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Young Children's Transfer of Series Completion in a Dynamic Test Setting: Does Cognitive Flexibility Play a Role?

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Abstract

Dynamic testing aims to assess potential for learning by measuring how much a child can profit from a training procedure during the testing process. These procedures often include transfer tasks as a measure of the potential for learning, as the ability to transfer learned skills and knowledge is considered essential in successful learning. The aim of the current study was to investigate whether including a specific type of transfer task in a dynamic testing context, a so-called reversal procedure, would provide extra information on 6-7-year-old children's potential for learning. Moreover, it was investigated whether children's ability to transfer newly learned skills was dependent on their level of cognitive flexibility, as this executive function has previously been argued to be of significant importance in the transfer of academic skills. The results revealed that children's transfer abilities were indeed related to another measure of potential for learning, i.e. children's learner status. In addition, children's cognitive flexibility predicted greater transfer abilities and appeared to play a greater role for children who did not receive training or did not profit much from the training procedure. The results underline the importance of supporting children's cognitive flexibility when teaching for transfer.

Keywords: Dynamic testing; Series completion; Transfer; Cognitive flexibility

Introduction

An important aim of education is to facilitate transfer of classroom learning to other in- and out of classroom activities. What is more, transfer is considered a key concept in education and learning in general [1-3]. Transfer of learning has been said to occur when a problem-solving approach taught in one context is generalized to a different but related one [4]. Notwithstanding the importance of transfer, it still remains a relatively poorly understood phenomenon [4,5]. Early research findings indicate that age and intelligence might play a role in efficiently carrying out transfer tasks, which was suggested to be influenced by better signs of executive functioning, such as planning and monitoring, in children who are older or have better intellectual capabilities [6,7]. With regard to executive functioning, these studies, in particular, suggest that flexible use of available information, cognitive flexibility, might play a pivotal role in children's transfer.

Because of the central role of transfer in learning, it is often utilized as a measure of children's potential for learning [1,8-10]. Insight into children's potential for learning is often gained through dynamic testing or dynamic assessment [11,12], which are assessment procedures that incorporate one or multiple cognitive training phases into the assessment process. The aim of the present study was to further investigate whether including a transfer task in a dynamic testing procedure may provide extra information about children's potential for learning. Moreover, to gain a better understanding of the cognitive processes involved in children's transfer abilities, the role that cognitive flexibility might play in this process was investigated.

Dynamic testing

Dynamic testing is different from conventional, also known as static, testing in that feedback and help are incorporated into the testing process to facilitate learning and gain insight into an individual's cognitive potential [12,13]. The dynamic testing approach is often linked to Vygotsky's [14] theory, in which it is proposed that educational professionals can learn more about children's cognitive potential by assessing what they can achieve with the help of more skilled others, rather than as a result of unassisted performance [15,16]. Dynamic testing and assessment are assumed to support the child in understanding the tasks at hand by drawing upon important cognitive processes. Therefore, these forms of assessment are said to provide important diagnostic information about the children's ability to profit from training and instruction, as well as their ability to maintain and transfer problem solving skills [17-19].

Dynamic tests can employ different formats and training procedures [12,13], among which the frequently used 'sandwich format'. This format refers to a pre-test-training–post-test design in which the child receives feedback and help during the training phase, often according to a standardized prompting model [13,20]. A particular form of standardized prompting that was pioneered by Campione et al. is the 'graduated prompts' procedure [6]. This procedure involves the administration of a series of adaptive and standardized, hierarchically ordered prompts that has been further developed and adapted in studies on dynamic testing [16,21,22]. Previous studies revealed that this procedure is beneficial for the acquisition of, for example, inductive reasoning skills under dynamic testing conditions [23,24], and, less obviously, in generalizing these skills to new but related problems [25,26].

Transfer of inductive reasoning skills

Static and dynamic measures of cognitive abilities often employ inductive reasoning tasks, as these abilities are considered central aspects of learning and transfer [27-29]. Inductive reasoning refers to the ability to discover regularity and order within a given set of objects, and is typically measured by tasks that ask the child to find similarities and differences with regard to objects or the relationships between them, such as analogies, series, and matrices [29]. In a study on the transfer effects of dynamic testing of inductive reasoning in young children with intellectual disabilities [26], young children with moderate to severe intellectual disabilities who received a graduated prompts training showed transfer of their analogy problem-solving to analogy construction skills in a 'reversal' procedure. This approach to measuring transfer of newly acquired skills, which involves a reversal of roles whereby the test leader becomes the testee and vice versa, was originally used by Kohnstamm [30], who found that children who were asked to construct inclusion problems were able to transfer these abilities to a reversal task in which similar materials were offered.

