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Analogical Transfer of Tool-Dependent Problem Solving in Toddlers: A Replication and Extension Study

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ANALOGICAL TRANSFER OF TOOL-DEPENDENT PROBLEM SOLVING IN TODDLERS: A REPLICATION AND EXTENSION STUDY

Abstract

Analogical transfer, or the ability to use similar solutions to solve seemingly dissimilar problems, has been studied in children using tasks that require the support of long-term memory. However, the transfer of solutions that require the use of tools, or objects with certain functional parts, has not been studied in great depth. This paper replicates and extends upon data collected from a novel study that investigated the role of age and memory on analogical transfer across children who attend public preschools in southern Sweden (Bobrowicz et al., 2020). The purpose of this study was to integrate analogical transfer with functional tool-dependent problem solving and study how both skills develop in toddlerhood. The replication yielded similar results to the original experiment in all five hypotheses tested, with the main finding being that age is not a significant predictor of being able to display analogical transfer from task to task. As an extension to the variables examined in the study, two additional models were created to see whether spending more time with the functional tool or with the relevant apparatus leads to a greater percentage of successes in solving the test task, but there were no significant differences found in this model.

Key terms: analogical transfer, functional tool-dependent problem-solving, long-term memory

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Introduction

The problem-solving mechanism, analogical transfer, requires utilizing memories of past experiences that slightly overlap with the current situation at hand. Through long-term memory, or more specifically episodic memory, people are then able to successfully solve the present problem. Analogical transfer is a skill used to solve everyday problems; a hallmark of human intelligence is being able to flexibly use inductive reasoning and transfer the known to the unknown (Brown, 1989). Analogical transfer marks the flexibility of human thinking through inductive reasoning. However, the extent to which very young children (2 to 3 years old) can solve problems through analogical transfer is not well understood. Studies on analogical transfer in 2 to 3-year-old children involved exercises such as solving 3 tasks where the goal in each was to locate a token in a box and then insert the token into a correct location on another box (Crisafi and Brown, 1986). All three tasks had apparatuses and tokens that looked quite different but had underlying similarities. The children all showed no transfer among these analogical problems and only a few could verbally state the solution to the puzzle (Crisafi and Brown, 1986). In another study, however, children as young as 2.5 years old were able to transfer a problem-solving strategy learned from a video to solve a puzzle related to process analysis (Chen and Siegler, 2013). This difference in findings could be due to the varying definitions of analogical transfer and how the experiment was performed. Crisafi and Brown's study utilized a tool and goal experimental design that tested many skills such as identifying locations and matching shapes, while Chen and Siegler tested analogical transfer based on the children's abilities to utilize a video display to solve analogous problems. It is also important to note that transfer reluctance may exist in tasks that are unfamiliar to children, as one study showed transfer of solutions in 3-year-olds only when they were able to understand and engage in a particular problem domain (Brown et al., 1989).

Long-term memory is especially important in analogical transfer, as the ability to draw from the past depends on one's memory of that experience. Studies on episodic memory further support the idea that children younger than 4 find it difficult to apply knowledge to a problem 24 hours after training on a similar problem (Milner, Squire, and Kandel, 1998). Through experiments regarding child amnesia, the inability to remember anything before the age of 3 or 4, researchers concluded that the hippocampus matures slowly and does not reach any reasonable maturity until about 3 to 4 years old (Milner, Squire, and Kandel, 1998). Since the hippocampus is required for long-term storage of those memories, 2 to 3-year-olds can often only remember things for a short period of time. Findings suggest the immaturity of the hippocampus before the age of 3 limits the transfer of long-term memory, supporting Crisafi and Brown's research (Josselyn and Frankland, 2012). Josselyn and Frankland genetically engineered infant mice to have a slower neuron build-up in their hippocampus and hypothesized that the mice would be able to form stable longer-lasting memories. The researchers found that the mice were more successful at retrieving long-term memories as they could complete a maze even after a long period of time had passed since they first learned to navigate it (Josselyn and Frankland, 2012). However, there is still much to learn regarding analogical transfer in children, such as the interaction of tool usage and the transfer of solutions immediately after learning the solution or after a longer delay of at least 24 hours.

Across toddlerhood, many milestones that impact whether children are able to display analogical transfer skills have been found. In addition to long-term memory, a pivotal part of the analogical transfer relates to one's sensorimotor development. Recognizing the features of a problem, the relevant components, the goal of the problem, and the problem-solving strategy all require sensorimotor coordination and activation that may not be as operative in children under 30 months of age (Morra and Panesi, 2017). The older the children are, the higher capacity they can encompass to attend to both relevant and irrelevant information. Children begin to develop specific skills regarding analogical transfer, such as sensorimotor development and attention, at approximately 2.5 years old (Crisafi and Brown, 1986). In order to transfer solutions, the ability to visualize the objects and actions required to complete the solution are required (Bobrowicz et al., 2020). One study found that this ability to create mental representations of problems may not be developed in children younger than 30 months (Hayne and Gross, 2015). These children had difficulty figuring out the conceptual similarities between the source and the problems at hand and could only transfer knowledge if there was someone verbally aiding them and highlighting the functional similarities (Hayne and Gross, 2015). Even when children verbally explained the solution in response to verbal prompts by an adult, they had greater success in transferring solutions (Brown and Kane, 1988).

