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# Can Infants Generalize Tool Use From Spoon to Rake at 18 Months?

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Infants start to use a spoon for self-feeding at the end of the first year of life, but usually do not use unfamiliar tools to solve problems before the age of 2 years. We investigated to what extent 18-month-old infants who are familiar with using a spoon for self-feeding are able to generalize this tool-use ability to retrieve a distant object. We tested 46 infants with different retrieval tasks, varying the tool (rake or spoon) and the target (toy or food). The tasks were presented in a priori descending order of difficulty: rake–toy condition, then either spoon–toy or rake–food, and finally spoon–food. Then, the same conditions were presented in reverse order to assess the transfer abilities from the easiest condition to the most difficult retrieval task. Spontaneously, 18-month-old infants performed the retrieval tasks better with the familiar tool, the easiest task being when the spoon was associated with food. Moreover, the transfer results show that being able to use a familiar tool in an unusual context seems necessary and sufficient for subsequent transfer to an unfamiliar tool in the unusual context, and that early and repetitive training of self-feeding with a spoon plays a positive role in later tool use.

***Keywords:*** transfer, cognitive development, practice, familiarity, toddler

Infants start to use a spoon for self-feeding at the end of the first year of life (Connolly & Dalgleish, 1989), but most do not know how to use unfamiliar tools to solve problems such as retrieving an out-of-reach object before the age of 2 years (Rat-Fischer et al., 2012). What can explain this developmental difference between these two types of tool use in infancy?



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Tool use such as retrieving an out-of-reach toy with an unconnected tool (e.g., a rake) is a particularly complex action. First, it is composed of several phases (Claxton et al., 2003), such as taking the tool, placing it in the right position relative to the object, and performing the adequate movement to retrieve the object efficiently. Thus, this action requires sophisticated planning abilities compared with other actions that infants perform in their everyday life. Second, infants have to inhibit trying to reach the goal directly with the hand or pointing toward it, and they have to switch their attention toward a potential tool. Third, they have to realize the simple fact that the tool might be useful in solving the problem, and then they need to identify its affordances, such as the handle that affords grasping, and an extremity which can act appropriately on the object (T-extremity for the rake, crook for a hook-like tool, etc.). Finally, infants have to be able to perform the motor action itself, and in particular, to place the rake behind the toy before performing the raking movement. All these elements may contribute to infants' difficulty in using a tool (e.g., a rake) to retrieve an out-of-reach object and may explain why the first spontaneous successes at such rake problem-solving tasks appear only after 18 months (Fagard et al., 2014; Rat-Fischer et al., 2012).

One might argue that using a spoon for self-feeding also requires similar skills, but is already in place before the use of other tools (albeit after considerable exposure). In fact, spoon use usually develops between 9 months and the end of the second year of life. At around 9–12 months, infants are able to hold a spoon, but with relatively unplanned grasping strategies and trajectories toward the mouth (McCarty et al., 2001). At around 14–15 months, infants become able to orient the spoon toward the food container, but are not able to fill the spoon efficiently, nor to bring it to the mouth without spilling its content (Gesell & Ilg, 1943). At 18 months, infants are able to fill the spoon, but still have difficulties feeding themselves efficiently without spilling the food. However, infants at this age show less variability than younger infants in their grasping patterns, as well as more involvement of the contralateral hand in task-related activities (such as holding the plate), and more stable movements in all components of the task (Connolly & Dalgleish, 1989). In addition, one study showed that when the spoon was presented at a difficult orientation, that is, with the handle oriented toward the nonpreferred hand, 19-month-old infants took the spoon's orientation into account, appropriately adjusting their grip before grasping the spoon (McCarty et al., 1999). Thus, in most 19-month-old infants, spoon use is not a difficulty anymore in terms of planning abilities, motor mastery and detection of affordances.

For these reasons, we argue that the difference of development between the use of a spoon for self-feeding and tools to retrieve out-of-reach objects is not due to differences in the level of difficulty between the rake task mentioned earlier and the spoon, but rather to other differences, the most probable one being the extensive amount of exposure with spoons that infants encounter in their everyday life. By exposure, we mean observation of others using a spoon as well as practice of the skill. Infants indeed have numerous opportunities to observe other agents using spoon-like tools. In contrast, they usually have much fewer opportunities to observe the use of rake-like tools. In this line of argument, a recent study has shown that 16-month-old infants could learn how to use a tool simply by observing an adult using a rake-like tool to retrieve objects in repeated sessions preceding the test (Somogyi et al., 2015). In addition to numerous observation possibilities, infants usually also have active

practice with a spoon from the end of the first year, and this may accelerate its mastery. Indeed, Sommerville et al. (2008) have stressed the importance of active experience for the development of motor representations of tool-use events that subsequently guide action perception and support action understanding. A last reason that may explain the developmental differences between spoon-use and other tool-use actions relates to the purpose behind the tool use. Using spoons and other cutlery for eating is essentially determined by sociocultural rules (Rodriguez et al., 2018). On the other hand, tool actions to retrieve out-of-reach objects are the consequence of physical constraints in the environment, like the impossibility to directly reach a desired object. Thus, tool use to retrieve out-of-reach objects is usually considered as a problem-solving task requiring particular cognitive skills (see Keen, 2011, for a review of problem-solving in infancy). In contrast, infants may use or try to use the spoon because of their willingness to imitate what they see around them or because of sociocultural pressures. Thus, spoon use could be more related to social constraints than to problem-solving involving cognitive reasoning.