In the current study, we sought to further examine whether transfer of series completion problem-solving, taught under dynamic testing conditions or practiced, to series completion construction, was related to children's potential for learning as measured through the ability to profit from a graduated prompts procedure. In other words, we aimed to explore whether including a reversal task to measure children's self-construction abilities in the dynamic testing procedure would provide more detailed information on children's potential for learning. To promote transfer of the taught or practiced series completion skills, a reversal self-construction task was employed that resembled the surface features of the open-ended series completion tasks that the children had to solve during the practice and training sessions. It was assumed that asking the children to construct series completion items of comparable open-ended format as the practice and training items, with the same materials, would prime them to activate and apply their previous experiences and learning. The reversal format was expected to be more challenging than the open-ended items, since it was assumed that self-construction explicitly required children to draw upon various advanced series completion skills in their memory in order to construct a correct series completion item [30,31].

According to Perkins and Salomon [3,32], transfer can be described in terms of 'low road' and 'high road' transfer. Low road transfer describes the automatic triggering of well-practiced skills in circumstances where there is notable perceptual similarity to the original learning context. Low road transfer is based on considerable overlap in superficial stimulus among situations. High road transfer, on the other hand, depends on deliberate, mindful abstraction of skills or knowledge from one context to another, without the trigger of superficial perceptual similarity. This form of transfer requires reflective thought with regard to abstracting from one context as well as finding relationships with other contexts, as opposed to low road transfer which seems to be of an automatic nature. As a consequence, the reversal task used in the present study was assumed to include triggers for both 'high road' and 'low road' transfer mechanisms.

Cognitive flexibility and transfer

In early dynamic testing research on transfer, large individual differences were found in children's ability to transfer newly acquired skills and knowledge [7,25]. According to these authors, these outcomes seemed to suggest that 'executive routines' were involved in this process, which were proposed to be responsible for overseeing and coordinating information and cognitive strategies. These executive processes, in turn, were assumed to enable learners to carry out actions necessary for adequate performance, including planning, checking, monitoring, and other actions such as sequencing. In these studies, more specifically, one aspect of executive functioning, flexibility in using available information, was suggested to play a large role in learning a new skill, and subsequently transferring these newly obtained skills to a different context. Campione, Brown, Ferrara, et al., moreover, argued that using information flexibly is essential for intelligent performance [25]. They stated that flexible use of information is a prerequisite for learning, and therefore, also for generalization of learning. This does not seem surprising as cognitive flexibility is considered to be a vital aspect of the ability to adapt to novelty [33], new task demands, utilize feedback, switch between cognitive strategies, and alter or modify previously learned behaviors [34,35]. Impairment in this domain is often associated with perseverative behavior, with children failing to adjust to changing activities or procedures [36]. The potential involvement of the executive functions in children's transfer of abilities has received only little attention in the more recent dynamic testing literature. Although some studies investigated the role of particular aspects of executive functioning in children's dynamic test performance, such as working memory [19,23,37], the role of cognitive flexibility remains explored less intensively.

The current study

In the current study, we sought to investigate whether children's ability to transfer newly acquired series completion skills, taught under dynamic testing conditions or practiced only, to a self-construction task, was related to their ability to profit from a graduated prompts procedure, and their level of cognitive flexibility. Transfer was measured using a 'reversal' procedure in which the children were asked to construct their own series completion items, similar to the ones they had solved before during training or practice [26,30,38]. A number of hypotheses were tested.

Firstly, we sought to examine the effectiveness of a graduated prompts procedure in improving children's series completion skills, in order to examine whether the graduated prompts procedure would indeed inform us about children's potential to learn from training. Children's progression in series completion reasoning was examined by means of a classification scheme on the basis of their learner status. Depending on their performance on pre- and post-test, children were grouped as 'Learner', 'High Scorer', or 'Non- Learner' [39]. Considering that previous studies utilizing the graduated prompts procedure indicated that this type of training led to improvement in children's series completion skills [20,24,] it was expected that children who received training would have a greater chance of obtaining a more efficient learner status, and be classified as 'Learner', than those who received practice opportunities only.

A second set of hypotheses concerned children's transfer skills in relationship to both their ability to profit from training, and their level of cognitive flexibility. The ability to transfer was defined as children's accuracy in transfer item construction, and the level of difficulty of the items they were able to construct [40,41]. It was expected that transfer accuracy and level of difficulty in the self-constructed series completion items would be predicted by children's ability to profit from training, as measured by children's learner status. More specifically, it was expected that children with a more efficient learner status after

training, i.e. 'Learners', would show greater transfer accuracy, and a higher level of difficulty, because these children were argued to have required a deeper understanding of series completion reasoning, necessary for successful self-construction [30,38]. This finding would support our expectation that including a transfer task in the assessment process can increase our understanding of the child's cognitive potential. In addition, because the ability to transfer newly acquired (inductive) problem solving skills under dynamic test conditions has been assumed to be related to a certain level of flexibility in the use of information [7], it was expected that children with higher levels of cognitive flexibility would show more efficient adjustment to the new rules of the reversal procedure, because these children are argued to switch more efficiently between novel and changing task demands and relevant problem solving strategies [33,34,36]. In other words, it was expected that children with more advanced levels of cognitive flexibility would show more transfer accuracy, and a higher level of difficulty in their self-constructed items.