Tool-use offers advantages to problem-solving because it shows goal-directed and planning behavior occurring in sequential steps that can be readily measured. Bruner emphasized that exploratory play and motor and physical development in childhood helps to support physically active behaviors later in life (Bruner, 1973). Functional tool-dependent problem solving can not only be used to investigate one's ability to transfer solutions, but also to study how people identify similarities between functional parts of different objects. One study found that the spatial proximity between the tool and the toy positively impacts the infants' insight to use the toy due to their familiarity with the tool (Fagard et.al, 2014). Tool use emerges from a long period of object manipulation that familiarizes infants with the use of an object to interact with other objects (Lockman, 2000). However, the internal and biological processes of how infants are able to use the tools for problem-solving still remain unknown.

Testing analogical transfer specifically using tool-dependent problem solving, as is done in the present study, is necessary to help identify if there are differences in the abilities of toddlers to exhibit transfer when tools are a part of the solution (Bobrowicz et al., 2020). This tests analogical transfer skills in conjunction with motor skills and critical thinking skills of toddlers to analyze how tool-dependent problems may be encoded in long-term memory. In a broader context, this idea of tool-dependent problem-solving plays an important role in everyday decision-making, as well as in politics, economics, and relationships. Understanding how children can use their previous knowledge to solve novice problems and work through tasks can be used to possibly enhance efficient problem-solving at younger ages. This can also impact the education field as one can learn how to best educate children so that they may develop these cognitive skills more effectively.

The Present Study

Replication

The present replication study used four generalized linear models to test five of the hypotheses in the original paper. All of the hypotheses were based on the same experimental set-up of a puzzle box containing a toy bee inside and a set of functional or nonfunctional tools that could be used on the test (Bobrowicz et al., 2020). In addition, the box had both relevant and irrelevant components, so only the combination of a functional tool inserted in the relevant component would release the bee from the box and be counted as a success (Bobrowicz et al., 2020). The first hypothesis tested if as age increased, the children would be more likely to solve the test task after training (Bobrowicz et al., 2020). The second hypothesis elaborated on the previous hypothesis by predicting that when a 24-hour delay took place, younger children would be less likely to solve the test task compared to older children. The third hypothesis predicted that as age increased, children who received training would interact longer with the functional tool and relevant components of the apparatus, and shorter with the functional tool and irrelevant components. The fourth hypothesis stated that decreased age and longer delay would result in a longer interaction with irrelevant components, but shorter interaction with relevant components when a functional tool was used. The fifth hypothesis predicted that children who successfully solved the test task would have interacted with the functional tool and relevant components for a longer period of time. Hypothesis six projected the insignificance of perceptual mismatch, tested by switching patterns on the functional and non-functional tools from baseline to the test task. However, no model was run for this last hypothesis in the paper and therefore, in the present replication as well, because there were not enough children who succeeded in the extra test task.

Extension

The second part of the present study extended upon the general linear modeling of interaction times presented in the paper, focusing on the interaction variables that had not been examined and compared. For instance, the replicated study focused on whether age and delay influenced the ability of children to successfully employ analogical transfer and solve a puzzle box. Some of the hypotheses in the paper investigated whether interacting with the functional tool and relevant components for a longer proportion of the time impacted whether children were able to solve the test task (Bobrowicz et al., 2020). However, whether the functionality of the tool or the relevance of the apparatus components contributed more to the success of the children was not addressed. Moreover, during the time the children spent with the nonfunctional tool, the impact of the relevant versus irrelevant apparatus was not tested in any of the hypotheses as well. Therefore, two extension models were created regarding the outcome of the test to compare these interaction times with each other. The first model tested whether finding the right tools or finding the relevant parts of the apparatus played a greater role in the toddler's success in solving the task. The hypothesis for this model was that spending more time with the functional tool leads to significantly greater success on the task compared to spending more time with the relevant component of the apparatus. The second model evaluated whether the apparatus played an importance in the success of the task, regardless of the tool's functionality. The hypothesis for this second model was that spending more time with the relevant apparatus, even when using the nonfunctional tool, leads to significantly greater success on the task compared to spending a greater portion of time with the irrelevant apparatus.

Methods

Participants

Participants (N = 105: M = 51, F = 54) in the original pilot study were recruited from a combination of urban and semi-urban preschools present in Sweden, ages 2-4 years (M = 40.42 months, SD = 7.49). Of these children, 15 were used as a control and received no training. The remaining 90 received training following the baseline attempt at solving the puzzle (Bobrowicz et al., 2020).

