mickey cats). ¹ Combining these two features results in 4 different card sorting tasks: the standard DCCS task with target cards and extra-dimensional shift; one variation with target puppets and extra-dimensional shift; one variation with target cards and reversal shift and one with target puppets and reversal shift.

¹ Our task differed from Hughes' teddy task in two ways. In her task the decision was between items teddy liked and didn’t like whereas in our task the choice was between items that one versus the other puppet liked. Moreover, in Hughes' study children had to discover which items teddy liked from feedback while in our study children were explicitly told puppets’ preferences.
Both theories (Inhibition and CCC-Theory) predict that there would be no large difference in children’s performance on these 4 card sorting tasks because all of them require an inhibition of a prepotent answer strategy and all of them have the same complex "if-if-then" structure.

A differential prediction can be derived by extrapolating the findings on attentional shift tasks with patients with frontal lobe damage or Parkinson's disease (Owen et al., 1991, 1992) or autism (Hughes et al., 1994) to normally developing children. In this case we expect the younger children to have much more severe difficulties on the two tasks involving an extra-dimensional shift than the two tasks with reversal shift. Another differential prediction can be derived from our intuitive suspicion that the visual clash created by target cards is responsible for children's problems. In this case children will have problems sorting correctly only when the sorting boxes are marked with target cards (for extra-dimensional as well as reversal shift) but not when the puppets are used.

Method

Participants

Fifty-six children (29 girls and 27 boys) from three nursery schools in Salzburg took part in the study. Two of them are located in the city of Salzburg and one of them in the surroundings. All children whose parents consented to their participation were tested. Their age ranged from 3;1 (years; months) to 4;11 (mean age 4;2, s.d. = 6.55 months). To analyse and display age trends we divided the children in two age groups: "three-year-olds" (3;1 to 3;11, N = 20, mean age 3;6, s.d. = 3.19 months) and "four-year-olds" (4;0 to 4;11, N = 36, mean age 4;6, s.d. 3.83 months). The testing took place from 8 a.m. to 11 a.m. in a quiet room separated from the nursery.
Design

Each child was tested in 2 sessions with an interval of about one week. The first session consisted of two card sorting tasks and a filler task (used for an exploratory study) between the two card sorting tasks. The two card sorting tasks for each session were chosen so that the same features (type of shift and type of targets) were never applied in the same session. For example the children had to solve the extra-dimensional task with target cards and the reversal shift task with target puppets in one session and the extra-dimensional shift with target puppets task and the reversal shift with target cards in the second session. Within these constraints the order of the card sorting tasks was counterbalanced according to a Latin Square design so that each version was equally often in each position. The direction of shift was always from colour to shape for extra-dimensional shifts and from shape (consistent with the targets) to shape (inconsistent with targets) for reversal shifts.

Materials and Procedure

Card sorting. On the variations with extra-dimensional shift we used two sets of cards which consisted of two target cards (yellow car and red sun; green rabbit and blue butterfly) and 12 test cards (6 red cars and 6 yellow suns; 6 blue rabbits and 6 green butterflies). The same objects were used for the reversal shift variations with the exception that they all had the same colour (one red sun and one red car target and 12 red suns and cars; one blue butterfly and one blue rabbit target and 12 blue rabbits and butterflies). On the variations with the target puppets instead of the target cards we used two pairs of pictures, each picture showing a target puppet (Mickey Mouse and Donald Duck) or a target person (a boy and a girl). In all conditions the two target cards or pictures of target puppets/persons were each affixed on one of two boxes into which the test cards had to be placed through a slit. Each task involved a pre-switch and a post-switch phase.
Extra-dimensional shift with target cards (standard DCCS): In the pre-switch phase the experimenter explained the two dimensions (colour and shape) of the target cards and said: "Now we are playing a game, a colour game. In this game, all the red cards go here (point) but all the yellow ones go in the other box". The child and the experimenter sorted two cards together (one red and one yellow) and the child was asked two control questions to ensure knowledge of the rules ("Where do the red ones go?" and "Where do the yellow ones go?"). If the child gave wrong answers the rules and the two questions were repeated. At least on the third repetition of the rules all children were able to answer both questions correctly. Then the children were required to sort 5 cards on their own. On each of these five pre-switch trials the experimenter repeated to children the pre-switch rules, randomly selected a test card, and labelled the card with the relevant dimension (e.g. "Here is a red one"). The children were asked to sort the card on one of the two boxes ("Where does this card go in the colour game?") and they were told whether or not they had sorted the cards correctly. After 5 trials the rules changed. As introduction to this post-switch phase children were told, "Now we are playing a new game, the shape game. The shape game is different. This time, all suns go here (point to the red sun target) but all cars go there (point to yellow car target)". Again the children were asked about the two new rules ("Where do the cars go?" and "Where do the suns go?"). If the children were wrong on these questions they were corrected until they answered both questions correctly². Then the children had to sort 5 cards according to the new shape rules but without feedback.

