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► **To cite this version:**

Jérôme Clerc, Patricia H Miller, Laurent Cosnefroy. Young children's transfer of strategies: Utilization deficiencies, executive function, and metacognition. *Developmental Review*, 2014, 34 (4), pp.378-393. 10.1016/j.dr.2014.10.002 . hal-02012210

**HAL Id: hal-02012210**

**<https://hal.science/hal-02012210v1>**

Submitted on 8 Feb 2019

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Young children's transfer of strategies

Young Children's Transfer of Strategies: Utilization Deficiencies, Executive Function, and  
Metacognition

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This article was written while Jérôme Clerc was a visiting research scholar at San Francisco  
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We thank Lyn Corno for her comments on a previous version of this article.

Abstract

The purpose of this review is to present a new perspective on children's development of transfer of learning. The focus is on transfer of the effectiveness of a skill (i.e., improved performance), rather than just the transfer of the skill (e.g., a strategy) itself. Specifically, we examined the role of strategy utilization deficiencies, along with cognitive capacity, in the transfer of a memory strategy and, especially, strategy effectiveness (increased recall).

Executive functions, metacognition, and mindset were considered as mechanisms that can both facilitate and hinder transfer of strategy effectiveness. Implications for theorizing about both transfer and utilization deficiencies were discussed.

Keywords: memory strategies; cognitive transfer; utilization deficiencies; metacognition; executive function

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Children's difficulties with transferring a new skill from the learning context to a new task or setting has been one of the thorniest problems facing both cognitive developmental and educational psychologists (e.g., Cox, 1997; Klahr & Chen, 2011; Salomon & Perkins, 1989). In research on children's memory strategy development, for example, it remains somewhat of a mystery why children trained to use a new memory strategy on one task often have such difficulty transferring it to another, seemingly similar, task or context, even a short time later, unless much aid is provided (e.g., Lange & Pierce, 1992; O'Sullivan & Pressley, 1984; Paris, Newman, & McVey, 1982; Ringel & Springer, 1980; see Pressley & Hilden, 2006 for a review). The issue of strategy transfer is important because no task or setting is exactly like the one in which the strategy is acquired, and thus children must overlook minor setting differences and see the relevance of the trained strategy in the new setting. The purpose of this paper is to provide a new perspective on strategy transfer by drawing on two literatures not previously directed toward the issue of transfer—strategy utilization deficiencies and executive functions. We also draw on relevant findings from research on children's mindsets about performance and children's metacognition that might identify processes involved in a utilization deficiency during transfer. We will show that even if a strategy is transferred well, its benefit on the task may not transfer. That is, a strategy that benefits performance on an initial task and is transferred to a second, similar task, may produce less benefit in that transfer task. We call this a transfer-utilization deficiency (t-UD), to distinguish it from the broader and more common use of the term utilization deficiency (UD), which refers to any situation in which an appropriate strategy is produced but provides little or no benefit (Miller & Seier, 1994).

We first discuss strategy transfer in children, focusing on the increased cognitive demand that typically occurs during transfer. Then we discuss how the construct of strategy utilization deficiency might clarify the difficulties of strategy transfer, and then summarize supporting results from previous research. Next, we show how the development of self-regulation, especially executive functions and metacognition, might lead to either increases or decreases in utilization deficiencies, depending on the child's developmental level. We also consider the possible role of mindsets during transfer. In the conclusion, we show the utility of bringing together the literatures on utilization deficiencies, executive function, and transfer to construct a more complete account of transfer during childhood.

### **Transfer of Cognitive Strategies in Children**

Cognitive transfer is a topic of great interest for developmental psychologists, as “Cognitive development would be impossible unless children could use what they learn in one context (both temporal and physical) when they encounter relevant tasks in another” (Klahr & Chen, 2011, p. 197). Indeed, transfer refers to the ability to re-use knowledge previously acquired in a situation, in a subsequent different situation, encompassing either different tasks or even sometimes trials of a different nature in the same task (a detailed account of transfer models is beyond the scope of this article but see Barnett & Ceci, 2002; Cox, 1997; Day & Goldstone, 2012; Salomon & Perkins, 1989, for reviews). What fundamentally defines transfer situations is the similarity-but-not-identity between tasks (Thorndike & Woodworth, 1901) and also between contexts (Klahr & Chen, 2011). Structural similarities (the causal chain in the logic for solving the task) are usually contrasted with surface similarities (superficial common features, such as in their appearance). Thus, the child must make an in-depth analysis of the essential structural and superficial qualities of both tasks (Chi & VanLehn, 2012). In other words, some similarities call for transfer and others do not (Gentner, Ratterman, & Forbus, 1993; Holyoak & Koh, 1987). Children therefore have to

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decide which, if any, similarities in the tasks call for transfer and then, if they decide to attempt transfer, actively adapt their previously acquired knowledge to the new task (Engle, Lam, Meyer & Nix, 2012; Schwartz, Chase, & Bransford, 2012). In this way a child applies the unchanged-already known structure to a superficially different task.

A long history of research shows that transferring one's strategies is a common form of transfer in preschool- and school-aged children (Black & Rollins, 1982; Borkowski, Cavanaugh & Reichhart, 1978; Borkowski, Levers & Gruenenfelder, 1976; Carr, Kurtz, Schneider, Turner & Borkowski, 1989; Clerc & Miller, 2013; Clerc & Rémy, 2014; Marchandise, Mansy-Dannay, Guerrien & Clerc, 2014; Pressley & Dennis-Rounds, 1980), though sometimes not without difficulties (Crowley & Siegler, 1999; Rittle-Johnson, 2006). Difficulties when trying to transfer a strategy are likely to occur as a consequence of high resource-demanding processes. With regard to the above-mentioned analysis of each task, analyzing similarities between tasks and adapting the knowledge acquired in the first task to the second one involve processes that are highly resource-demanding. Especially demanding is the "knowledge compilation" mechanism involved in transfer, which "operates like a translation device, interpreting prior declarative knowledge into a set of procedures or cognitive rules to perform a specific task...[and]...can cause performance errors because of the working memory limitations that constrain how much declarative information can be retrieved" (Nokes-Malach & Mestre, 2013, p. 187). Researchers infer transfer from scores in the transfer task in measures such as recall (O'Sullivan & Pressley, 1984), number of analogies produced (Brown & Kane, 1988), or number of problems solved (Gamo, Sander, & Richard, 2010). However, a more precise assessment of transfer requires measuring not only these performance scores but also the degree of transfer of the strategy (or rule, etc.). Both scores together would reflect the benefit of the strategy, but very few studies have measured the transfer of both. Even when both are assessed, little if any attention is given to potential