Experimental Set-Up

The experimental design consisted of a series of apparatuses available to the child depending on their success or failure to accomplish the task (Bobrowicz et al., 2020). There were seven apparatuses in total, each test task requiring the completion of a task navigating a unique set-up. For instance, one apparatus required the functional tool being inserted into a hole and pulled toward the participant to open the lid. Children were also offered two distractors: a nonfunctional tool that looked similar to the functional tool but had nonfunctional ends, and a useless tool that differed from the functional tool in length, shape, and rigidity. The tools also varied in pattern (wave-patterned, stripe-patterned, and dot-patterned). The test box held a bee that was only accessible by use of the functional tool. The test apparatus contained a stripe-patterned functional tool, a dot-patterned nonfunctional tool, and a wave-patterned useless tool. The pattern on the functional and nonfunctional tools was switched to test perceptual mismatch. Altering the patterns present on the tools was meant to test whether participants were still able to identify which tool was functional, independent of perceptual similarity. The final testing round consisted of all three tools being presented in a uniform x-pattern.

Procedure

Participants were randomly assigned to one of two different delay periods (a short delay of 10 minutes or a long delay of 24 hours) between the baseline test and the second test task, which had a similar puzzle box and similar tools, but required a different solution (Bobrowicz et al., 2020). In addition, the participants were randomly assigned to one of two training groups between the baseline and second test. In the control group, the experimenter played with the child for 10 minutes but did not teach them how to correctly solve the problem. In the experimental group, the child received training on how to correctly solve the problem. Both groups were then tested for analogical transfer with the test toolset.

Outcome Measures

One outcome measure investigated in the original study was a score where children received either a 0 (failed to solve the puzzle) or a 1 (successfully completed the puzzle within the first three attempts) for the baseline and test tasks. The data set was organized in a 2 x 2 factorial design: condition (training vs no training) x delay format (10 minutes vs 24 hours).The tool and the component of the apparatus were given specific interaction variables:functional (F), non-functional (NF), or useless (U). The particular component of the apparatus is defined to be either relevant (rel) or irrelevant (irrel). Measurements were taken for the time spent interacting with a set of certain tools and components. For example, the time spent holding the functional tool and interacting with the relevant component of the apparatus was given the variable F_rel.

Data Analysis

Generalized linear models were used to investigate the hypotheses. All analysis was conducted using RStudio (RStudio Team, 2020).

The ages in months were normalized, and two datasets, one provided as supplementary material in the paper and the other obtained from the researchers to include the ages of the participants, were merged using the common ID of participants. The glm package was used to fit the models and to investigate a linear relationship between the predictor and response variables. All generalized linear models created used the binomial family.

Replication Data Analysis

Hypotheses one and two were grouped together in the replication model due to the common variable of age. The first portion of hypothesis three, predicting that increased time spent with relevant components allowed for success when engaging with the puzzle, was given its own model. Hypothesis four was also given its own model, while the second portion of hypothesis three and hypothesis five were combined to serve as the fourth replication model.

For the models created for hypotheses one and two, the outcome of the test served as the response variable, and the two predictor variables were delay (short vs long) and age. To investigate hypotheses three, four, and five, proportions were created for the different interaction times: the first proportion referred to the time spent interacting with relevant components of the puzzle, the second proportion focused on the time spent with irrelevant components, and the final proportion was the difference calculated between the time spent with relevant and irrelevant tools provided in the puzzle. These proportions were modeled as a linear function of age, delay, and test performance.

Extension Data Analysis

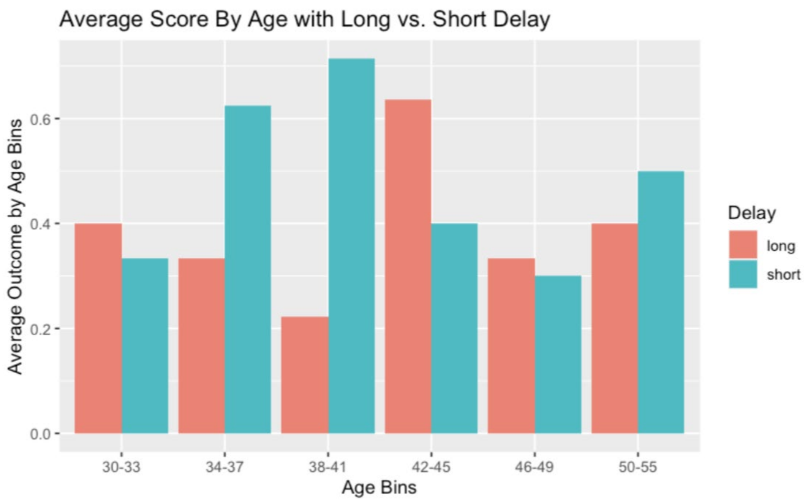
Two extension models were created using generalized linear models similar to the ones used for replication. The first model examined whether a greater portion of the children who interacted longer with the functional tool and irrelevant components of the apparatus or those who interacted longer with the non-functional tool and relevant components were able to solve the test task. A new proportion of interaction times was created, this time by subtracting the time spent with the nonfunctional tool and relevant component from the time spent with the functional tool and irrelevant component and dividing the total by the overall interaction time. The second model specifically looked at the interaction with the nonfunctional tool and examined whether a greater portion of the children who interacted longer with the relevant components or those who interacted with the irrelevant components had more success with the test task. Another interaction proportion was created for this model, by subtracting the time spent with the nonfunctional tool and irrelevant component from the time spent with the nonfunctional tool and relevant component, and again dividing the total by the overall time spent on the task.