All the above reasons lead the infants to master the use of a spoon for self-feeding at around 18 months, whereas usually they are not yet spontaneously able to solve other unfamiliar tool tasks, like retrieving an out-of-reach toy with an unconnected rake. Since these two tasks have many similarities, such as type of movement (toward the self), and tool grasp (at the handle extremity), and that transfer abilities from one problem to another are emerging at this age (Chen & Siegler, 2000; Keen, 2011), we wondered to what extent 18-month-olds may generalize their spoon-use knowledge to retrieve a distant object.

The aim of the present study was first to investigate whether familiarity with the tool (rake or spoon) and the nature of the target (toy or food) can influence 18-month-olds' performance in a retrieval task. We then studied to what extent the infants were able to transfer a retrieval success in a facilitated condition to a more difficult retrieval task. Finally, to better understand the performance differences among infants in our retrieval tasks, we explored potential links with the amount of tool use (including a spoon) in the infant's daily life.

We tested 18-month-olds in a toy-retrieval task that they usually fail at this age: retrieving an out-of-reach toy using a rake (rake–toy condition), in a way similar to previous work (Fagard et al., 2014; Rat-Fischer et al., 2012). We then presented them with different facilitating conditions which have gradually more similarities with the mastered self-feeding task. First, we replaced the rake (unfamiliar tool) by a spoon (familiar tool), to test for the effect of familiarity of the tool in a retrieval task (spoon–toy condition). As the spoon may be strongly associated with food, and not the toy, in a third condition we replaced the toy by a piece of food. We did this to test for the effect of the familiarity of the tool and the context in which it is usually used (spoon–food condition) on the performance in the retrieval task. The second way to end with a spoon–food condition, starting with the rake–toy task, is to keep the initial tool (rake) and replace the toy by a piece of food in the intermediate condition. We tested this other facilitating path in a different group of infants. Using this group, we evaluated a potential effect of the food, independently of the tool (because unlike the spoon, the rake is not usually associated with food). Different motivations for food and toy, or the more familiar food context, could cause this potential food effect (leading to a success in the rake–food condition after a failure in the rake–toy task). Thus, during the first

facilitation phase, all the infants were presented with three successive tasks, starting first with the rake–toy retrieval task which they are expected not to succeed and ending with the spoon–food situation that they are supposedly more familiar with. The intermediate task differed from the first and the last task by one single change: either the tool or the out-of-reach item. This scheme in the facilitation phase with an a priori descending order of difficulty allows the comparison between different conditions, avoiding a potential transfer of one task's success to a subsequent more complex task. This potential transfer of success was evaluated in the second phase of our experiment. During this second phase, the infants who succeeded in the spoon–food condition were re-presented with the same tasks but in reverse order.

If some of the infants who failed the initial rake–toy task can use the spoon as a means for retrieving in our experiment, it means that they gained something from having learned to use a spoon for self-feeding. We can make several hypotheses about the nature of this potential gain. Based on these hypotheses, we predict different outcomes in the conditions with a spoon or a rake to retrieve an out-of-reach toy or piece of food.

At the lowest level of understanding, some infants may only have learned a manual routine when self-feeding, consisting in grabbing the spoon, filling its bowl end, and putting it in the mouth. These infants would thus perform this action in an automatic manner when they have a spoon and food in front of them, which would not necessarily require having the notion that the spoon is a tool that can help them to bring food to the mouth. In this case, we expect that these infants will not succeed in retrieving the out-of-reach toy with the spoon, nor the out-of-reach biscuit with the rake but may succeed in the spoon–food condition because of the familiarity with the spoon used in a more natural context. They just have to apply the familiar movement with the spoon toward the food to retrieve it to the self. Another low-level consideration is that when infants eat with a spoon, they are used to paying attention both to the spoon and to the food at the same time, and to make a link between them. In contrast, 18-month-olds rarely link an out-of-reach toy and a rake, usually paying attention to one or the other element (Rat-Fischer et al., 2012; Fagard et al., 2014). Thus, infants may be more likely to succeed in the spoon–food condition, even if they failed in another retrieval task. Moreover, they are used to planning their actions in the self-feeding context and to temporarily inhibiting their desire to grasp the food with their hands. This may help them to succeed when they have to use a spoon to retrieve the out-of-reach biscuit.

At a relatively higher level, infants may extend their manual space so as to include the tip of the spoon. In that case, they may be more willing to interact with the out-of-reach item (including toys) with a spoon than with a rake, without considering, however, the context of solving a problem to retrieve an out-of-reach object. This behavior would be automatic in the sense that it would not necessitate having abilities at a particularly cognitive level and should not transfer back to the unfamiliar rake.