Extra-dimensional shift with target puppets: Instead of the target cards two pictures, each with one target puppet/person were affixed on each of the boxes and the experimenter asked the children if they could name these puppets. The procedure was the same as in the standard DCCS task except that in the pre-switch phase one target puppet was described as

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² This repetition of rules constitutes a minor deviation from the standard procedure. It was designed to enhance
wanting all red things and the other as wanting yellow things. The switch to the new dimension (post-switch phase) was explained as a change of preference to the other dimension (e.g. "Donald now wants the suns") amounting to a reversal in preferred cards e.g. Donald who wanted red cars, now wants yellow suns.

Reversal shift with target cards: In the pre-switch phase the children were told that they had to play the "normal" shape game in which they have to put, e.g., the cars to the car target and the suns to the sun target. In the post-switch phase they were instructed to play the "reversed" shape game: "Now you have to put the cars to the sun-box and the suns to the car-box".

Reversal shift with target puppets: In the pre-switch phase one target puppet (e.g. Donald) was described as wanting e.g. cars and the other (Mickey) as wanting suns and in the post-switch phase the children were told that the preference of the puppets had changed: now Donald wants the suns and Mickey the cars.

Results
As a first step we analysed the children’s performance on the 4 different card sorting tasks. To this end a 2 x 4 x 4 mixed design ANOVA (2 age groups, 4 orders of tasks between participants and 4 task versions within participants) was carried out on the number of cards sorted correctly. Besides all three main effects (age group: \( F(1, 48) = 12.66, p = .001 \); task order: \( F(3, 48) = 6.63, p = .002 \); task versions: \( F(3, 144) = 15.99, p = .000 \) ) the three two-way interactions were also significant: age group \( \times \) task order: \( F(3, 48) = 3.82, p = .016 \); age group \( \times \) task versions: \( F(3, 144) = 3.18, p = .026 \); task order \( \times \) task versions: \( F(9, 144) = 2.79, p = .005 \).

We first look at the interaction between order and task versions. The relevant means are shown in Figure 1, which make clear that the interaction is principally due to the fact that the contrast between correct answers to the rule questions and subsequent incorrect sorting of the cards.
only the original DCCS task (extra-dimensional shift with target cards) poses any serious difficulty and only when presented as the first task. Post hoc analysis of the DCCS results shows that the children who had this task first sorted significantly fewer cards correctly than those who had the task after one of the other versions (LSD test: \( p = .013 \), SPSS, Narusis, 1997).

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Figure 2 shows the means for the significant interaction of age by task versions. The interaction is due to the fact that only on the DCCS task we find a substantial age effect (\( t(54) = 3.55, p = .001 \)) whereas on the other three versions even the 3-year olds sorted on average more than 85% of the cards correctly.

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Since these two interactions indicate that children's difficulty was mostly confined to the DCCS task when it was presented first, we investigate further the age effect on this task when presented first. A 2 x 2 x 2 ANOVA (2 types of shift: extra-dimensional vs. reversal, 2 types of target: cards vs. puppets, 2 age groups) was carried out on the number of cards sorted correctly on first position tasks. All 3 main effects (type of shift: \( F(1, 48) = 7.75, p = .008 \); type of target: \( F(1, 48) = 14.51, p = .000 \), and age group: \( F(1, 48) = 9.28, p = .004 \)) and also the 3-way interaction between type of shift \( \times \) type of target \( \times \) age group (\( F(1, 48) = 5.41, p = .024 \)) were significant. Figure 3 shows the relevant means indicating that the interaction is due to the fact that a substantial age effect only exists for extra-dimensional shift but not for reversal shift, and only for target cards but not for target puppets, i.e., the
traditional DCCS task. A t-test for independent samples showed that the age groups differ only on the standard DCCS task \((t(15) = 3.44, p = .004)\).