discrepancies between good strategy transfer and a low transfer task score, which may reflect a utilization deficiency, the subject of this paper. We now turn to strategy utilization deficiencies and their possible role during transfer.

### **Strategy Utilization Deficiencies During Transfer**

Strategy development involves not only strategy acquisition but also strategy effectiveness, evidenced by better recall when an appropriate strategy is used. Somewhat surprisingly, producing a good memory strategy does not always insure improved performance. A strategy utilization deficiency (UD, Miller, 1990) is a temporary developmental phase in which children produce an appropriate memory strategy but cannot yet benefit from the strategy for their recall. Evidence for a UD (e.g., Bjorklund, Miller, Coyle, & Slawinski, 1997; Miller & Seier, 1994) includes a) a lower level of recall in strategic children than expected (e.g., not significantly better than in children not using a strategy or not the benefit that older children accrue from the strategy), b) the lack of a significant correlation between strategic behavior and recall, or c) no increase, or even a decline, in recall over trials while strategic performance improves. Most studies of UD have involved memory tasks and memory strategies, though studies also have shown UDs in various sorts of problem-solving tasks (e.g., Blöte, Resing, Mazer, & Van Noort, 1999; Miller & Aloise-Young, 1995; Miller & Seier, 1994; Rittle-Johnson & Siegler, 1999; Sophian & Wellman, 1987).

Most of the UD studies by Miller and her colleagues (e.g., Miller, 1990; Miller, Seier, Barron, & Probert, 1994) used a selective memory task in which children were to remember the location of each of six drawings from a particular category (e.g., animals) in an apparatus with twelve doors arranged into two rows and six columns. These six relevant items were behind doors with a drawing of a cage on the doors, while six irrelevant items (not to be remembered) were behind doors with a drawing of a house on the doors (and drawings of

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household items were underneath). During a half-minute study period, younger children tend to open all the doors, whereas older children tend to open only the relevant doors, thus efficiently using their study time. However, some children, especially during ages 5-8, produce the relevant selective strategy but their recall is not better than that of same-aged children who do not produce that strategy and/or there is no significant correlation between producing the selective strategy and recall.

Researchers also have demonstrated UDs with other memory strategies, such as sorting items into categories and clustering during free recall (e.g., Bjorklund, Schneider, Cassel, & Ashley, 1994), as well as verbal rehearsal (e.g., Miller & Seier, 1994). A UD can occur both when the initial strategy production is spontaneous (Miller & Seier, 1994) and when it requires an adult's prompt (Bjorklund et al., 1997). UDs have been documented in children aged as young as 3 (Blumberg & Torenberg, 2005) to at least 11. At any age, UDs are thought to be more frequent when a child first acquires a strategy and to diminish as the strategy becomes stronger and less resource-demanding (Miller & Seier, 1994). UDs are less common when the task is contextualized within a meaningful story (Miller et al., 1994), when children have a large working memory (e.g., Schneider, Kron-Sperl, & Hünnerkopf, 2009), and when children possess good task-specific metamemory (DeMarie, Miller, Ferron, & Cunningham, 2004). Today, the main debates concern how prevalent UDs are and the specific conditions under which UDs occur or do not occur (Clerc, 2013; Miller, 2000).

Researchers have identified several causes of UDs, including high cognitive load (Miller & Seier, 1994), low intelligence (Gaultney, 1998; Gaultney, Bjorklund, & Goldstein, 1996), poor metacognition (Alexander & Schwanenflugel, 1994; DeMarie et al., 2004; DeMarie & Ferron, 2006), and a weak knowledge base (Miller et al., 1994). These are all "cold cognition" causes. We know little about the "hot cognition" (e.g., motivational) causes.



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Specifically, why do children so often apply, again and again, correct but highly effortful strategies that do not help their recall?

Of the various causes of UD's examined, the strongest evidence is for insufficient cognitive resources (e.g., memory span, working memory). For example, children with greater memory capacity are less likely to show a UD (e.g., Kron-Sperl, Schneider, & Hasselhorn, 2008; Woody-Dorning & Miller, 2001). Moreover, when the effortfulness of producing a strategy is reduced by having an adult execute the strategy, fewer children show UD's (DeMarie-Dreblow & Miller, 1988; Miller, Woody-Ramsey, & Aloise, 1991). Also, when children of two ages are instructed to use a strategy and they expend comparable expenditure of mental effort to produce the strategy, recall improves only for the older children (Bjorklund & Harnishfeger, 1987). The resource interpretation of UD's is as follows: As with any new skill, at first a strategy is very resource-demanding. Children must select it from their available strategies, set it in motion motorically, and continue to monitor it (e.g., not slip back into a less mature, less effortful strategy, such as opening all doors rather than only relevant doors on Miller's selective memory task). Children also must modify the strategy to the specifics of the task as needed. Strategy production may consume so many resources that none are left for other memory-related activities such as encoding the items to be remembered, processing them at a deep level, and rehearsing them. As a child uses the strategy more and more, automatization of the strategy occurs and it becomes less resource-demanding. At that point there are enough resources for both strategic behavior and memory-related activities, and the UD disappears. Producing the strategy now enhances recall. Evidence for this role of strategy automatization as a result of practice is supported by cases in which recall is enhanced only after a strategy has been produced over several trials (e.g., Coyle & Bjorklund, 1997).