At the highest level of understanding, certain infants may have acquired some notion of the causal mechanism underlying the use of a spoon for self-feeding. These infants would be capable of using the familiar spoon in a different context (e.g., to retrieve an out-of-reach toy), attributing a new function to the spoon. In addition, according to Brown (1990), who argued that infants' transfer ability depends on their

adequate understanding of the particular problem's causal structure, they should then be able to generalize this knowledge to achieve a similar goal with a new tool.

Finally, to determine how infants' previous experiences with both spoons and other tools may have influenced their performances at our tool tasks, we asked the infants' caregivers to fill in a questionnaire about the infants' behaviors with tools. In line with the perception–action hypothesis (Lockman, 2000), according to which tool use arises from a cumulative result of infants' sensorimotor exploration during their first year of life, we expected infants who had accumulated more experience with the spoon and/or other tools across development to perform better in our toy-retrieval task.

# Materials and Methods

## Participants

Participants were 53 healthy full-term infants tested at 18 months (mean 553 ± 7 days). The infants were recruited from a list of local families who expressed interest in taking part in developmental studies. During the recruitment phase, we only selected infants who, according to their parents, were already trying to feed themselves with a spoon on a regular basis. Parents provided written informed consent before the infants did the experiment, and the research protocol was approved by the Université de Paris institutional human research ethics committee (CERES-00002013-17). Infants were randomly assigned to one of two groups, named after their intermediate conditions. $\text{Group}_{(\text{spoon–toy})}$ initially included 28 infants, of which four infants were excluded from the analyses either due to fussiness ($n = 3$) or fear/refusal of the rake used in the experiment ($n = 1$). The 24 remaining infants had a mean age of 550 days (±7 days; 11 girls). $\text{Group}_{(\text{rake–food})}$ initially included 25 infants, of which three infants were excluded from the analyses due to fussiness. The 22 remaining infants had a mean age of 555 days (±7 days; 12 girls). Because some trials in our experiment involved food, the time at which infants were tested may potentially have influenced their state of hunger, and thus their motivation to participate in these food trials. A control analysis showed that the proportion of infants tested at different time periods during the day did not differ between the two groups (see Supplementary Material [available online] for the distribution of infants across the day and the detailed analysis).

## Materials and Procedure

The rake used in this experiment was a T-shaped object made of white cardboard ($20 \times 15$ cm). The spoon was a silicone spoon for babies (17.2 cm long). The toys used for the study were small plastic ducks that children find attractive at 18 months. They were colorful, with some having a flickering internal light. The food items used in the experiment were standard biscuits for babies, brought by the parents or given by the experimenter with parents' approval. The choice of solid instead of viscous liquid food—more frequently used when using spoons—was motivated by the fact that toys and biscuits share more similarities in terms of motor action to be performed when it comes to bringing them into reach with a tool.

While retrieving a toy or a piece of biscuit requires raking toward the self, liquid food in contrast involves scooping the food out of a container. A small pilot study prior to the current study showed no difference in performance between cases when the item to be retrieved with the spoon was a biscuit versus when it was applesauce placed in a small container.

In all conditions, the desired toy/biscuit was placed on a table, out of the infant's reach, and the infant was given the tool (rake or spoon) to retrieve it. During the experiment, infants sat on their caregivers' laps. An experimenter sat facing the infant behind the table.

The tool was placed next to the infant's preferred hand, as assessed using a short laterality test (Fagard & Marks, 2000). If during the retrieval task, the infant ignored the tool and pointed toward the goal with the contralateral hand, then the tool was repositioned next to the pointing hand. To prevent infants from being more interested in the tools than in the target items, directly after the laterality test, the infants were allowed to familiarize themselves with the rake and the spoon by manipulating them one after the other for 30 s. After this, the infants were presented with the facilitation and transfer phases of the actual experiment (Figure 1).

### *Facilitation Phase*

Infants from both groups were presented with three retrieval tasks in assumed descending order of difficulty. First, all the infants were presented with the rake–toy condition, during which the tool was the rake and the out-of-reach item was the toy. The infants were then presented with either the spoon–toy condition for $\text{Group}_{(\text{spoon–toy})}$ or the rake–food condition for $\text{Group}_{(\text{rake–food})}$. Finally, all the infants were presented with a same spoon–food condition.

This condition was expected to be the easiest because it was the closest to the natural use of a spoon in a self-feeding situation (familiar context). Spoon–toy and rake–food were intermediate tasks with only one single change compared with rake–toy and spoon–food conditions (either the tool or the out-of-reach item). The interest of the spoon–toy condition was to test if a familiar tool (the spoon) might facilitate a retrieval task outside of the usual tool context (food). The objective of the rake–food condition was to control for a potential food effect (independent of the tool) that might facilitate solving the task (either due to more motivation or to a more familiar context).

### *Transfer Phase*

This second phase consisted in the same conditions presented in reverse order to infants who successfully retrieved the out-of-reach item in one or two conditions of the facilitation phase. The interest of this phase was to investigate a potential transfer from a success in a certain condition to a more difficult one that was previously failed during the facilitation phase.