Discussion

Our results conform to previous findings (e.g. Zelazo, Frye & Rapus, 1996) that 3-year olds have severe difficulties on the DCCS card sorting task when they have to switch from one sorting dimension to another. They were much more likely than the 4-year olds to perseverate on the pre-switch rules. Our results make clear that the combination of two features is critical for the task's difficulty: The shift must be extra-dimensional and the task must involve target cards creating a visual clash between target cards and cards to be sorted, because children had severe difficulties only on the standard DCCS task where these two features are combined.

These data are difficult to accommodate by the two standard explanations (CCC-Theory and Inhibition Theory). The Inhibition Explanation (Executive Function Theory) argues that the DCCS task requires inhibition of a prepotent answer strategy, which is difficult for 3-year old children. This theory cannot explain why performance on the 3 other card sorting tasks was so much better since all 4 tasks require a switch to a new answer strategy. Gerstadt et al. (1994) suggested that it might not be the need for inhibition alone but rather the specific conjunction of inhibiting a prepotent response and a significant memory load that might account for the executive problems of children at this age. With this addition our data might be explained but at the cost of having to make additional assumptions about working memory load in need of independent evidence. One would need to establish that keeping a new dimension in mind (extradimensional shift) requires more effort than remembering that one is supposed to sort to non-matching targets (reversal shift). One would also need to
establish that shifting to a new dimension requires more effort in the presence of target cards than without such cards. This is far from obvious since on the face of it the target cards seem to provide memory support rather than impose additional memory load. For, provided one remembers which dimension is to be used the target cards provide a clear cue where each card is to be placed, whereas, without target cards one has to remember which puppet likes which item. A more plausible extension of this approach is to look beyond simple memory load to factors of interference, which we will consider later.

One should also mention that Gerstadt et al. (1994) formulated their claim about inhibition and memory load in the context of their "Stroop like" day/night task. In this task children have to name pictures in incompatible ways, e.g., a picture of a sun has to be labelled "night" and a picture showing a moon to be labelled "day". The majority of children between 3 years 4 months and 4 years 3 months could not give correct responses on both trials thus failing the pretest. This difficulty is surprising since this task is akin to our reversal shift task, i.e., the child has to reverse the labels that are usually used for labelling these two pictures. There are, however, also apparent differences between these tasks that may account for the discrepant results. The day night "Stroop" task is based on a natural and presumably automatic tendency to use the correct label for a picture. That is why in this task the difficulty occurs right away without having to first practice an incompatible response tendency as in the DCCS task. Moreover, Carlson and Moses (in press) found performance on this task to be closely related to the grass/snow task where children have to point to the incompatible picture for a given label. We also know from Carlson et al. (1997) that pointing to a wrong place contains executive demands not shared by making a pointer point to the wrong place. So we think that young children find the day-night Stroop task difficult due to the requirement to overcome a natural/automatic answer tendency (and similarly Luria’s hand game, e.g., Hughes, 1998, where there is a natural tendency to imitate). Sorting cards by putting same category objects
together is not a real strong natural tendency (in fact young children often prefer to group different objects thematically, e.g., Bjorklund, 1995). Making the cat visit the snake (target) may be as natural a tendency as putting cats to cats.

The fact that the day/night Stroop task involves inhibition of an automatic natural tendency also explains another difference between it and the DCCS task. Gerstadt et al. (1994) reported for those children who were able to master the task initially (i.e., passed the pretest) that they kept sorting correctly for some trials but then started committing errors after 5, ten or more trials. Few studies with the DCCS task use more than the standard 5 post switch trials. However Perner, Lang & Kloo (submitted) used 9 trials. There was no evidence that children started to make more errors on the last 4 than on the first 4 trials: On 11 occasions children committed more errors on the last than on the first 4 trials and on 12 occasions more on the first than the last 4 trials.

Now, of course, we do not know whether children would have regressed in the reversal shift task had they been tested for 9 or more trials but the contention is that such regression only happens when children have to inhibit a natural tendency as in the day/night Stroop task, but not in the reversal shift card sorting task where no such a natural tendency exists.