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Researchers have focused on the occurrence of a UD on a single task and have given little attention to the possible occurrence of a UD during strategy transfer. That is, once a child has acquired a good strategy and can use it to increase recall (i.e., has overcome a UD), might a UD reappear during transfer? Specifically, when children are faced with a new task they may need to redirect cognitive resources towards cognitive activities involved in the transfer of, or rejection of, that strategy for the new context. These cognitive activities would drain resources away from task performance *per se*, which would lead to a UD (i.e., good strategy production but poor recall on the transfer task). That is, a strategy that enhanced recall on the first task might no longer help recall on a second (transfer task), or help it less, because of the increased demands of transfer on the child's limited cognitive resources. Consequently, recall drops on this transfer task. Clerc and Miller (2013) recently labelled this type of UD that occurs in the context of transfer a *transfer utilization deficiency* (t-UD).

Evidence for a t-UD comes from three sources: an older study of UD's with a selective memory strategy by Miller and colleagues that involved a design containing elements of transfer, studies of organizational strategies during free recall by Bjorklund and Schneider and their colleagues with transfer designs that addressed strategy transfer, and a recent study focused specifically on t-UD's. First, regarding the early UD study involving selective memory, with the task described above, children aged 7 to 9 first had three trials in which they were to remember the locations of animals and to ignore household objects, and many of them produced the appropriate strategy of studying only the animals (DeMarie-Dreblow & Miller, 1988). Producing this selective strategy was significantly correlated with recall, which indicates strategy effectiveness. Then, however, the task changed (i.e., the goal was reversed) such that household objects were now relevant and animals were not, and a UD appeared among the younger children. That is, 7-year-olds continued to use (transferred) the selective memory strategy (looking only at relevant items) but using this strategy no longer

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significantly correlated with recall (until the final trial). This suggests that a change in a task may cause a UD when a child tries to continue to use the strategy on a slightly different version of the task.

Second, regarding UDs on a free recall task, Bjorklund and Schneider and their colleagues (Bjorklund, Coyle, & Gaultney, 1992; Bjorklund et al., 1994; Coyle & Bjorklund, 1996; Schwenck, Bjorklund, & Schneider, 2007, 2009) introduced new words and categories on their free recall task from one phase to another during the same session or from one session to another. Of interest for the current paper is whether children (aged 4-13, depending on the study) transferred their organizational strategy (putting same-category items together) to this very slightly different task. UDs did sometimes emerge; for example, children might remain strategic over the slightly-changing tasks (i.e., showing high levels of categorical sorting or clustering in recall), but recall declined, thus again demonstrating that transfer after task changes may lead to a UD (Bjorklund et al., 1994).

Third, a recent study (Clerc & Miller, 2013) provided a stronger test of transfer, with more substantial changes between the main task and two later transfer tasks in which it was less clear that the underlying structure between tasks remained the same. Each task (adapted from the Miller selective memory task) required children to attend selectively, during the study time, to six items belonging to one of two categories (animal vs household objects) while ignoring the six items belonging to the second category (irrelevant items), in order to be able to recall the positions of each relevant item in the array. Then, in terms of transfer at a later time, the first task and the two transfer tasks had the same structure, specifically, six items to be recalled out of twelve and the same selective attention strategy to be used. However, the tasks differed from each other in their surface elements in three possible ways: two-dimensional (cardboard apparatus) versus three-dimensional, a unitary row x column array versus items scattered randomly around a carpet depicting a village, and upright versus

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horizontal (flat on a table). The three tasks were (1) 3D-one piece-vertical (Miller's task), 2) 2D-one piece-horizontal (cardboard task), and (3) 3D-12 pieces-horizontal (carpet task, see Clerc & Miller, 2013). These tasks were counterbalanced as to whether they were the initial task, the first transfer task, or the second transfer task. On the initial task the children either spontaneously produced the selective strategy or were trained to do so, such that strategy production was nearly perfect on this task. Recall was good (there was no UD). When moving from the initial task to the first and second transfer tasks, children aged 4 to 5 transferred the selective strategy but their recall scores decreased in both transfer tasks compared to the initial one. Thus, the t-UD involved the co-occurrence, in a transfer task, of high strategic performance (at least equal to that in the initial task) and lower recall than in the initial task. Clerc and Miller proposed that the necessity of effortful cognitive activities during strategy transfer can interfere with recall. Specifically, a strategy may transfer, but lose some of its effectiveness due to resource-demanding activities required during transfer.

This study also makes a methodological contribution to the literature on transfer by showing that when studying transfer of strategies it is critical to assess both strategies and their effectiveness (in this case recall). Assessing only strategies may lead to the erroneous conclusion that transfer has occurred, but in fact only the strategic behavior, and not its successful application to recall, has transferred. Assessing both permits the detection of asynchronies, particularly a high strategic score but low recall, which is evidence for a t-UD. A child may need further practice with the strategy on the transfer task to reach strategy effectiveness.

These three sets of studies together support a new theoretical perspective not only on transfer but also on strategy UDs, a perspective focused on strategy transfer rather than strategy acquisition. In contrast to most strategy research, which has emphasized the early phases of acquiring a strategy, this research focused on the final phases of strategy

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development—the accurate application of one's strategies to a new task and the ability to benefit from the selected strategy (the effectiveness of the strategy in the slightly different task or setting). UD refers to the initial development of a strategy, when a good strategy provides little or no benefit for task performance (e.g., recall), whereas t-UDs refer to what happens after this strategy does benefit recall, when children try to transfer their learning. Successfully transferring the strategy, but with decreased benefit for recall, constitutes a t-UD.