In both phases, each condition consisted of two to three trials of about 1 min each. The exact number of trials was based on infants' immediate performance: with two consecutive failed trials, the condition was considered as failed and the next condition was presented; with two consecutive successes, the condition was considered as succeeded and the next condition was presented; with one failure and

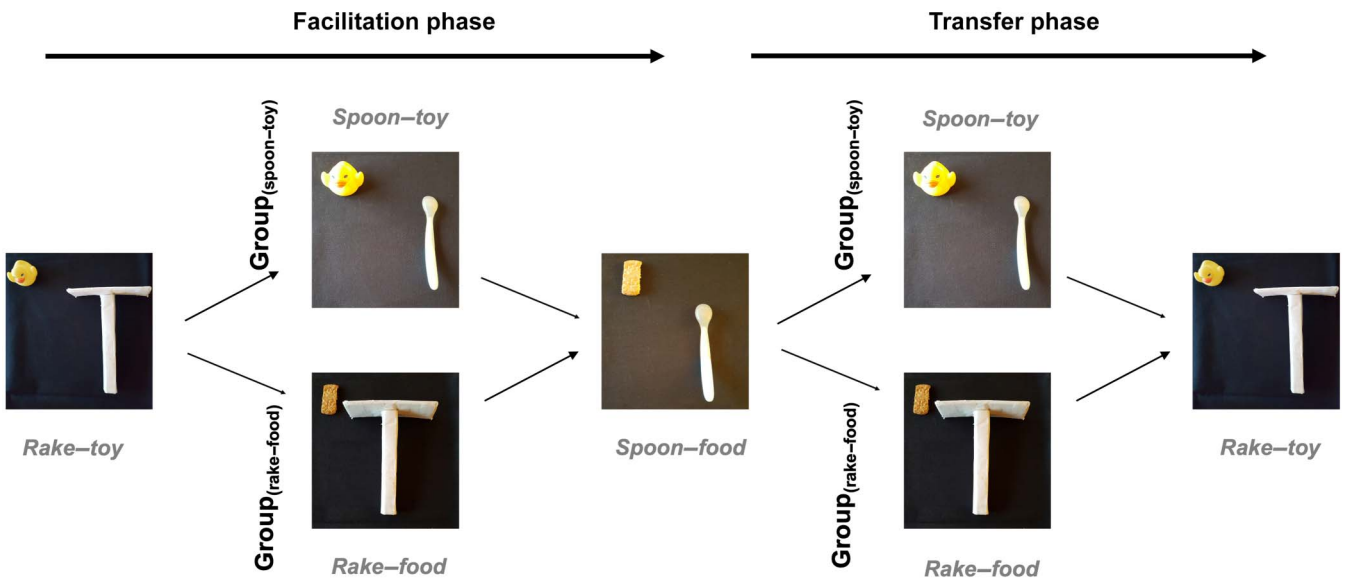


**Figure 1** — Illustration of the design of the study. First, a facilitation phase was performed, with three conditions presented in a priori descending order of difficulty: rake–toy, then spoon–toy for $\text{Group}_{(\text{spoon–toy})}$ or rake–food for $\text{Group}_{(\text{rake–food})}$, and finally spoon–food. Then, the transfer phase consisted in the same conditions, presented in reverse order (spoon–toy or rake–food, then rake–toy), to infants who successfully retrieved the out-of-reach item in at least one condition of the facilitation phase.

one success, a third trial was presented to assess whether the infant was able to repeat the success (successful trial) or not (failed trial).

In addition to the behavioral data, parents were asked to fill in a questionnaire (detailed in the Supplementary Material [available online]) about how much visual and manual experience their infant had with a spoon and other tools during their development.

## Data Analysis

Infants' performance (success/failure in each condition) was coded from the video recordings. All videos were double coded by an independent observer to assess interobserver reliability. Unweighted Cohen's kappa showed excellent agreement between the observers ($\kappa = .92$, $p = .0$). All analyses were performed using R Software (version 3.2.1) for Mac OS X. Nonparametric analyses with Bonferroni corrections were used to investigate differences in the performance between groups and conditions.

A factorial analysis of mixed data (FAMD) was performed on the questionnaire data (Pagès, 2014), in order to get an overview of the potential similarities between infants who most succeeded in the experiment.

From the eight questions contained in the questionnaire (provided in the Supplementary Material [available online]), we derived the following eight variables: two quantitative variables about the ages (in months) at which infants were first fed with a spoon and first used a spoon for self-feeding; and six qualitative variables about the frequency of use of a spoon at the time of the test (rarely, about 25%, more than 50%, and about 100%), the social context during feeding times (alone, with younger siblings, and with adults/older siblings), the similarity between a spoon at home and the spoon used for the experiment (not similar vs. similar or had a similar spoon at a younger age), the hand preference for a spoon according to the parents (left, right, and nonlateralized), the presence of a rake–toy at home (yes/no), and the previous observations by the parents of their child using a stick or a similar tool to retrieve an out-of-reach toy at home (yes/no). Exploratory analyses were performed in order to identify potential differences between infants among these variables according to their performances with the rake and/or the spoon. The data extracted from the questionnaire were analyzed using the FAMD (package FactoMineR). This methodology is known to be appropriate when both quantitative and qualitative variables (i.e., mixed data) are analyzed simultaneously, and when the relatively limited number of individuals (usually less than 100 individuals) prevents running a multiple correspondence analysis by transforming the quantitative variables into qualitative variables. With FAMD, infants are represented in a multidimensional space based on the response to each question from the questionnaire. Individuals with similar profiles will lie together in the same part of the space, and individuals with reversed patterns will lie on opposite sides of the origin. This analysis allows us to explore if some profiles of previous experience with spoons and tools could be related to the performance with the spoon and the rake. Before running the FAMD analysis, we used the complementary package missFDA to extrapolate missing data, in the rare cases where some answers were missing in the questionnaires because the parents lacked the answer to a question (4.1% of