Our data also pose some difficulty for the CCC-Theory, which sees children’s difficulties with the DCCS task in their inability to cope with "if-if-then" rules. Again this fails to explain the difference in performance on the other tasks as all 4 task variations share the same "if-if-then" structure. The CCC theory needs to be amended to explain our data. Phil Zelazo (as one of the reviewers) suggested an interesting way to account for the better performance on the reversal shift task than on the DCCS task. Although both tasks have an if-if-then structure children may solve the tasks differently in terms of higher order rules. The reversal shift task may not require a shift from one rule pair to a new pair of rules (as in the DCCS task) but simply a transformation of a single rule from its normal form to its opposite.
To account for why the lack of target cards created better performance is more difficult. One could surmise that the lack of target cards made the pre-switch rule less salient and, thus, easier to forget when the rules change. Consequently, there is less perseveration with the old rule. Evidence for this post hoc explanation would be provided if children showed some difficulty maintaining the rule in the pre-switch phase. However there is no trace of such a difficulty in our data. All children were correct in the pre-switch phase of the DCCS task and only one child committed two errors in the pre-switch phase of the extra-dimensional change task without target cards.

Apart from the two standard explanations just discussed our data also pose problems for the assumption that younger children have specific problems with extradimensional shift tasks analogously to patients with frontal lobe injury or Parkinson’s disease and children with autism. Contrary to this assumption extradimensional shift seemed well within the youngest children's abilities when there were no target cards involved. Similarly, our suspicion that it is primarily the visual clash provided by target cards that is responsible for children's difficulty in the DCCS task was not supported since a similar visual clash also occurred in the reversal shift task without making that task difficult for children.

A new attempt to explain our results is a generalisation of "negative priming". This term comes from research on attention. On the Stroop task there are colour names written in another colour (e.g. the word "green" is written in red) and the task is to name the colour in which the word is written (red). In this case the reading of the word has to be inhibited and its physical colour has to be named. Negative priming occurs when on the next trial an item appeared in the colour that had been the ignored word of the previous stimulus (e.g. "yellow" printed in green) and the inhibited colour (green) during the task "naming of colour" becomes the target colour. This results in a greater delay and in an increased error rate because "of a
Applied to the card sorting tasks with the extra-dimensional shift and target cards (DCCS) one can argue that something like negative priming occurs for the following plausible reason. For instance, having to sort a yellow sun into the box with the yellow car rather than into the box with the red sun on it, is likely to create some tendency to put that card with the sun into the box with the sun (our intuitive idea of a "visual clash" because there is a visual match between target card and test card on the irrelevant dimension). This tendency needs to be actively inhibited. This inhibition during the pre-switch phase then leads to negative priming in the post-switch phase when the formerly suppressed dimension becomes the target dimension. This analysis of the task combined with an executive deficit theory about younger children can explain why the 3-year olds had serious problems on this task.

In contrast on the extra-dimensional shift task with puppets, there is no need to actively inhibit the irrelevant dimension during the pre-switch phase since there are no target cards suggesting the use of this dimension for a match, e.g., Donald wanting yellow things only highlights the colour on the test cards and there is no need to suppress the fact that the cards contain the shapes of a sun because there is no temptation to put suns into Mickey's box. Consequently this task is easy. Similarly, the reversal tasks (with target cards or puppets) only involve one dimension. Hence there is no irrelevant dimension to be suppressed on the pre-switch trials that then would lead to negative priming on the post-switch trials.

Müller (2001) recently reported some direct evidence for negative priming of the ignored dimension in the DCCS task. When in a new version the attended dimension of the pre-switch phase was dropped for the post-switch phase, hence prohibiting any tendency to perseverate with the old predominant dimension, but the formerly unattended dimension
became relevant children found this task almost as difficult (only 25% correct) as the standard DCCS task (13% correct).