Materials and Methods

Participants

Participants were 64 and 7-year-old children (34 boys, 30 girls) from first and second grade of primary education (M=6;11, SD=7.8 months). All children were native Dutch speakers from three elementary, middle class schools in the Western part of the Netherlands. Schools and children were selected based upon their willingness to participate. Written informed consent was obtained from all parents.

Design

A pre-test-training-post-test control-group design was employed. A randomized blocking procedure was used to equally allocate the children to one of two conditions: (1) training with graduated prompts and (2) a practice-only control group. Blocking was based on children's performance on a test of Visual Exclusion [42]. The experimental design of the study is depicted in Table 1. In the first session, all children were administered the Modified Wisconsin Card Sorting Test [43,44]. In the second session, all children completed the pre-test of the dynamic series completion test. In the third and fourth session, the children in the training condition were trained with the graduated prompts procedure, whereas the children in the practice-only control condition solved dot-to-dot tasks. In the fifth session, all children made the post-test of the dynamic series completion test, followed by the reversal procedure. The sessions took place weekly at the child's school and lasted approximately 30 minutes per session.

Condition	N	Visual exclusion and M-WCST	Pre-test	Training session 1	Training session 2	Post-test and Reversal Task
Practice-control	33	X	X	-	-	X
Graduated prompts training	31	X	X	X	X	X

Table 1: Experimental design of the study.

Visual exclusion

The visual exclusion subtest of the RAKIT [42] was used to measure children's initial inductive reasoning ability. The aim of this subtest is to determine children's inductive reasoning ability by asking them to induce a rule that determines which of four figures does not belong to the other three.

Modified Wisconsin card sorting test

The Modified Wisconsin Card Sorting Test [43,44] was used to measure children's level of cognitive flexibility. The M-WCST is a simplification of the original Wisconsin card sorting test [45] and consists of 48 cards. The children were asked to sort the cards according to color, shape, or number. Four stimulus cards were presented (a red triangle, two green stars, three yellow crosses and four green circles) which the child used to start the sorting procedure. As opposed to the original version of the test, the first sorting criteria was determined by the child which implied that the completed first sorting was always accepted as correct [46]. The child then determined the second sorting criterion, leaving the third criterion to be automatically established by the choice of the first two criteria. In other words, if the child correctly sorted the cards according to 'color', and then to 'number', the third criterion was automatically 'shape'. After each card-sort, the children were informed about the correctness of their sort. After six consecutive correct responses the category was considered complete and the children were instructed to switch to another criterion with the words 'now the rules have changed'. After completing every category twice or after sorting all 48 response cards, the procedure was completed.

Series completion test

A dynamic series completion test was used to measure children's inductive reasoning skills. The procedural guidelines, prompting protocol and construction principles have previously been described in Resing and Elliott and Resing et al. and Elliott [20,41]. The series completion items were provided as open-ended construction tasks (an example is presented in Figure 1).
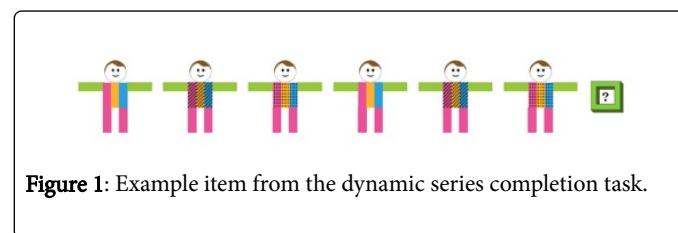

Figure 1: Example item from the dynamic series completion task.

All items consisted of a schematic puppet series that the children were asked to complete by constructing the correct puppet with plastic body parts on a plasticized plastic puppet shape. The body parts could be used to construct every possible solution and consisted of: a head,

two arms, two legs and three belly-parts. All body parts were available in three designs: stripes, dots, or no design, and in four colors: yellow, green, pink and blue. In order to correctly complete each series, the children were required to encode the different task elements of the series while simultaneously identifying the changing relationships between these task elements. The task difficulty of the items was determined by the number of recurring transformations and the frequency of these recurring transformations across the item (i.e. the periodicity). For each constructed puppet, the examiner noted down what the constructed puppet looked like, whether the answer was correct or incorrect, and how much time the child needed to solve the series. After each answer, the child was asked to explain why he or she made that specific puppet.