the overall data). One infant who was successful at the spoon–toy condition of the facilitation phase had to be removed from this analysis because of a change in the procedure (the infant lost interest in the toy and the reward was replaced by a piece of biscuit). Thus, this analysis included 45 infants, with 23 infants in $Group_{(spoon–toy)}$ and 22 infants in $Group_{(rake–food)}$, including the four infants (three in $Group_{(spoon–toy)}$ and one in $Group_{(rake–food)}$) who spontaneously succeeded in the first rake–toy condition and then successfully solved all further conditions.

## Results

Figure 2 presents the percentage of infants who succeeded in each condition of the facilitation phase and the transfer phase, for both groups. Infants are represented

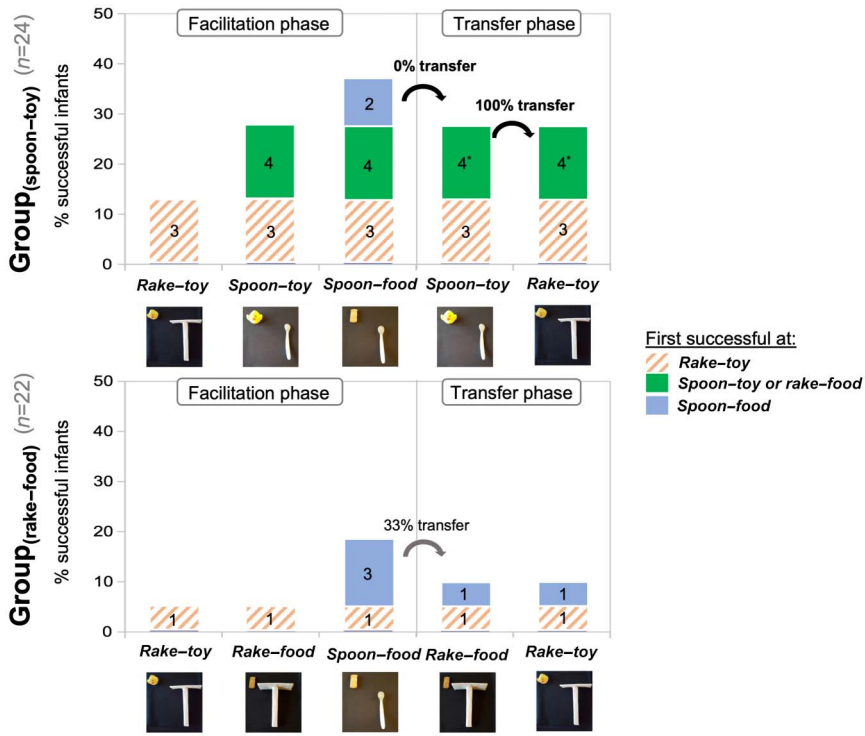


**Figure 2** — Percentage of infants who succeeded in the different conditions. First, the facilitation phase, composed successively of the conditions rake–toy, spoon–toy or rake–food, and spoon–food, followed by the transfer phase, composed successively of spoon–toy or rake–food, and rake–toy. Colors segregate infants as a function of the first condition in which they succeeded during the facilitation phase. Thus, identical colors in different conditions correspond to the same infants. *One infant has to be considered separately because of a procedural change.

with different colors according to the first condition they solved during the facilitation phase.

## Facilitation Phase

In $\text{Group}_{(\text{spoon–toy})}$, three infants (shown in striped orange in the Figure 2) directly solved the rake–toy retrieval task (and all subsequent conditions). Four additional infants solved the spoon–toy task (and the easier spoon–food task), and two succeeded in the spoon–food task only. In $\text{Group}_{(\text{rake–food})}$, one infant directly solved the rake–toy retrieval task (and all subsequent conditions). No additional infants solved the rake–food task, and three solved the spoon–food task only. The four infants who spontaneously solved all the tasks in both groups were removed from the between- and within-group analyses, leaving 21 infants in each group. Indeed, our interest lay in infants who were not able to spontaneously solve the rake–toy retrieval task.

### *Between-Group Differences*

A Wilcoxon–Mann–Whitney test comparing the success rate at facilitation conditions spoon–toy versus rake–food showed that significantly more infants succeeded in the spoon–toy condition ($n = 4$) than in the rake–food one ($n = 0$; $W = 262.5$, $p < .05$). Moreover, as could be expected since the spoon–food condition is the same for the two groups, no significant differences were found between $\text{Group}_{(\text{spoon–toy})}$ and $\text{Group}_{(\text{rake–food})}$ for this condition ($W = 252$, $p = .27$).