A minor problem of our data for this "negative priming" theory would be that the younger children had difficulties only when the standard DCCS task was presented first but performed practically as well as on the other tasks when one of them preceded the DCCS task (see Figure 1 and 3). However, as this order effect was unexpected and our tasks had not been designed to test it we need to await proper replication of this effect before attaching too much weight to its theoretical implications. For instance, Phil Zelazo made the following intriguing suggestion of how earlier tasks might influence later tasks. Whenever the DCCS task was not first it was preceded by at least one reversal shift task. Once children had encountered a reversal shift task they may expect another reversal shift whenever a change of rules is announced and, consequently, treat later DCCS tasks as reversal shift tasks resulting in perfect sorting performance. Our informal impressions of how some children approached the DCCS task indeed conform to this idea.

Another possible account of the observed order effect and the difference between DCCS task and the other task versions is that the switch in dimension is not as obvious for children in the standard task as it appears to be for us—who know the point of the game. In the pre-switch phase of the standard task the children might interpret the point of the game, e.g., "All the red cards go here (point to box with something red on it), and all the yellow cards go here (point to box with something yellow on it)," more generally as "put each card to the corresponding target". Although the instructions for the post-switch phase try to indicate the immanent change, "Now we are playing a new game, the shape game. The shape game is different. This time, all suns go here (point to the red sun target) but all cars go there (point to yellow car target)," children may understand something like this: "Now I’ll get something new (new cards) but still I have to put each card to the corresponding target (sun to sun, car to
So, from the child’s point of view there is no explicit mention that the same old cards have to be treated differently. Hence when, despite the promise of impending change, one of the old cards is handed out again, children unthinkingly apply the old colour description since they had not explicitly been alerted to the need of having to treat the same cards differently.

In contrast, in the sorting task with puppets the relevant change is announced by a change in preference: Donald (who wanted red things) now wants the suns. This is a clear indication to pay attention to whether cards contain a sun or not. Similarly, in the tasks with reversal shifts the change is announced as having to put the cars now to the suns. This is a clear indication that the old rule "put each card to the corresponding target" no longer holds and that the opposite action is to be carried out.

Doing one of these new task variations first may teach children that with the announcement of a change in the game cards have to be treated differently. Being alerted to this difference may help them realise in the DCCS task that the new instructions, "this time all suns go here (point to box with a sun on it), etc." , not only give a new exemplification of the old matching rule but also indicate that cards will have to be treated differently. With that realisation most of the difficulty of the DCCS task disappears.

This still leaves us to explain why the older children apparently do not need these prompts. They spontaneously understand the post-switch instructions of the DCCS task as intended by the experimenter. And we need to explain why this spontaneous understanding tends to emerge with the mastery of the false belief task as demonstrated in several studies. One possible explanation could be that with the mastery of the false belief task children become highly sensitive to the fact that one and the same thing can be identified under different labels. Doherty and Perner (1998) reported a strong correlation between understanding false belief and the ability to follow instructions to name a thing differently, e.g., after explaining that the animal in a picture can be called a "rabbit" but also a "bunny" the
task is to use the other name than that which puppet uses (e.g., if puppet says "bunny" the child has to say "rabbit"). The emerging ability indexed by this task cannot be directly applied to the DCCS task, since 3 year old children only have problems with alternative names for things (akin to the mutual exclusivity problem in word learning, Markman, 1989) but not with switching from ("it's a bunny" to "it's brown"). The fact that 3-year old children have no deeper problem with realising that something can be a car and that it can be red makes sense in view of their ability to perform well on the DCCS task after having had the other task versions. But why can't they perform well on this task spontaneously whereas the 4-year olds (who succeed on false belief) can? Our tentative suggestion is that with the understanding of false belief and the understanding that things can have alternative names children become very sensitive to alternative descriptions. This sensitivity enables them to spontaneously interpret the post-switch instructions in the DCCS task the way they are intended by the experimenter. The younger children need extra clues.

**Summary.** Our central finding is that children find the DCCS task only difficult because it combines an extra-dimensional shift with the use of target cards. To accommodate this finding the traditional theories (inhibition of prepotent strategy and CCC theory) would need to be amended. Also the "frontal lobe" theory that the difficulty resides primarily in the extra-dimensional shift would need to be amended to account for the role of target cards. Promising new accounts include the theory that children find it difficult to attend to what they have learned to ignore as irrelevant in the pre-switch phase ("negative priming"). Another possible explanation is that children have difficulty in re-describing cards under a different property unless this need of re-description is directly emphasised.
References