Apart from research on memory strategies, several studies with other kinds of cognitive strategies are relevant to t-UDs, though this was not their aim. Their patterns of results either demonstrate the specific pattern of strategy maintenance on the transfer task along with decreasing scores, or at least approach such a pattern. A recent longitudinal study in a same-different task showed a t-UD in 4-year-old children using a systematic matching strategy (Clerc & Rémy, 2014). In a first task, children were presented with two sets of toys – one visible on a table in front of them and one in a bag on a chair close to them. They had to judge whether the sets contained exactly the same seven toys (identity judgment). The matching strategy consisted of removing a toy from the bag, searching for the identical toy on the table and putting the “bag toy” near the “table toy”. The criterion for a systematic matching strategy was the child's use of this strategy for all the toys present in a trial until giving the identity judgment. A transfer task was then given with wooden blocks, again using a set of items lying on the table and another set in the bag. Children now had to decide if the two sets of blocks were the same or not. Again a matching strategy score was computed, based on the number of trials in which the strategy was used. Results showed that children maintained their strategic performance at the same level from the main task to the transfer task, but the accuracy of their same-different judgments significantly decreased. Two studies on reading strategies also show t-UD patterns. In one (De Corte, Verschaffel, & Van de Ven, 2001), 10- and 11-year-olds in a control group had the same level of strategic performance at

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pre- (2.89) and post-test (3.44), with the latter including a transfer task. However, text comprehension declined in the transfer task (see fig. 8, p. 552). The other study (Pacton, Perruchet, Fayol, & Cleeremans, 2001) showed that 6- to 10-year-olds manifested a systematic decrease in performance in transfer tasks when applying implicit learning of orthographic rules (experiment 3b). Although this 'transfer decrement' effect was not directly tied to a specific cognitive strategy, the pattern of systematic decreased performance in the transfer task when transferring a rule is similar to those observed in t-UDs.

These studies suggest that t-UDs are not limited to memory strategy tasks.

Interestingly, it is difficult to determine the prevalence of t-UDs across various kinds of tasks because many transfer studies do not present their data in such a way that it is possible to determine whether a t-UD has occurred. That is, they do not report both strategic performance and task performance on both the first task and the transfer task. Also, many transfer tasks do not meet the criteria for being examined for a t-UD because they do not insure a high level of strategy production and a high level of strategy effectiveness on the first task before assessing transfer to a second task. Moreover, theoretical models of transfer fail to give attention to such strategy-task performance patterns that would reflect a t-UD. Indeed, neither typical cognitive-experimental approaches to transfer (e.g., Barnett & Ceci, 2002; Detterman & Sternberg, 1993; Gentner et al., 1993; Singley & Anderson, 1989) nor broader conceptualizations of transfer (eg. Lobato, 2012) consider any need to assess, separately, both the quality of the strategy transferred and its effectiveness.

A UD and a t-UD differ in that a UD appears on a single task, whereas a t-UD appears on a second (transfer) task. Thus, they may have different causes. We discuss some likely causes of the t-UD in the next section on cognitive self-regulation skills. Specifically, executive functions and metacognitive activities involved in decisions about whether and how to transfer may cause t-UDs. A novel aspect of our analysis is that we will show how a) *poor*

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self-regulation can lead to a t-UD, and thus the development of such regulation may facilitate overcoming a t-UD, and b) *good* self-regulation skills can lead to a t-UD, because self-regulation involves cognitive activities that temporarily are a setback (produce more t-UD) but ultimately will pay off for a child.

### **A Transfer-Utilization Deficiency Can be Due to Either Poor or Good Cognitive Self-regulation**

A recent conceptual analysis of the transfer distance between the training and transfer tasks by Klahr and Chen (2011), although intended for researchers designing transfer tasks, also can serve as a framework to suggest the cognitive processes in which children likely engage when faced with the transfer task. Klahr and Chen proposed that the main task and transfer task can differ along three dimensions: task similarity (e.g., similarity of task materials, instructions, content domain), context similarity (e.g., lab versus classroom, people present, immediate physical context), and temporal interval (time between tasks). A child presented with a transfer task thus encounters numerous task differences to be analyzed. Each feature may show large or small differences between the two tasks. Some features may be relevant (e.g., instructions) and some (e.g., people present, time between tasks, superficial physical task features) likely are not. These features must be considered not only for the decision of whether to transfer the strategy but also for the decision of whether it is necessary to modify the strategy slightly and, if so, in what way. In other words, facing a transfer task inevitably involves some novelty, and thus requires coping with a somewhat high degree of uncertainty since “novelty [...] can be interpreted as [a value] on a continuum of uncertainty or ambiguity” (Jirout & Klahr, 2012, p. 147). These cognitive activities of comparison and decision-making during transfer carry significant cognitive load, which may negatively impact the effectiveness of the strategy transferred.

We now turn to what cognitive and metacognitive processes this cognitive activity might entail during this time of uncertainty and high cognitive load, such that t-UDs become more probable or less probable. The child's developmental level with respect to these cognitive processes is influential as well. Thus, both child and situational-task variables must be considered when predicting whether a t-UD will occur.

### **Poor Self-Regulation Can Lead to a Transfer-Utilization Deficiency**

Children develop various ways to regulate their cognitive activities during learning. Two developmental literatures involving cognitive self-regulation can fruitfully be applied to the issue of strategy t-UDs. One is executive function and the other is the self-monitoring and self-evaluating aspects of metacognition. Executive functions (EF) are cognitive skills involved in adaptive, goal directed behaviors, particularly in novel situations. EFs develop from infancy through at least adolescence (Best & Miller, 2010). EFs range from simple components such as inhibition of a highly practiced response to complex skills such as planning. EFs have been of great interest to developmentalists recently, in part because they predict academic achievement (e.g., Best, Miller, & Naglieri, 2011; Monette, Bigras, & Guay, 2011). Metacognition—knowledge about cognition and knowledge how to monitor, regulate, and evaluate one's cognitive skills--has a long history in cognitive developmental research, and has been shown to play a central role in the development of memory strategies (Kuhn, 2000; Kuhn & Pearsall, 1998; Roebers, 2014). Because little research has examined the influence of EF and metacognition on UD, our analysis can serve as a guide for future research in this area.