### *Within-Group Differences*

A Cochran's $Q$ test comparing the number of successful infants between each condition within $\text{Group}_{(\text{spoon–toy})}$ showed a significant difference between all conditions in the proportion of successful infants, $\chi^2(2) = 8.4$, $p < .05$. Pairwise comparisons using continuity-corrected McNemar's tests with Bonferroni correction ($\alpha = .017$) revealed marginally significant differences between conditions, with only the comparison rake–toy versus spoon–food significant after Bonferroni correction, $\chi^2(1) = 4.17$, $p = .04$. In $\text{Group}_{(\text{rake–food})}$, a Cochran's $Q$ test did not reveal any significant difference in the performance between conditions, $\chi^2(2) = 6$, $p = .11$.

These results indicate that using a familiar tool (spoon) facilitated the infants' performance in the retrieval tasks. The task was even more facilitated when the toy was replaced with food, being closer to the more familiar self-feeding context. The results from $\text{Group}_{(\text{rake–food})}$ suggest that this additional facilitation was brought by the association of the spoon with food and not by the food alone. We see this from the fact that the food context alone (rake–food condition) did not facilitate solving of the retrieval task.

## Transfer Phase

In $\text{Group}_{(\text{spoon–toy})}$, the infants shown in green in Figure 2 who succeeded in the spoon–toy condition of the first phase were systematically able to transfer their success to the rake–toy condition of the second phase. In contrast, the two infants

(shown in blue in Figure 2) who only succeeded in the spoon–food condition were unable to transfer their knowledge to conditions involving a different out-of-reach item. One infant who solved spoon–toy and spoon–food during the facilitation phase has to be considered separately because he lost interest in the toy after having seen the biscuit in the spoon–food condition. For this particular infant, the toy was replaced by the biscuit until the end, and the child successfully transferred to the rake–food task.

In $\text{Group}_{(\text{rake–food})}$, out of the three infants who succeeded in the spoon–food condition (shown in blue in Figure 2), only one infant was able to transfer to rake–food then to the rake–toy condition.

The results of the $\text{Group}_{(\text{spoon–toy})}$ transfer phase show that all the infants who succeeded in the spoon–toy condition of the facilitation phase, and only they, were able to transfer their performance to the rake–toy condition. Thus, to the question: Can the infants transfer from a successful use of a spoon (familiar tool) to a new tool? We can answer positively, but only if they can use the spoon in an unfamiliar context (with a toy in place of food). In $\text{Group}_{(\text{rake–food})}$, the only infant who succeeded in the rake–food condition during the transfer phase, also succeeded in the rake–toy condition of the same phase, confirming that the food alone was not facilitating for the retrieval task.

## Questionnaire

The factorial analysis carried out on the data of the questionnaire resulted in five components related to different aspects of the infants' past experience with tools. Table 1 gives the results on the five components derived from the FAMD. The first component explains about 27% of the variability of the data set and is strongly associated with the quantitative experience that infants have had with the spoon, namely the age at which infants first used a spoon for self-feeding and the frequency at which they used a spoon at the time of the experiment. The four other components represent a similar amount of variability (between 17% and 10%) and were all considered for the visualization of the profiles of individuals. Component 2 is mainly associated with infants' previous use of tools, as observed by parents. Component 3 is weakly associated with the age at which infants were first fed with the spoon and the laterality for the spoon, providing little information about the potential factors responsible for the variability between groups of performance. Component 4 is mainly associated with whether the spoon used for the experiment was similar to the one used at home. Finally, Component 5 is strongly associated with infants' hand preference for using the spoon at the time of testing. All components were then used to identify potential differences and similarities between successful and nonsuccessful infants. For this purpose, we visualized the individuals on plots with all possible combinations of components from 1 to 5, while differentiating between (a) infants who spontaneously succeeded in the rake–toy condition and all further conditions, (b) infants who failed the first rake–toy condition but succeeded in the easier spoon–toy/rake–food and spoon–food conditions (all were then able to transfer back to the rake–toy task), (c) infants who only succeeded in the spoon–food condition, and (d) infants who failed all the conditions.

The different plots showed that the infants who were the most successful in our experiment had similarities regarding Component 1 (related to the quantitative

**Table 1 Components Derived From the FAMD on the Questionnaire Data**

| | Component 1 | Component 2 | Component 3 | Component 4 | Component 5 |
|---|---|---|---|---|---|
| % of inertia (variability of the data set) | 27.43 | 16.49 | 13.45 | 11.21 | 10.22 |
| Eigenvalue | 2.35 | 1.41 | 1.15 | 0.96 | 0.88 |
| Age at which infant was first fed with a spoon | | 0.22 | 0.32 | | |
| Age at which infant first used a spoon | **0.46** | | | | |
| Presence of experienced spoon-user during meals | 0.37 | | 0.27 | | |
| Frequency at which infant currently uses the spoon | **0.62** | | | | |
| Laterality for the spoon | 0.24 | | 0.34 | | **0.66** |
| Similarity between test spoon and spoon at home | | 0.31 | | 0.39 | |
| Possession of a rake–toy at home | 0.37 | 0.2 | | | |
| Infant's previous use of a stick to retrieve things | | **0.43** | 0.2 | 0.2 | |