Series completion: pre- and post-test

The pre- and post-test both consisted of 12 series completion items, increasing in difficulty. The post-test items were constructed in such a way that they reflected the pre-test item difficulties; the items only differed in gender, color and design, not in number of recurring transformations or the periodicity of these recurring transformations. During the pre- and post-test, the children did not receive prompts to support their performance or feedback regarding the correctness of their responses.

Series completion: Graduated prompts training procedure

The graduated prompts procedure consisted of four prompts which gradually changed from metacognitive prompts through task specific instructions to, finally, a step-by-step scaffold that helped the child to construct the correct answer. After one example series, each item was presented with a general instruction. The child was asked to construct the correct solution using the plastic body parts and then received feedback regarding the correctness of the response. The children were only provided with a prompt if they constructed an incorrect solution. This meant that for each series, the children could be provided with four prompts, from which the last one always guided the children towards the correct solution. A schematic structure of the prompting procedure with brief descriptions of the prompts is provided in Figure 2. Qualified undergraduate psychology students, trained in advance in all testing and training procedures, implemented the prompting procedure.
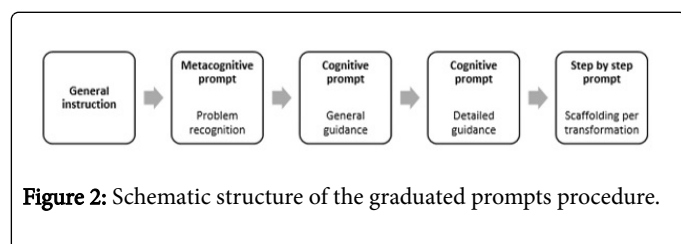

Figure 2: Schematic structure of the graduated prompts procedure.

Series completion: Reversal procedure

The reversal series completion procedure used the same basic puppet series as the initial puppet task, and consisted of three self-construction items. On these three items, the child was asked to construct a series completion item, which was then to be completed by the examiner. In other words, the child was asked to take on the role of the examiner and the examiner to take on the role of the subject.

Similar to the series completion task, the reversal task consisted of series of six puppet figures. In the reversal task, the children were asked to construct the series completion items themselves. The following instruction was given: 'we are going to work with the puppets again, but this time you will be the one who makes the puppet rows, and I have to complete them. For the first row, the first three puppets are already there. But you can decide how you want the row to continue' (the first self-construction item is depicted in Figure 3). On the first item, the first three puppet figures of the series were already given, and the child was required to provide the following three puppet figures to complete the item. This item supported the child in making the transition from problem-solving to problem-constructing, by having the first three puppets of the series already provided to them. After the child had constructed the remaining three puppet figures, the examiner provided an incorrect solution to the series. The examiners were instructed to provide such an incorrect answer that it was easy to spot it was incorrect. After this, the child was asked to explain to the examiner how to correctly solve the series, in order to examine the child's level of understanding [47]. On the second item, only the first two puppet figures were provided, and the child was asked to complete the series' remaining four puppets. On the third item, the children were asked to construct a complete series of six puppets. After each item constructed by the child, the examiner provided an incorrect answer and the child was asked to explain how to solve the series correctly. The task was administered via a laptop pc to enable the children to change the colors and patterns of the puppet pieces with relative ease.
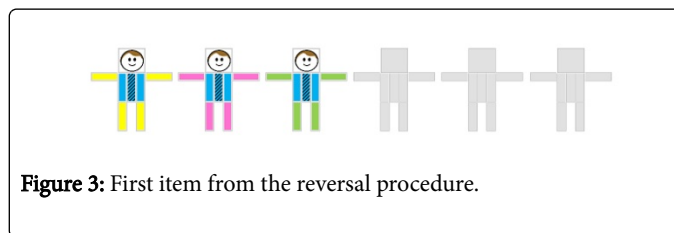

Figure 3: First item from the reversal procedure.

Scoring

Modified Wisconsin card sorting test

A measure of cognitive flexibility was derived from the M-WCST by determining the percentage of perseverative errors made by the child. A perseverative error was defined (1) as an error made because the child persisted in sorting according to the previously incorrect sort and (2) as an error made when the child did not switch between sorting strategies after being told that the criterion had changed [43,48].

Series completion: Training and learner status

Children's gain scores, post-test minus pre-test scores, are often used to examine children's performance change after cognitive training. However, gain scores are argued to provide unreliable representations of children's progression from pre- to post-test as they do not sufficiently reflect the child's pre-test level and do not account for regression to the mean. Therefore, in this study, children were classified as 'non- learner', 'learner' or 'high scorer', enabling a group-wise comparison of performance gain. This classification was applied using a pragmatic standard deviation rule of thumb [39] that was previously found to be valid in classifying children according to their learner status [39]. Learners were those children who improved their performance between pre- and post-test with 1.5 SD. High scorers

were those children who obtained a score between the pre-test upper level minus 1.5 SD on the pre-test. Non-Learners did not meet either of these criteria.