Results

Replication Results

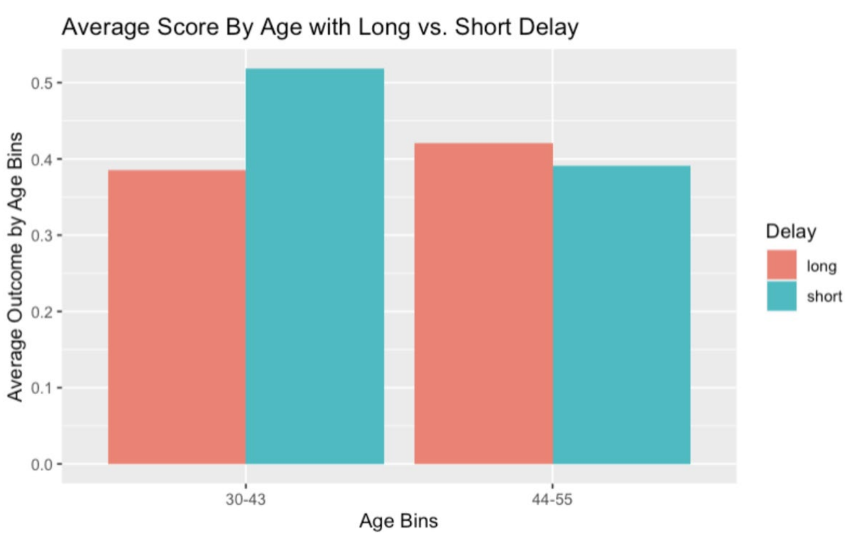
The replication of hypotheses one and two did not yield any significant p-values (>0.05) for the prediction of the outcome on the test by age and delay (Table 1). In order to emphasize the lack of significance of age and delay, two different bar graphs were created, one with only two age bins and another with six bins. Neither of the graphs showed any notable trends in outcome due to increased age, or long versus short delay (Figure 1, 2).

Figure 1



Note. The average outcome on the test task by long delay versus short delay, analyzed over 6 different age bins. Long delay is 24 hours, short delay is 10 minutes. Average outcome is between the score of 0 (fail) and the score of 1 (success).

Figure 2



Note. The average outcome on the test task by long delay versus short delay, analyzed over 2different age bins. Long delay is 24 hours, short delay is 10 minutes. Average outcome is between the score of 0 (fail) and the score of 1 (success).

Table 1

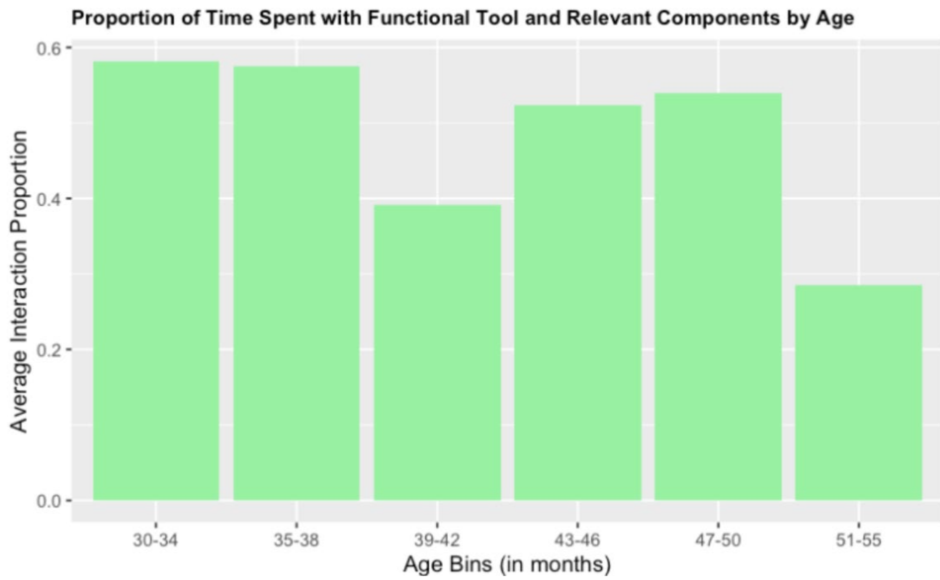
Generalized Linear Model for Hypotheses 1 and 2

Variable	Estimate	Standard Error	z-value	p-values
Delay	0.2496	0.4183	0.597	0.551
Age	0.2201	0.3121	0.705	0.481
Delay*Age	-0.3847	0.4230	-0.910	0.363

Note. Results of generalized linear model with outcome as the predictor variable and delay, age, and the interaction between delay and age as the explanatory variables.