*Note*. Scores with an absolute value greater than 0.4 are displayed in bold. Scores below 0.2 are not displayed. FAMD = factorial analysis of mixed data.

experience that infants have had with the spoon during their development). All other components failed to link infants' performance with variables from the questionnaire. Figure 3 represents each infant on the bidimensional space defined by Components 1 and 2. We observe a separation between infants who succeeded in the most difficult tasks (rake–toy and spoon–toy conditions), with centers of

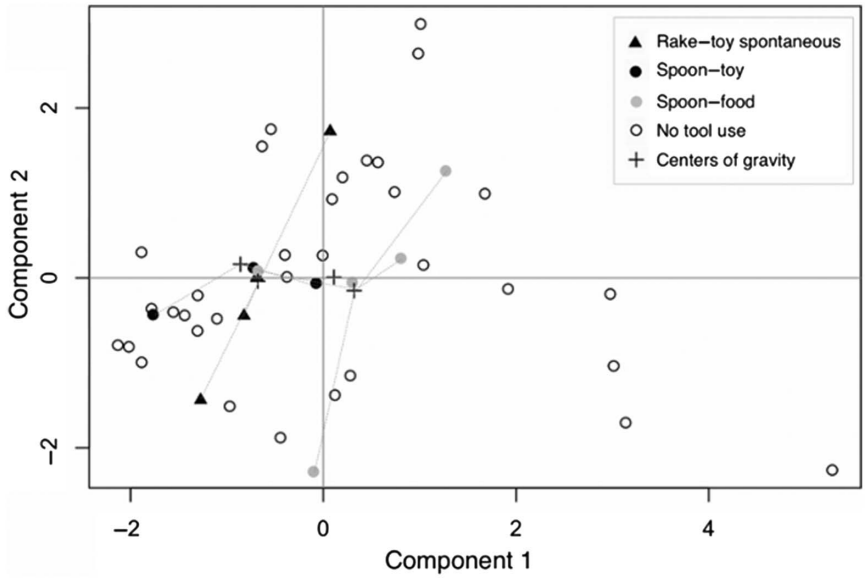


**Figure 3** — Biplot of Component 1 (*x*-axis), related to the start age and frequency of spoon use, and Component 2 (*y*-axis), related to previous use of tools, extracted from the factorial analysis of mixed data on the questionnaire data. Individuals are distributed over Components 1 and 2, and represented according to their spontaneous performance in the experiment: (○) no success, (gray •) success at spoon–food only, (black •) success at spoon–toy (they all transferred to rake–toy), and (▲) spontaneous success at rake–toy and all following conditions. The symbols (+) represent each group's center of gravity, in order to identify each group's profile within Components 1 and 2. All individuals from the three success groups are linked to their center of gravity, whereas individuals who did not succeed (○) were not linked to their center of gravity for visual clarity purposes.

gravity on the negative side of Component 1, and the other infants. This means that on average, the most successful infants had an earlier independent use of a spoon for self-feeding with a higher frequency than the others. Interestingly, Component 2, which mainly corresponds to parental observations of their infants' use of tools as a means for retrieving, is not related to any performance profile.

To conclude, the first component (and only this one), which explained the highest amount of variability of the data set, and in our case represented the quantitative experience that infants have had with the spoon for self-feeding during their development (start age and frequency), separated well the infants in accordance with their performance in our experiment. The most successful infants in the rake–toy and spoon–toy tasks had on average the most experience with self-feeding with a spoon.

## Discussion

The aim of this research was to explore to what extent 18-month-old infants, who are familiar with using a spoon for self-feeding, are able to generalize this tool-use

ability to more difficult tool use: the retrieval of a distant object. First, we investigated whether familiarity with the tool (rake or spoon) and the nature of the target (toy or food) might influence 18-month-old infants' performance in a retrieval task. Then, we studied whether the infants were able to transfer a retrieval success in a facilitated condition to a more difficult retrieval task. Finally, we explored a potential link between the use of tools (including a spoon) in the infant's daily life and success in retrieval tasks.

## Facilitation

We observed that the infants performed the retrieval tasks better with a familiar tool (spoon), the easiest task being when the spoon was also associated with food (even though success rate remains low). This confirms our hypothesis that the spoon–food condition should be easier, due to more similarities with the natural use of a spoon in a self-feeding situation (familiar context). The failures of the infants who had to retrieve a biscuit with a rake showed that the food was not helping with the retrieval task unless it was combined with the spoon.

The higher performance in the spoon–toy compared with the rake–toy condition contrasts at first sight with the results obtained by Barrett et al. (2007) and Kaur et al. (2020). These authors observed that 12- to 18-month-old infants were less likely to correctly use a familiar spoon than an unfamiliar tool to accomplish a novel task (turning on light inside a box). Nevertheless, contrary to our study, their task required an unconventional grasp of a spoon (at its bowl). Infants thus had to inhibit their normal handle-grasping response in order to plan their grasp in a way that allowed them to solve the task. In addition, in these studies, the spoon movement had to be directed toward a box (away from the self), which is another difference with self-feeding and with our experiment (self-directed movements).