Series completion: Reversal procedure

Scoring for the item construction reversal task was based on whether the constructed series followed a recurring pattern that could be solved through inductive reasoning. The series could be scored as either (1) non-inductive, (2) partially inductive, or (3) fully inductive. If a series did not contain a recurring pattern that led to an inductive rule, the series would be scored as non-inductive (1). For series that contained an inductive recurring pattern, as well as transformations that could not be determined by an inductive rule, the series would be considered partially inductive (2). If all transformations in the series formed a recurring pattern that followed an inductive rule, the series were scored as fully inductive (3).

Additionally, to evaluate the level of difficulty, the series were scored on the number of correct inductive transformations the child made within the series. For example, if a series contained one transformation

in color (e.g., the arms alternately changed from blue to pink throughout the series) and one transformation in patterns (e.g., the legs alternately changed from dots to stripes throughout the series), the number of correct transformations was scored as two.

Results

Initial group comparisons

Prior to the dynamic testing process, initial group comparisons were conducted to investigate possible differences between conditions with regard to children's age, initial inductive reasoning skills, and cognitive flexibility. Table 2 shows the descriptive statistics of pre- and post-test performance scores. One-way ANOVAs revealed that the groups did not differ in age (F (1, 65)=0.16, p=0.69), inductive reasoning skills as measured with the test of Visual Exclusion (F (1, 65)=0.05, p=0.83) and cognitive flexibility as measured with the M-WCST (F(1, 65)=0.47, p=0.49). After the start of the dynamic series completion test, pre-test performances were compared between conditions. The result did not reveal a significant difference (F (1, 65)=0.16, p=0.70).

Variables		Pre-test			Post-test	
Condition	Learner status	N	M	SD	M	SD
Practice-control		33	4.29	2.37	5.18	2.54
Graduated prompts		31	4.03	2.90	6.39	3.17
Graduated Prompts	Learner	14	2.93	1.67	7.93	1.71
	Non-learner	17	2.18	3.50	4.94	3.57
	High scorer	0	-	-	-	-
Practice-control	Learner	9	2.11	1.97	6.67	1.41
	Non- learner	24	4.53	2.060	4.64	2.66
	High scorer	0	-	-	-	-

Table 2: Means and standard deviations of pre-test and post-test scores divided by condition and learner status.

Psychometric properties

Internal consistency of the series completion pre- and post-test was calculated using Cronbach's alpha. A Cronbach's α of 0.74 was found for pre-test and a Cronbach's α of 0.78 was found for both conditions of the post-test, practice-control and training. Regarding the Modified version of the Wisconsin Card Sorting Test, prior research demonstrated that moderate stability estimates were obtained for the Percentage of Perseverative Errors (=0.64) (Lineweaver, Bondi, Thomas, and Salmon).

Effectiveness of the graduated prompts training

A binary logistic regression analysis was conducted to investigate whether training would indeed predict a more efficient learner status. Learner status (learner and non-learner) was included as dependent variable, and condition as factor. Children's classification according to learner status was based on a pragmatic 1.5 SD rule of thumb [39]. Learners were those children who improved their performance from pre- to post-test with 1.5 SD, whereas non-learners did not meet this

criterion. In the current study, 24 children were classified as learner, and 40 children as non-learner (Table 2). No children were classified as high scorer. The results of the regression analysis showed that condition significantly predicted the classification of children as Learner or Non-Learner (b=0.90, Wald $\chi^2(1)$=2.91, p<0.05). The odds ratio of the analysis revealed that a child in the graduated prompts training condition was 2.5 times more likely to be classified as Learner than a child in the practice-only control condition. This result supported the expectation that the training procedure improved children's series completion reasoning.

Transfer effects in series completion skills

To examine children's transfer skills in relationship to both their ability to profit from training as represented by their learner status and their level of cognitive flexibility, several ordinal regression analyses were carried out. All regression analyses were performed separately for the three self-construction items of the reversal procedure, as each item differed in the amount of initial help provided. First, ordinal regression analyses were carried out for the three self-construction items with condition and learner status as factors, M-WCST

performance as covariance, and Accuracy as dependent variable. Accuracy was defined as non-inductive, partially inductive, or completely inductive. The basic statistics of the level of accuracy, divided by Condition, are reported in Table 3.

Variables	Self-construction item 1			Self-construction item 2			Self-construction item 3		
	Graduated pr.	Practice-control	Total	Graduated pr.	Practice-control	Total	Graduated pr.	Practice-control	Total
Non-Inductive	3	16	19	6	13	19	6	11	17
Partially Inductive	9	8	17	6	11	17	17	16	33
Inductive	19	9	28	19	9	28	8	6	14

Table 3: Children's transfer accuracy level, divided by condition.