#### *Cognitive Processes: Poor Executive Function*

Executive functions are an important part of cognitive self-regulation (Blair & Razza, 2007; Molfese et al., 2010). A transfer task, because of its new elements, would be an instance of a novel situation, for which EFs are supposed to be especially important. The development



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of EFs should help a child select and apply relevant skills in order to achieve the goal of producing a strategy and generating good recall. A classic study by Miyake and colleagues (Miyake, Friedman, Emerson, Witzki, & Howerter, 2000) identified three related, but somewhat separable, basic EFs: updating in working memory, inhibition of prepotent or automatic responses, and switching between cognitive sets. A number of studies confirm the existence of these three basic EFs and their development throughout childhood and adolescence (for reviews, see Best, Miller, & Jones, 2009, and Best & Miller, 2010). Young children with poor EF in any of these three components could have poor recall despite transfer of a strategy (i.e., the emergence of a t-UD). One recent study (Stone & Blumberg, 2013), using a test battery with all three EF components, demonstrated that preschoolers with a strategy utilization deficiency on a spatial memory task had lower EF than preschoolers showing strategy effectiveness for recall. We now examine the possible role of each of the three components in a t-UD.

*Updating in working memory (WM).* This EF component involves holding information in mind and performing mental operations on it, continuously monitoring the contents and often quickly adding or deleting certain contents as needed. As noted earlier, research suggests that UD's often are the consequence of WM capacity being overwhelmed by the demands of producing and executing the strategy or, after the strategy can be used effectively, transferring the strategy to another task. Several studies by Schneider and colleagues showed that most children classified as utilization-deficient obtained low scores on a backward digit span WM test (Kron-Sperl et al., 2008; Schneider, Kron, Hünnerkopf, & Krajewski, 2004; Schneider et al., 2009). Backward digit span tasks are considered one of the best ways of measuring WM, and can be used even in very young children (Monette & Bigras, 2008)

How might we apply this link between low WM (e.g., remembering only a few digits on a backward digit-span task) and UD to understand the case of a t-UD? Consider three types

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of children who would be vulnerable for a t-UD because of limited WM: a young child (because young children generally have low WM), an older child with below-average WM capacity compared to same-age children, or a child at any age who recently acquired a new strategy and thus finds it somewhat resource-demanding. For all these children, both producing a strategy for a transfer task and applying it to recall are resource-demanding, and together create the necessary conditions for a t-UD.

Poor WM may be problematic at two points during transfer. First, when a child tries to transfer a strategy to a new task, the cognitive demands may overwhelm the child's WM. The child must keep in mind both tasks, mentally switch back and forth between them to compare them in terms of their similarities and differences, decide whether the earlier strategy is relevant, and adapt the strategy slightly to the physical qualities of the new task. Task differences, though small, may call for the same strategy as used before, or a different one, depending on factors such as the number of items to be recalled or the manner in which items to be memorized are presented (e.g., words presented alone or in the context of a sentence). This extensive processing of the tasks during transfer has great cognitive cost to WM.

Second, even if a child has sufficient WM to conduct these numerous fine-grained analyses and manages to produce the strategy for the transfer task, other resource-demanding activities then need to take place. In particular, the child must keep the goal of the transfer task (e.g., remember only animals) in mind and carry out the strategy without error. During this process, the child faces several questions about goals: Do the main task and the transfer task have identical goals or has the goal changed from the first to the second task? If the new goal is a—even slightly—different one, how should the child deal with the goal's transformation? Must the child use the same standards for good performance as before, which may be the case if very superficial changes occur between goals of both tasks (e.g., memorizing only animals in the main task and only household objects in the transfer task)?

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On the contrary, if the goal change is a significant one pertaining to the transfer task's different structure, which new standards for good performance must the child use to guide his or her own behaviors and self-evaluate the outcomes? Addressing these questions requires cognitive resources, and thus may interfere with using the strategy for memorizing per se and thus improving recall. In this way transfer introduces risk for a UD.

In the particular case of t-UD, not only would there be no benefit of the strategy, but recall could even *decrease* when compared to the main task, where there was no UD.

Although on the surface the child would seem to transfer the strategy and apply it fully, in fact the child mainly masters the behavioral component of it and cannot use it in the service of recall. Such a case in which two children overtly appear to be the same cognitively (both highly strategic in their behaviors) but covertly (in the cognitive use of the strategy) are different has been discussed in the UD literature (Miller, 2000; Waters, 2000).

In short, although UDs in general have been attributed to inadequate cognitive resources, including limited WM, t-UDs are caused by elements inherent in the transfer situation that introduce new sources of cognitive load (e.g., uncertainty, comparing two tasks), beyond the usual capacity demands of producing a strategy. That is, in the case of a t-UD, a child is not utilization deficient on the initial task, because of sufficient WM for that task, but becomes utilization deficient during transfer because increased demands on WM create a condition in which that level of WM is insufficient (Clerc & Miller, 2013).

*Inhibition.* During transfer, the issue for the inhibition component of EF is that the new surface elements of the transfer task may elicit prepotent (habitual) cognitive and/or behavioral responses rather than a strategic response. For example, in Clerc and Miller (2013), children aged 4 and 5 had to transfer a selective attention strategy to a playful context (a play mat depicting a village), which likely required the children to inhibit spontaneous playing responses in order to be able to apply the strategy. That is, the new context (village,

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play) involved surface features associated with prepotent playful behaviors that had to be inhibited in order to transfer the strategy. If inhibition processes are not efficient, children have to invest much effort in inhibiting in order to compensate for this inefficiency, which results in less mental effort available for encoding the items per se. Again, the strategy would be correctly applied but with a decreased recall score because of the greater amount of cognitive resources consumed by the resource-demanding inhibition processes. This constitutes a t-UD. In Clerc and Rémy (2014), in order to judge whether two sets of materials are identical, 4-year-olds had to transfer a matching strategy from a set of toys to a set of toy wooden block blocks. These blocks were likely associated with spontaneous playing behaviours that had to be inhibited in order to transfer the strategy. Again, inefficient inhibition processes would lead children to invest much mental effort to compensate for this inefficiency, which would in turn hinder an effective use of the matching strategy. Then, the strategy would be correctly applied but with decreased accuracy of identity judgments. In DeMarie-Dreblow & Miller (1988), during transfer children had to switch from attending to animals and ignoring household items to attending to household items and ignoring animals. Children successfully transferred their selective memory strategy but it no longer was related to good recall, perhaps because when animals no longer were relevant it was effortful, to inhibit their tendency to attend to animals. In this way, less capacity remained for the effective application of the selective strategy to recall.