## Transfer

Interestingly, in our experiment, all the infants who succeeded in the spoon–toy task were then able to transfer this retrieval ability to the more difficult rake–toy task. It thus could be that when they were confronted with the situation with a spoon and an out-of-reach toy, they realized that they could use the familiar spoon to solve this problem (attributing a new function to the spoon), and then, when confronted again with the rake, deduced that they could also use a nonfamiliar object to accomplish the same task. From this, we can therefore assume that they expanded their notion of tool use. This would be in agreement with Brown (1990), who argued that infants' transfer ability depends on their adequate understanding of the particular problem's causal structure. Thus, in our experiment, the infants who succeeded in retrieving the toy with the spoon would have understood the underlying causal mechanism of their action, and then generalized this knowledge to achieve a similar goal with a new tool. These infants correspond to the high-level hypothesis presented in the introduction. In contrast, the infants in $\text{Group}_{(\text{spoon–toy})}$ who only managed to retrieve the biscuit with the spoon were not able to transfer to the nonfood context (spoon–toy and rake–toy). They probably just slightly extended their self-feeding manual routine without real causal understanding, and

correspond to the low-level hypothesis presented in the introduction. Thus, being able to use a familiar tool in an unusual context seems necessary and sufficient for the subsequent successful use of an unfamiliar tool in this unusual context. This would imply that the infant who succeeded the spoon–food task in $Group_{(rake–food)}$ and successfully transferred back to the rake–food and the rake–toy conditions would probably have been successful in the spoon–toy condition during the facilitation phase, if he had been in $Group_{(spoon–toy)}$. Overall, our results suggest that transfer ability from one tool to another is strongly associated with infants' flexible use of a given tool in different contexts. Indeed, the ability to use tools flexibly in different ways, to serve different functions, and to act on different goals has been emphasized as an important aspect in the development of tool use (Paulus et al., 2011).

## Relation With Daily Life

According to our questionnaire analysis, this flexibility seems to be associated with earlier and more frequent use of a spoon for self-feeding. This is further empirical evidence for the perception–action perspective on tool use development (Lockman, 2000) stating that tool-use learning is rooted in the perception–action routines that infants employ to gain information about their environments. Kahrs et al. (2012), for example, have shown that repetitive behaviors such as banging performed during the second half-year had a strong influence on infants' later hammering and tool use. Our results are also in agreement with the study of Kaur et al. (2020), which showed that infants with a greater frequency of spoon use at home for self-feeding performed better in a novel task requiring a spoon to illuminate a box. They hypothesized that with the intensive use of a spoon for self-feeding, the infants developed a more accurate representation of this tool's geometry, which is very important for determining new uses for the tool. Nevertheless, the questionnaire data must be taken with caution because they rely on the parents' subjective memory and interpretations of past events.

## Explanations of the Overall Low Success Rate

A second aspect we would like to discuss is the overall low success rate, even in the spoon–food context (13 out of 46 infants). Several explanations could be given.

First, it might be thought that motor difficulty manipulating the tools, in particular performing the appropriate raking movement toward the self, could be the cause of this failure. However, it is known that children at 18 months have the motor capacity to perform this movement, even in the absence of manual experience with a rake-like tool. Somogyi et al. (2015), for example, showed that infants as young as 16 months successfully performed the rake task after repeatedly observing caregivers using a rake-like tool to retrieve objects in natural, everyday-life situations.

Failure to reach a distant biscuit or toy with the spoon could also be caused by "functional fixedness," a phenomenon describing infants' inability to reach a solution to a problem because they cannot detach themselves from the knowledge of an object's conventional function (Barrett et al., 2007; Duncker, 1945; German & Defeyter, 2000). Yet, if this was the reason for the failures in our experiment, the

infants would have succeeded more with the rake than with the spoon, since the rake's conventional function is unknown at 18 months.

Ultimately the reason seems to relate to other cognitive aspects, such as inhibiting the action of trying to reach the goal directly with the hand, or causal reasoning and attentional capacities toward several elements separated in space. Indeed, we noticed that most of the infants who failed the retrieval tasks did not even attempt to bring the rake into contact with the target. The presence of a spatial gap between tool and target has previously been shown to impair infants' performance in tool and other means-end tasks at 18 months, compared with situations in which the tool and the target are directly connected (Brown, 1990; Fagard et al., 2014).

Since infants improve their capacity to use the spoon out of its natural context during the second half of the second year, at the same time as they improve their capacity to use other tools such as in the rake task (Rat-Fischer et al., 2012), it would be interesting to repeat our experiment on older infants, for example at 20 months, and on a larger data set, to confirm our results.

To conclude, the present study tackled the issue of generalization abilities in 18-month-olds from a mastered tool use (spoon) to a novel tool use (involving an unfamiliar tool, a rake, and an unfamiliar task). Our results showed that the infants tend to perform a retrieval task better when the tool is familiar. Moreover, the transfer ability from a familiar tool to a new tool seems to depend on the infant's capacity to use the familiar tool flexibly in a novel context. Finally, our results indicated that this flexibility is related to early and frequent use of the spoon for self-feeding.

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