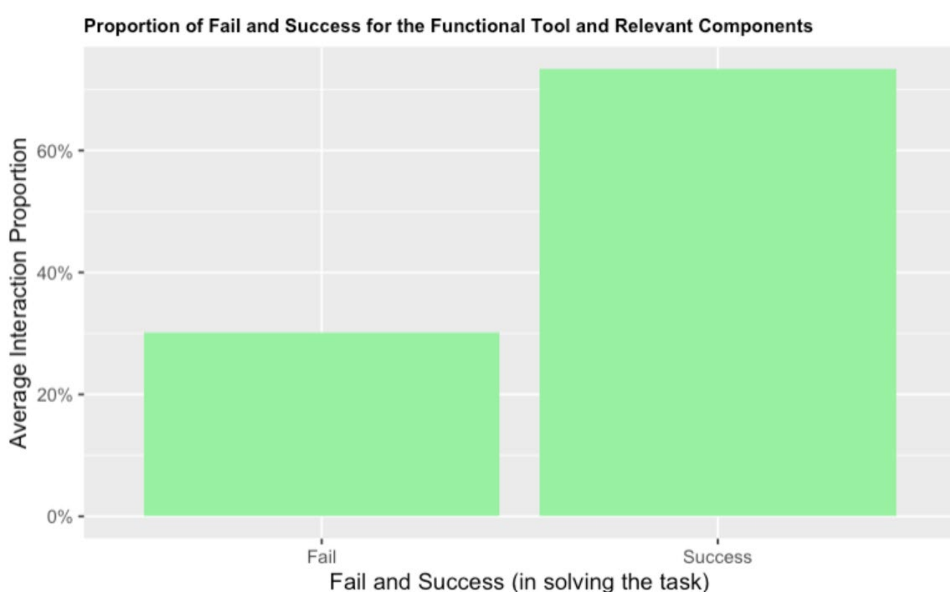
The generalized linear model for part 1 of hypothesis three and hypothesis five did not yield any significant p-values either for delay, age, and outcome (Table 2). There is no notable trend in interaction proportion across all age bins, although an increased proportion was predicted to be a result of increasing age in part 1 of hypothesis three (Figure 3). In regards to hypothesis five, although an increased interaction between the functional tool and relevant components shows a greater proportion of successes, the outcome does not significantly predict the interaction proportion, as indicated by the insignificant p-value (p=0.990) (Figure 6).

Figure 3



Note. Average interaction proportion is calculated by dividing the time spent with the functional tool and relevant components over the total interaction time.

Figure 6



Note. Average interaction proportion is calculated by dividing the proportion of time spent with the functional tool and relevant components over the total interaction time.

Table 2

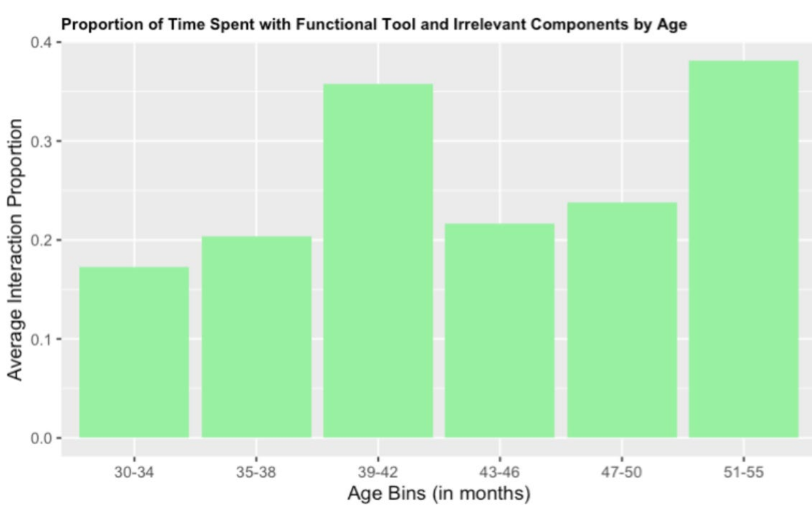
Generalized Linear Model for Hypotheses 3 (Part 1) and 5

Variable	Estimate	Standard Error	z-value	p-values
Delay	-0.3270	0.5920	-0.552	0.581
Age	-0.0927	0.4261	-0.217	0.828
Outcome	19.93	1667	0.012	0.990
Delay*Age	-0.2310	0.6056	-0.381	0.703

Note. Results of generalized linear model with the proportion of time spent with functional tool and relevant component over the total test time as the predictor variable and delay, age, outcome, and the interaction between delay and age as the explanatory variables.

For the replication of the second part hypothesis three, only outcome significantly predicted (p=0.0109) the average interaction proportion, or time spent with the functional tool and irrelevant component (Figure 4, Table 3). Neither age nor delay significantly predicted the interaction proportion.

Figure 4



Note. Average interaction proportion is calculated by dividing the time spent with the functional tool and irrelevant components over the total interaction time.