*Switching.* Even if a child has adequate WM and inhibition, if the *switching* component of EF is impaired (an individual difference) or not adequately developed (a developmental difference), the comparison between the main and the transfer task, a mandatory step in cognitive transfer (Gentner et al., 1993; Klahr & Chen, 2011), will be incomplete. In particular, both structural and surface elements of the tasks (Gentner et al., 1993) must be compared. For example, surface elements (e.g., physical appearance of task,

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number of items, specific instructions) may differ during transfer, but they may not change the basic logic (structure) of the task. On Miller's selective memory task, for instance, the type of containers hiding the objects and the distance between objects may differ on the original task and the transfer task, but the goal of remembering only one category of items (e.g., animals) even when other types of items are present, is the same (see Clerc & Miller, 2013). The selective attention strategy is basically the same (e.g., study only relevant items and ignore others), with minor adaptations to the specific physical changes in the task. In contrast, if structural elements (underlying logic; goal of task) change (e.g., "remember all the items"), then transfer of the strategy would not be appropriate. The child needs to switch attention back and forth between tasks and determine that while the surface elements differ, the structural element is the same. If the needed mapping between the two tasks during transfer does not occur, because of a child's limited ability to engage in cognitive switching, the child may not produce the strategy and thus not transfer even the strategy. Or, the child may engage in switching and produce the appropriate strategy, but may find it so resource-demanding to do so, that recall suffers and a t-UD results.

In summary, this analysis based on EF provides a new perspective on transfer. Poor transfer could be due to poor functioning in any of these three EF components during transfer, and thus a t-UD is likely to occur. An important question for future research is whether the particular component or components of EF that influence whether a t-UD occurs changes developmentally. For example, in young children all three components typically are just beginning to be developed, which may make a t-UD even more likely. Moreover, it may be more difficult to identify the specific EF processes that challenge strategy effectiveness in younger children than in older ones. The structure of EF seems to shift from age 3 to 15 from a single undifferentiated factor to two factors to three factors (Best & Miller, 2010; Lee, Bull, & Ho, 2013; van der Ven, Kroesbergen, Boom, & Leseman, 2013; Wiebe et al., 2011), with

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debate among researchers as to the specific ages for the shifts. In addition, in older children, some EF components may be better developed than others (Best & Miller, 2010) and thus may not impact t-UDs equally.

### *Metacognitive Processes: Poor Self-monitoring and Self-evaluation*

An important aspect of cognitive self-regulation is metacognitive activities such as monitoring (e.g., differentiating between correct and incorrect answers), controlling (e.g., efficient allocation of study time), and evaluating (e.g., judgment of the appropriateness of a strategy). For example, Pintrich (2004) and Winne (1995) refer to Nelson's model of metacognition (Nelson, 1996; Nelson & Narens, 1990), which posits that learners represent information at two levels, the object level (that is, cognitions concerning external objects) and the meta-level (cognitions concerning cognitions of external objects). The links between these two levels take place by means of two kinds of operations, metacognitive monitoring and metacognitive control. Metacognitive monitoring is a bottom-up process from the object level to the meta-level. The outputs of this process are metacognitive judgments, such as judgment of learning (e.g., predictions of one's ability to subsequently recall a memorized item). If the metacognitive judgments underscore a discrepancy between the ongoing work and the learner's performance standards, then activation of new cognitive strategies is likely to occur. Self-monitoring also involves self-evaluation (Glaser & Brunstein, 2007; Zimmerman, 2000). Metacognitive control is a top-down process that shapes behavior (Nelson, 1996; Nelson & Narens, 1990); control of cognitive activities depends on the outputs of monitoring. In the case of transfer, if, after transferring the strategy, children do not have the metacognitive skills to assess whether the strategy is leading to good recall, they may continue to produce the strategy even if it is not helping, and thus show a t-UD.

Metacognitive activities also may be important during transfer for managing the uncertainty during transfer (for a review of children's judgments of uncertainty, see Roebbers,

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2014). As stated by Lyons and Ghetti (2013) "...young children can introspect on their uncertainty, and (...) this capacity is associated with early self-regulation" (p. 735). When faced with a transfer task, children must self-monitor enough to become aware of the feelings of uncertainty as to what to do. Should they use a known strategy? If so, which one? Are they sure how the chosen strategy should be adapted? Are children aware that, given this uncertainty, they should try to adapt their strategy to the changed task in order to benefit both from what they already understand of the task and from what they currently are discovering as new unexpected features? If children cannot or do not cope with this uncertainty they may not make the slight modifications to the strategy that are needed in order to successfully transfer the strategy in such a way that it helps recall. Ringel and Springer (1980) showed that third graders' diminished transfer of a sorting strategy in a sort-recall task can be explained by an absence of self-monitoring, due to the absence of feedback about recall accuracy. Indeed, children receiving no feedback on the strategy they used during phase 2 mostly abandoned it during the transfer task taking place in phase 3, their recall level consequently being only marginally higher than it was in phase 1 (baseline). In contrast, children receiving feedback transferred the strategy and their recall increased much more when compared to baseline. These results, along with the presence of even negative transfer (decreased recall) in a control group, suggest that self-monitoring is required when facing a transfer task. Self-monitoring allows children to decide both whether the strategy must be transferred, and whether it proves efficient once transferred.