The results of the regression analyses (Table 4) revealed that condition*learner status significantly predicted accuracy for item 1 and 2 (where initial help was provided). More specifically, children in the graduated prompts condition, who were classified as Non-Learner, showed less accuracy on the first two self-construction items than the children who were classified as Learner. The results supported our expectation that children with a better ability to profit from training would construct more inductive series on the reversal task. This result did not apply to the most difficult item 3.

Accuracy	Self-construction Item 1			Self-construction Item 2			Self-construction Item 3		
Predictors	b (SE)	χ2	P	b(SE)	χ2	P	b(SE)	χ2	P
M-WCST	-0.12 (0.06)	4.05	0.04	-0.23 (0.11)	4.57	0.03	-0.11 (0.05)	4.09	0.04
Condition	-1.69 (0.51)	11.13	0.00	-1.27 (0.49)	6.71	0.01	-0.41 (0.48)	0.75	0.39
Condition [=0] *Learner Status [=0]	-0.24 (1.54)	0.03	0.87	-0.53 (1.39)	0.15	0.70	-22.02 (-)	0.00	0.99
Condition [=0] *Learner Status [=1]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Condition [=1] *Learner Status [=0]	-5.75(2.05)	7.89	0.01	-5.62(2.59)	4.70	0.03	1.20 (1.44)	0.70	0.40
Condition [=1] *Learner Status [=1]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Condition [=0] *Learner Status [=0] *M-WCST	-0.13 (0.06)	4.88	0.03	-0.23 (0.11)	4.41	0.04	-0.10 (0.06)	3.25	0.07
Condition [=0] *Learner Status [=1] *M-WCST	-0.16 (0.08)	3.95	0.05	-0.25 (0.12)	4.61	0.03	-0.11 (-)	0.00	1.00
Condition [=1] *Learner Status [=0] *M-WCST	-0.18 (0.07)	7.31	0.01	-0.26 (0.11)	5.55	0.02	-0.10 (0.06)	2.77	0.09
Condition [=1] *Learner Status [=1] *M-WCST	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Note. Model 1 χ2(7) =12.80, p=0.08; Model 2 χ2(7)=14.87, p=0.04; Model 3 χ2(7)=20.57, p=0.00									

Table 4: Overview of the ordinal regression parameter estimates examining the effects of hypothesized predictors of accuracy.

M-WCST performance was found to significantly predict accuracy for all three items, supporting our expectation that a more flexible use of information improves children's transfer abilities. More interestingly it was found that for the non-learners and the Learners in the practice-only control condition, and for the non-learners in the training condition, interaction effects were found with M-WCST performance. These results indicated that for these children, a more advanced level of cognitive flexibility as measured with the M-WCST, predicted higher accuracy on the first two items of the self-construction task. For the children in the training condition who showed substantial progress as a result of training, i.e. the Learners, cognitive flexibility seemed to be less important in their transfer accuracy. These interaction results were less profound for the third self-construction item.

Next, a series of linear regression analyses were carried out for the three self-construction items with level of difficulty as dependent variable. The level of difficulty was determined by the number of recurring transformations across series. The analyses, including Condition and Learner Status as factors and M-WCST performance as covariate, revealed fewer significant results as compared to the regression analyses concerning accuracy (Table 5). Condition*Learner Status did not show any significant effects in relation to the item difficulty. M-WCST performance was found to predict the level of

difficulty of the second self-construction item only. Condition*Learner Status*M-WCST was found to hold significant predictive value for the level of difficulty, but again only for the second item. In line with the results of the accuracy analyses, the level of M-WCST performance predicted the level of difficulty for this self-construction item for both Learners and Non-Learners in the practice-only control condition, and for Non-Learners in the graduated prompts condition, but not for children who showed substantial progress after having received training. This result was less profound for the first self-completion item, and not at all significant for the third self-construction item.