Table 3

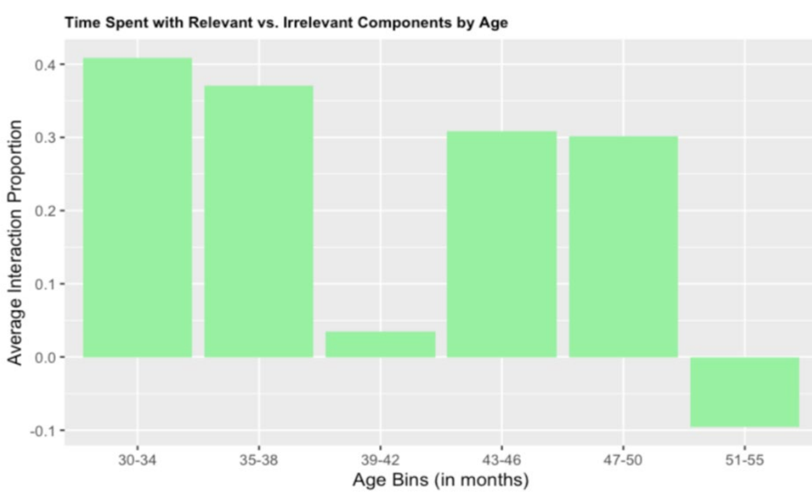
Generalized Linear Model for Hypotheses 3 (Part 2)

Variable	Estimate	Standard Error	z-value	p-values
Delay	0.5332	0.4508	1.183	0.2369
Age	-0.1284	0.3386	-0.379	0.7045
Outcome	-1.160	0.4556	-2.545	0.0109*
Delay*Age	0.0362	0.4582	0.079	0.9371

Note. Results of generalized linear model with the proportion of time spent with functional tool and irrelevant component over the total test time as the predictor variable and delay, age, outcome, and the interaction between delay and age as the explanatory variables.

Lastly, the generalized linear model for hypothesis four failed to produce any significant results as well, showing that neither delay nor age nor outcome significantly predict the length of interaction with relevant or irrelevant components, when the functional tool was used (Figure 5, Table 4).

Figure 5



Note. Average interaction proportion is calculated by subtracting the time spent with the functional tool and irrelevant components from the time spent with the functional tool and irrelevant components and dividing by the total interaction time.

Table 4
Generalized Linear Model for Hypothesis 4

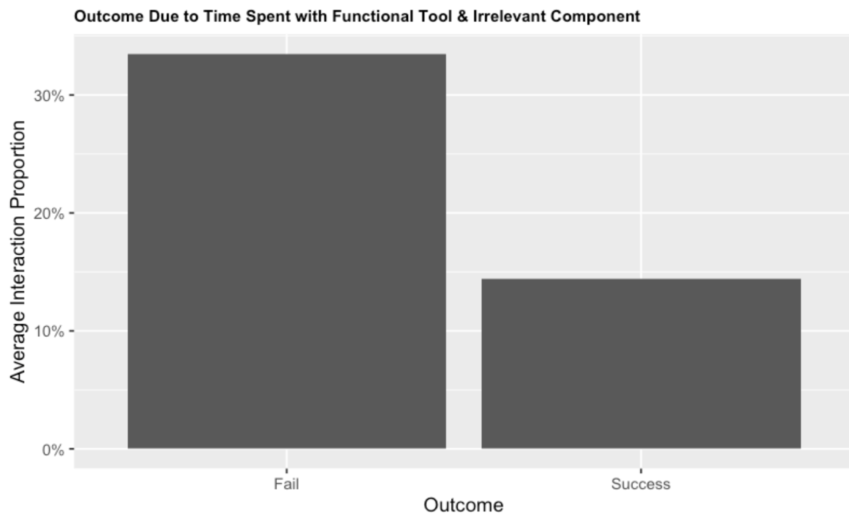
Variable	Estimate	Standard Error	z-value	p-values
Delay	-1.428	1.233	-1.158	0.2467
Age	0.3155	1.087	0.290	0.7715
Outcome	18.40	2652	0.007	0.9945
Delay*Age	-0.873	1.254	-0.696	0.4866

Note. Results of generalized linear model with the proportion of time spent with functional tool and irrelevant component subtracted from time spent with functional tool and relevant component over the total test time as the predictor variable and delay, age, outcome, and the interaction between delay and age as the explanatory variables.