### **Good Self-Regulation Can Lead to a Transfer-Utilization Deficiency**

Above we proposed that immature executive functioning in working memory updating, switching, and inhibiting, as well as weak metacognitive skills, could contribute to a t-UD. That is, these resource-demanding skills may be sufficient to help children transfer a good strategy that had helped them on the initial task, but not sufficient for also utilizing the

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strategy in the service of recall on a transfer task. Could it also be the case, however, that a t-UD might sometimes result from *good* self-regulation?

The developmental literature suggests that UD's can be especially likely in children who typically have particularly good self-regulation. A prime example is high IQ and gifted children. In memory strategy studies, one surprising finding is that higher-IQ children (Bjorklund et al., 1994) and gifted children (Gaultney, 1998; Gaultney, Bjorklund, & Goldstein, 1996, exp. 1) are more likely than other children to show UD's. Similarly, on a problem-solving task, UD's emerged in gifted, but not in non-gifted, children (Hettinger-Steiner, 2006). Since higher-IQ children generally are considered to have better self-regulation than lower-IQ children (Planche, 2008; Whitman, 1990), it seems that UD's can appear in well self-regulated children (Bjorklund et al., 1997).

Why might UD's occur in children with high self-regulation? It seems unlikely that they are deficient in such a basic competence as self-evaluation, so that they would not notice that the strategy is not helping them. We next consider some other possible explanations—as above, in both cognitive and metacognitive processes, and in the case of t-UD.

### *Cognitive Processes: Mindsets Leading to Persistence*

One of the most influential current perspectives on how cognitive processes affect motivation to achieve academically is Dweck's (1986, 2006) work on mindsets. Mindsets are implicit theories describing how people conceptualize the nature of abilities and traits. Individuals use these theories as a framework for explaining events and making predictions. Dweck finds that people hold one of two possible implicit mindsets about ability (e.g., intelligence)—ability is fixed and cannot change versus ability can change through effort and practice. This *fixed* versus *growth* view of ability impacts how children cognitively process and interpret failure. Children with a fixed view of ability see themselves as good at particular things and not good at other things—general personal traits. When they perform poorly they



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interpret this as an indication that they inherently are not good at that particular activity, and there is no point in continuing to try hard and practice because that would not make any difference. In contrast, children with a growth view of ability see their performance as a skill that can improve with effort and practice. When they perform poorly they interpret this as an indication that they need to try harder and continue to practice, which they believe will improve their performance eventually. Such students, even in the face of difficulty, believe that these strategies are necessary for learning (Dweck & Master, 2008).

In a strategy transfer situation, the two conceptions of ability would lead to two different ways of processing information about recall failure during strategy transfer, and thus two different ways of responding to this failure. A child with a fixed mindset, upon experiencing failure when the transferred strategy does not help recall, is not likely to persist with the strategy to develop it to the point where it can help recall even if he already fully masters it in the first task. In contrast, a child with a growth mindset is likely to persist with the strategy and accept the temporarily decreased recall score because of a belief that it is temporary and will disappear with continued effort. This may explain why some children continue to use transferred strategies that are not working for them—a t-UD. Persistence refers to perseveration when encountering difficulty during task engagement (Elliot, McGregor, & Gable, 1999). It is a key indicator of self-regulation if the strategy is a good one that should be kept. Such persistence should eventually lead to the disappearance of a t-UD because, as mentioned earlier, a well-practiced strategy becomes less effortful. In this way, a t-UD could be seen as a consequence of good cognitive self-regulation associated with a growth view of ability. Although to our knowledge transfer researchers have not examined the role of mindsets, this individual difference, because of its likely impact on a t-UD, offers a useful perspective for understanding transfer.

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It should be noted that whether a growth mindset stimulates a t-UD, as outlined above, may depend on the child's developmental level. The developmental studies of perceived control have shown that children's beliefs are first organized around the dimensions "known" and "unknown" causes when they begin school, then beliefs are organized around the opposition internal versus external causes. Finally, at the end of elementary school, the category internal causes splits into ability and effort that are fully differentiated and negatively correlated (Skinner, 1990). Older children with a growth mindset may be able to detect the low efficacy of their strategy use after transfer but still persist with the strategy (a t-UD) and then detect when the strategy finally does help. Younger children, regardless of their mindset, may simply continue to use the strategy on the transfer task simply because of their cognitive immaturity.

Finally, even if a growth mindset increases the likelihood of some children showing a t-UD, it probably is not the only way that hot cognition is linked to t-UDs. According to Perkins and Salomon (2012), many motivations compete in a transfer situation--often leading to transfer failure--especially when children are at the point that they must decide whether to devote some effort to transfer the given knowledge (what authors call the "elect" phase). Indeed, even with a growth mindset a child may have some reason to give up the already known strategy in the transfer task, preferring to produce a new one or even to perform the task in a non-strategic manner. In both cases, no t-UD would appear.

### *Metacognitive Processes: Developmental Progress in Metacognition*

Good metacognition during transfer might lead to t-UDs because of the cognitive dangers of transferring a strategy "prematurely"—before a child has the cognitive resources to fully utilize the strategy efficiently. A child's metacognitive knowledge about why a strategy should be transferred to the new task may run ahead of the child's current ability to both transfer the strategy and apply the strategy to recall. Winne (1995) argued that an early

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demand for self-regulation may well be responsible for a decreased performance in problem-solving tasks. If the child is just beginning to proceduralize the strategy, considerable resources are needed. In contrast, a child with poor metacognition might not see the relevance of an existing strategy to a new task and might not even attempt to transfer the strategy, and thus would show no t-UD.

Another, related, consequence of good metacognition encouraging the transfer of an appropriate strategy is that when good metacognition leads to strategy monitoring activities during transfer, these activities themselves are resource demanding. That is, even when a memory strategy *is* transferred, the need for resource-consuming strategy monitoring in the transfer task might result in insufficient capacity for encoding the items. Resources that could have been used for good recall as well as strategy production during transfer must be diverted to metacognitive activities, and a t-UD results.