Difficulty Predictors	Self-construction Item 1			Self-construction Item 2			Self-construction Item 3		
	b (SE)	χ2	P	b(SE)	χ2	P	b(SE)	χ2	P
M-WCST	0.02 (0.01)	1.86	0.17	-0.05 (0.02)	7.51	0.01	0.03 (0.02)	2.00	0.16
Condition	0.10 (0.16)	0.39	0.53	-0.22 (0.29)	0.57	0.45	-0.04 (0.32)	0.01	0.91
Condition [=0] *Learner Status [=0]	0.82 (0.39)	2.83	0.10	1.33 (0.66)	2.47	0.12	0.08 (0.72)	0.01	0.92
Condition [=0] *Learner Status [=1]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Condition [=1] *Learner Status [=0]	1.00 (0.45)	2.73	0.09	1.45 (0.76)	2.43	0.11	1.16 (0.83)	1.98	.16
Condition [=1] *Learner Status [=1]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Condition [=0] *Learner Status [=0] *M-WCST	-0.02 (0.01)	3.43	0.06	-0.06 (0.02)	6.67	0.01	-0.02 (0.02)	0.76	0.38
Condition [=0] *Learner Status [=1] *M-WCST	-0.03 (0.02)	2.72	0.09	-0.08 (0.03)	5.04	0.03	-0.03 (0.04)	0.57	0.45
Condition [=1] *Learner Status [=0] *M-WCST	-0.03 (0.02)	3.34	0.07	-0.06 (0.03)	5.11	0.02	-0.04 (0.03)	2.46	0.12
Condition [=1] *Learner Status [=1] *M-WCST	0.0	0.0	0.0	0.0	0.0	0.0			
Note. Model 1 χ2(7)=8.85, p=0.26; Model 2 χ2(7)=8.16, p=0.31; Model 3 χ2(7)=12.28, p=0.09									

Table 5: Overview of the ordinal regression parameter estimates examining the effects of hypothesized predictors of difficulty.

In conclusion, children who did not seem to profit much from the graduated prompts training as reflected by their learner status showed significantly less accuracy on the first two self-construction items as compared to children who showed greater progress after training, supporting our expectation that including a transfer task in the assessment process can provide a more detailed picture of children's potential for learning. In addition, children's performance on the M-WCST seemed to be a good predictor of transfer accuracy, in particular for all children in the practice-only condition, and for the non-learners in the graduated prompts training condition. With regard to the level of difficulty of the self-construction items, significant results were only revealed for the second self-construction item. M-WCST performance predicted the level of difficulty of the second self-construction item, but only when Condition and Learner Status were included in the prediction model. In line with the results concerning transfer accuracy, M-WCST performance influenced the level of difficulty for all children, except for the children who were classified as learners after having received the graduated prompts training. The overall results indicated that for these children, who already seemed to have mastered the series completion skills to a greater extent, cognitive flexibility played a less important role in their transfer performance.

Discussion

The current study aimed to investigate whether including a transfer task in a dynamic testing context would provide more detailed information on young children's potential for learning. Moreover, it was investigated whether the process of transfer was dependent on children's level of cognitive flexibility, as flexibility has previously been argued to significantly contribute to children's ability to apply newly learned skills and knowledge to new situations.

In line with the results of previous studies utilizing a graduated prompts training in series completion [31,42], the training procedure proved to be effective in improving children's series completion skills from pre- to post-test. This improvement, as reflected by their learner status, was therefore considered a useful measure of children's ability to profit from the training procedure.

The extent to which children were able to transfer the newly learned knowledge and strategies to a novel, but related task, and its relationship with the ability to profit from training and cognitive flexibility, was the main aim of the present study. By means of a reversal procedure [26,31], during which the children were asked to construct three series completion items by themselves, their transfer abilities were examined. Transfer was measured through two performance measures: the accuracy and level of difficulty of the self-construction items. The reversal task was assumed to be very challenging for the children as self-construction requires a deep understanding of the reasoning processes behind successful series completion [23,38]. Our findings revealed that the mere fact of having received training predicted transfer accuracy, as well as, and more importantly, the extent to which children were able to profit from training, as reflected by their learner status. Children who showed substantial progression after having received training were able to construct more accurate series than children who did not seem to profit much from the training procedure. In other words, children who had acquired a better understanding of the reasoning processes at hand, and were therefore considered better strategic solvers, showed greater transfer of their abilities [30,49]. This finding supported our expectation that including a reversal task in the testing procedure can shed a more detailed light on children's potential for learning.

Although children's ability to profit from training was found to predict transfer accuracy, this was only true for the first two self-construction items. Performance on the third and supposedly most difficult item was found not to be related to having received training, nor to the ability to profit from training. This result seemed to suggest that the children were effectively trained in how to complete series, regardless of the amount of initial help offered, but not necessarily in how to construct a completely new item. This supported the assumption that the construction of a whole new item was indeed a more complex task [50].

As expected, better cognitive flexibility predicted greater accuracy for all three construction items. The ability to deal with novelty played an important role in the successful application of the previously taught information-processing components in the novel task-construction situation [33]. However, when training and learner status were taken into account, this was only true for the first two self-construction items. What is more, untrained children, and the children who did not profit much from the training procedure, seemed to rely to a greater extent on their cognitive flexibility in order to complete these self-construction items. These results are in line with developmental research regarding executive functions [51-53]. In these studies, it is argued that executive functions are especially important in optimizing one's approach to novel, unfamiliar circumstances, for which automatized strategies are not sufficient [51-53]. The reversal items were considered to be relatively more demanding for children who had not mastered the series completion strategies as much, because the newly taught strategies were not sufficiently automatized yet. For these children, their cognitive flexibility seemed to play a more significant role in their performance, as they needed this function to support their problem-solving abilities. Although these results were less profound for the third self-construction item, the same trend could be identified. In this light, it might be argued that, due to this item being challenging for all children, regardless of their learner status, all children depended more heavily on their cognitive flexibility in order to construct this item correctly, thereby attenuating the differences in the degree of cognitive flexibility involvement.