Extension Results

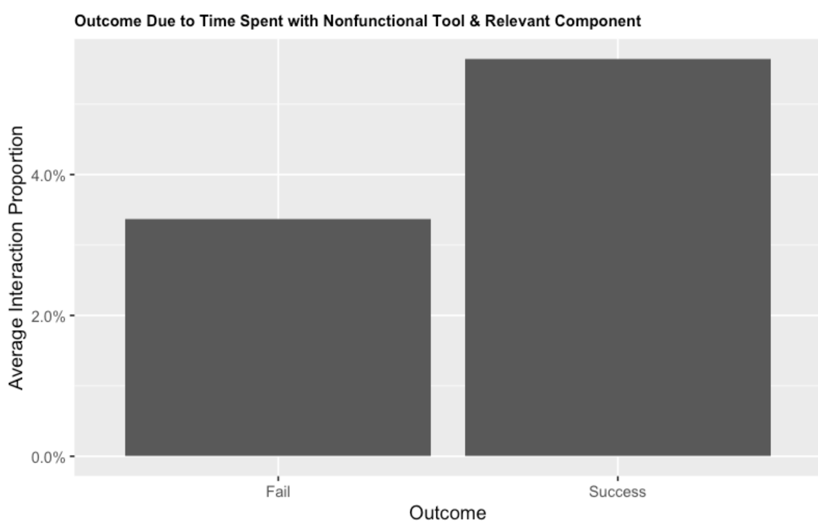
The first part of the extension yielded insignificant p-values (>0.05) for the effect of outcome on the average interaction proportions (Table 5). There was no significant difference noted between the interaction proportions of functional tool and irrelevant component versus nonfunctional tool and relevant component, when looking at the rate of failures and successes on the test task (Figure 7, 8).

Figure 7



Note. The average outcome proportion on the test task by the interaction between the functional tool and irrelevant apparatus component. Average outcome is between the score of 0 (fail) and the score of 1 (success).

Figure 8.



Note. The average outcome proportion on the test task by the interaction between the nonfunctional tool and relevant apparatus component. Average outcome is between the score of 0 (fail) and the score of 1 (success).

Table 5

Generalized Linear Model for Extension Part 1

Variable	p-value	z-value	Standard error	Estimate
Outcome	0.9969	0.004	4565.340	17.716

Note. Results of generalized linear model with the proportion of time spent with nonfunctional tool and relevant component subtracted from time spent with functional tool and irrelevant component over the total test time as the predictor variable and outcome as the explanatory variable.

The second model created as an extension also yielded insignificant p-values (>0.05) for the effects of outcome, age, delay, and the interaction between age and delay (Table 6). Therefore, no significant difference in outcome was shown between the interaction proportions of relevant and irrelevant components when using the nonfunctional tool in both cases (Figure 8, 9).

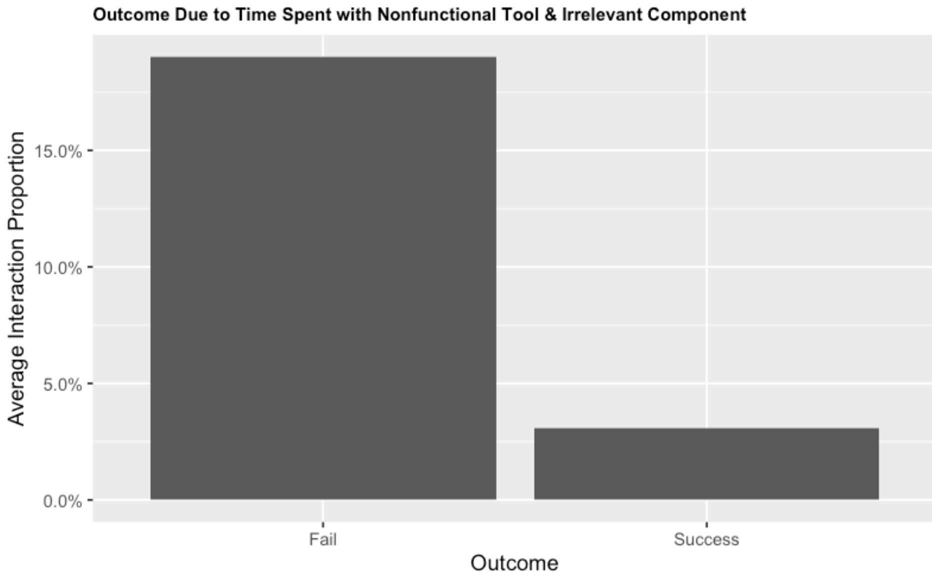
Table 6

Generalized Linear Model for Extension Part 2

Variable	p-value	z-value	Standard error	Estimate
Delay	0.8897	-0.139	1.6028	-0.2223
Age	0.5433	0.608	1.1751	0.7142
Outcome	0.9968	0.004	4509.1447	18.378
Delay*Age	0.6747	-0.420	1.5547	-0.6525

Note. Results of generalized linear model with the proportion of time spent with nonfunctional tool and irrelevant component subtracted from time spent with nonfunctional tool and relevant component over the total test time as the predictor variable and delay, age, outcome, and the interaction between age and delay as the explanatory variables.

Figure 9



Note. The average outcome proportion on the test task by the interaction between the nonfunctional tool and irrelevant apparatus component. Average outcome is between the score of 0 (fail) and the score of 1 (success).