These regressions in recall as a result of good metacognition may be a necessary developmental step (Miller, 1990). Indeed, on the surface a t-UD seems to reflect poor cognitive self-regulation, but in reality might reflect good self-regulation in that the child temporarily is going backwards, in a sense, in order to go forwards (i.e., eventually transfer a strategy that leads to recall). It is also consistent with the cognitive economy principle hypothesized by Nokes-Malach and Mestre (2013) in their recent model of transfer. This principle is based upon the concept of “satisficing” (Simon, 1956) which means that “people rarely produce an optimal solution when solving a problem or making a decision but instead generate solutions that simply accomplish their goals” (p. 189). These authors argue that when individuals meet their minimal criterion with their transfer, the cognitive economy principle will lead them to stop, even if a better solution could be found (but with greater cognitive cost). In the case of a t-UD, it means that good metacognition may allow children to correctly assess that the transferred strategy does not allow for the maximum benefit but they decide

that the level of benefit reached (even if it is less than in the initial task) is enough, and they stop.

This account of how both poor and good self-regulation could lead to a t-UD indicates that it is important to differentiate between a t-UD and other kinds of UD because the specific causes of the cognitive demands in the two cases may differ. A t-UD may partly be due to the uncertainty created by the new task and the child's resource-demanding response to this uncertainty. Borrowing a recent conceptual view of transfer by Perkins and Salomon (2012), we argue that the three phases of *detect* (comparing the two tasks), *elect* (making a decision to transfer a strategy), and *connect* (modifying the strategy slightly) likely involve executive functions, metacognition, and mindsets that encourage or discourage continued strategy use in the face of recall failure. Thus, a t-UD may be caused by the very self-regulatory activities that facilitate strategy transfer.

### Conclusions

In this paper we have tried to advance our understanding of strategy transfer. We took a new perspective on this issue by examining it in terms of strategy utilization deficiencies. When faced with a new task, a child must engage in effortful activities to determine whether to apply a strategy, engage in strategy selection, and determine what minor modifications are necessary for applying the strategy. The cost of these activities, both cognitive (e.g., executive functions) and metacognitive, may result in a t-UD, such that the transferred strategy is ineffective.

Our account also has important implications for research on transfer more generally. One is that it directs attention to not only examining transfer of the skill that was trained, but also the effectiveness of that skill in improving performance. The need for multiple measures of transfer of learning has been recently highlighted by Nokes (2009): "Using multiple assessment measures and tasks enables the researcher to capture the dynamic, constructive

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nature of transfer. By using such an approach one can assess both *what* knowledge is transferred as well as *how* that knowledge is transferred.” (p. 31). In this regard, we showed that it is useful to examine different aspects of performance, such as strategy production and recall, separately. Transfer may occur in some aspects (in our case, strategies) but not others (recall). Indeed, what is a theoretical issue in developmental psychology--when and where UD<sub>s</sub> occur (Schlagmüller & Schneider, 2002)--is also a methodological point in educational psychology--how to measure transfer in a consistent way (Bransford & Schwarz, 1999).

The notion of t-UD<sub>s</sub> also provides several theoretical advances regarding UD<sub>s</sub>, adding information about when, where, and how UD<sub>s</sub> occur. First, t-UD<sub>s</sub> show that UD<sub>s</sub> can occur either during the acquisition of a strategy or, after that strategy becomes effective, during the transfer of that strategy. Second, t-UD<sub>s</sub> and acquisition UD<sub>s</sub> may have different causes, because the significant uncertainty introduced by a new task and the need to engage in a comparison of the two tasks likely elicits cognitive and metacognitive activities not required in the original task. The working memory needed for task comparison and the metacognitive self-monitoring while adapting the strategy to the specific task may be particularly important. Third, whereas acquisition UD<sub>s</sub> typically take the form of increased strategic mastery but unchanged cognitive performance, t-UD<sub>s</sub> imply a stable strategic score along with *decreased* cognitive performance. This is of particular interest since it may lead a child to give up a strategy after transfer when noticing this decreased cognitive performance, instead of persisting until cognitive performance increases again. That is, a t-UD may diminish a child's willingness to produce the appropriate strategy repeatedly until it becomes efficient. This decreased motivation would hinder the development of strategy effectiveness.

Fourth, just as a UD can be considered a temporary phenomenon occurring at a precocious stage of strategy acquisition, a t-UD should also be temporary. It should disappear after a number of trials, as cognitive resources become available either by automatization of

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the strategy or by eliminating feelings of uncertainty. Future studies including a microgenetic design, with numerous trials on a task over several sessions, would clarify this process. Fifth, although acquisition UD and t-UDs are developmental phenomena in that they are more common in younger children for the reasons discussed in this paper (e.g., immature EF), they also may reflect a learning phenomenon found at any age (Miller, 2000). Several studies (e.g., Gaultney, Kipp, & Kirk, 2005; Welch, 1998) have reported traditional UD in adults.

Although not directly tapping into strategy transfer, a study by Nokes (2009) showed that adults sometimes obtain seemingly inconsistent scores of transfer in different transfer outcomes such as accuracy, solution time and solution type. Nokes emphasized that a trade-off exists between applicability and efficiency of different mechanisms implied in transfer, noting that the higher the cognitive effort due to adaptation to the transfer task, the more the efficiency of the mechanism is at risk to be reduced.

Finally, our analysis identifies a previously unexamined role for executive functions, namely, how they might be involved during transfer of a skill. Although the field now has a large body of EF research, the current paper is the first to our knowledge to direct it to theorizing and research about transfer. Indeed, given the importance of transfer in classroom learning, it might be fruitful to study whether the observed associations between EF and academic achievement (e.g., Best, Miller & Naglieri, 2011; Monette, Bigras & Guay, 2011) are partly due to EF activities during transfer.

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