The finding that the ability to profit from the graduated prompts procedure was not a significant predictor of the complexity of the reversal items might be explained through the fact that the current study employed two short training sessions only. Although the ability to profit from training was a predictor of children's transfer accuracy, the training sessions might not have sufficiently taught the children about the factors underlying task complexity, such as the number of transformations present in the item, or the periodicity of the recurring changes. A longer, more intensive training, for example with more items, or with more prompts, might lead to children being able to construct more difficult items [31]. Moreover, it is important to note that children were not instructed to construct difficult items. In this light, it is plausible that some children could have constructed more difficult items than they actually did. Minimal instructions were given to the children in order to promote spontaneous transfer [38]. In future research, differential instructions could be given for different reversal items to investigate this hypothesis further.

The findings of our study suggest that the ability to construct accurate series completion items was related to the capacity to solve them [26,47] and could therefore contribute to our understanding of children's potential for learning. Children constructed more adequate series when they executed their series completion strategies more efficiently [49], and it was therefore argued that during the testing phase they gained a better understanding of the underlying principles involved [3,31]. In addition, cognitive flexibility played a significantly greater role in performance on the complex self-construction task, when children could insufficiently rely on the previously learned problem-solving strategies, when working on the self-construction items. This result suggests that, when designing in-classroom instruction methods that aim to facilitate children's transfer of newly taught skills and knowledge, attention must be paid to supporting children's flexibility. In line with the theory of successful intelligence in the classroom [54], supporting children's flexibility is likely to increase children's performance in different settings of assessment or instruction. Previous studies on the effects of dynamic testing procedures have shown that the graduated prompts training can attenuate differences in executive functioning by supporting weaknesses in, for example, working memory, through the prompts provided during training [23,37]. We therefore strongly recommend that future research focuses on investigating which prompts in the training procedure might be effective in supporting young children's flexibility, providing teachers and other education professionals with concrete instructions on how to be able to support children in showing more of their flexibility and potential for learning.

An important point for discussion concerns the measurement of cognitive flexibility in the current study. The Modified version of the Wisconsin Card Sorting Test has been argued to be especially suitable for the assessment of flexibility in children, because the test contains fewer cards than the original test, and includes explicit switch cues that prompt the children to switch between sorting categories [48]. However, the regular switch cues have been argued to facilitate performance as compared to the original test, thereby attenuating differences in perseverative behavior [55]. The question arises whether similar results as found in the present study would be revealed if flexibility would be measured in a purer form, for instance with the original administration procedure of the card sorting test. It might be argued that the role of cognitive flexibility would then become more profound, providing a more detailed insight into the mechanisms underlying transfer performance.

A second substantial point for discussion refers to the relatively static nature of the reversal task as compared to the graduated prompting procedure. Although the initial help provided differs between the self-construction items, the children received no further prompting or feedback regarding the accuracy or complexity of their self-construction items. To increase the ecological match between the dynamic test of series completion and the reversal procedure, a prompting procedure could be included in the reversal procedure, similar to the graduated prompting approach, to gradually enhance children's understanding of the task requirements [56,57]. In earlier research by Campione, Brown, Ferrara, et al. [25], for instance, prompts were administered to children during a transfer task when they had indicated they needed more help to correctly solve the transfer tasks. In this study, the manner in which these prompts were provided was similar to the training procedure. Applying this type of prompting to the reversal task utilized in the current study could not only enhance the ecological match, but also provide more insight into instructional needs during transfer. This latter notion could, ultimately, provide teachers and other educational professionals alike with important information to tailor their instructions in order to facilitate the transfer of learned skills and knowledge in a classroom setting.

Conclusion

Nevertheless, our findings suggest that a self-construction task, as a measure of transfer, can provide additional information about young children's depth of learning and potential for learning. Providing children with the opportunity to move beyond a practice or instruction situation to engagement in problem construction may shed light on children's ability to transfer learning, an important aim of education. Cognitive flexibility appears to support children's transfer of learning when the taught problem-solving skills are not yet sufficiently automatized. The practical implications seem to suggest that, when incorporating teaching for successful transfer in the classroom, supporting children's ability to use and develop their cognitive flexibility will facilitate the transfer of learning.

Acknowledgments

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