Discussion

All of the children who lacked training were unable to complete the test. Based on these results, it is likely that analogical transfer is not dependent on minuscule differences in age among toddlers that are 2-4 years old. In addition, younger children were not less likely to solve the task after a delay. Age was also not a significant predictor of interaction times with functional tools and relevant components as younger children did not interact with relevant components of the puzzle for shorter periods of time when compared to older children. Surprisingly, older children interacted with relevant components of the puzzle less than younger children. In the original study, these results were significant, but they were not for this replication, possibly due to limitations present within the sample size used. Lastly, the children who were able to successfully solve the puzzle interacted with relevant components for longer intervals of time, but the difference was not statistically significant enough to support the hypothesis.

The results of the present replication showed that many of the tested relationships were insignificant, and this was also shown in the original study (Bobrowicz et al., 2020). However, in the original study, increased interaction between the functional tool and relevant components significantly predicted a greater proportion of successes, whereas there was no significant relationship found in the replication. This may be due to the additional analysis done in the original study regarding hypotheses three, four, and five. The original paper dropped insignificant predictor variables within their regression analysis and analyzed the distribution of residuals. This replication did not drop these predictors, which could have resulted in varying p-values.

The first extension model found no significant difference in outcome when comparing increased interaction time with functional tool and irrelevant component versus interaction time with nonfunctional tool and relevant component. The second linear model for the extension study also found that there was no significant difference in outcome, comparing the interaction time with relevant versus irrelevant components when using the nonfunctional tool in both cases. Based on the insignificant results of the first part of the extension, whether the functional tool or the relevant component of the apparatus plays a greater role in the success of the test task is unclear. Moreover, the second part of the extension failed to support the hypothesis that even when the nonfunctional tool was in use, spending greater time interacting with the relevant components compared to the irrelevant components leads to a more successful test outcome.

One of the main reasons why there was insignificance in the models for extension could be the method by which interaction times were calculated in the original study. In the overall interaction time variable, which was used to create the interaction proportions, the value also included the time spent on other parts of the puzzle, aside from the times of interest. These additional variables make it difficult to see a clear relationship between the functionality of the tool or the relevance of certain apparatus components on the outcome of the task. To obtain a better understanding of the tool versus apparatus conflict, an additional experiment must be done wherein each cohort of children, the time spent with the functional tool must be calculated separately from the time spent with the relevant component. These two times can be divided by the total time to obtain more clear interaction proportions.

In addition to the limitations in the present replication and extension, there are also limitations to the original study that could be investigated further. For example, it was difficult to distinguish whether the children's failure was due to the inability to analogically transfer solutions or due to their trouble identifying the perceptual mismatch of tools. In other words, it is uncertain whether the success or failure of the children on the task was due to being able to transfer solutions between the similar puzzles or due to identifying that the patterns on functional and nonfunctional tools had been swapped. When the researchers attempted to manipulate the experiment to specifically discover which variable carried more weight, they were unable to disentangle the variables from one another. Further studies should aim to test a group of children with varying analogical transfer difficulties and another with perpetually mismatching tools to have a clearer idea of the variable influence. Additionally, the language skills of younger versus older children may be different. The rapid linguistic knowledge children gain from the ages of 2 to 4 years old cannot be discounted, and that may play a significant role in their understanding of the experiment and therefore, their problem-solving abilities. Finally, the sample size of children who received training was relatively small (N = 90) and the sample of children who did not receive training was even smaller (N=15), so it is difficult to draw conclusions about the general population. The participants were all recruited from preschools in southern Sweden, so a larger sample size that includes different countries and more preschools with various educational systems may provide a more holistic view of how analogical transfer develops in toddlerhood.

The interaction between analogical transfer and functional tool-dependent problem-solving is a novel area of research, so further research with a larger sample size, wider variety of ages during childhood, and a more specific experimental set-up is required to provide a clearer picture of the factors that impact the transfer of solutions.

Conclusion

The main objective of this study is to test how solutions of puzzles that require the use of tools are transferred from task to task in 2 to 4.5-year-olds. Analogical transfer of problem-solving using tool use was investigated both immediately after training and after a 24-hour delay. The main results showed that analogical transfer was not possible before the age of 2.5 years. The delay in time did not seem to play a significant role in the children's performance; the children were equally likely to solve the test after 10 minutes and 24 hours. The children between the ages of 2.5 and 4.5 years of age are able to perform non-verbal transfers using episodic memory, as long as the success does not require the comprehension of verbal instructions. For the present replication, generalized linear models were used to statistically interpret the results, and reproduce five of the hypotheses in the original study. Age, delay, and outcome in many of the hypotheses were shown to be insignificant in predicting the interaction times with apparatus components, due to small sample size and differences in the data included between the present replication and the original study. The extension models tested whether the tool or the apparatus played a greater role in determining the interaction times and because of the extraneous variables within the overall interaction proportions, there was little significance in these results as well. The understanding of how children are able to shift attention toward relevant aspects of solutions and problems can help inform future interventions. A prime example would be to enhance the problem-solving skills of adolescents and enhance spontaneous focusing on relevant aspects of abstract problems in adults. Though verbal instructions were not required in the analogical transfer of tool use in the current setup, in the future, the pairs of problems and tools can be tested in a clinical setting with those who have hearing impairments or impairments.

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