Received: 16 February 2020 | Revised: 21 March 2020 | Accepted: 1 April 2020

DOI: 10.1002/dev.21978

Check for updates

RESEARCH ARTICLE

Developmental Psychobiology WILEY

Social interaction in the emergence of toddler's mealtime spoon use

Tetsushi Nonaka[1] | Thomas A. Stoffregen[2]

[1]Graduate School of Human Development and Environment, Kobe University, Kobe, Japan

[2]School of Kinesiology, University of Minnesota, Minneapolis, MN, USA

Correspondence
Tetsushi Nonaka, Graduate School of Human Development and Environment, Kobe University, Tsurukabuto 3-11, Nada-ku, Kobe 6578501, Japan.
Email: tetsushi@people.kobe-u.ac.jp

Funding information
Japan Society for the Promotion of Science, Grant/Award Number: JP18K12013 and JP18KT0079

Abstract

The use of a spoon for eating is among the important daily skills in early development. The article provides an analysis of how caregiver–toddler interactions guides the attention of toddlers who were first learning how to use a spoon to spoon-related action opportunities that were relevant to the mealtime context. Our analysis revealed several related results. First, caregivers often manipulated objects on the table (i.e., food and dishes), and toddlers were more likely than chance to use their spoon to contact food immediately after watching these caregiver manipulations. Second, toddlers looked more often at the caregiver's hand than at their face. Third, toddlers tended to look at the caregiver's hand when the caregiver was manipulating objects on the table, and after these looks, toddlers were more likely than chance to contact food with their spoon. Finally, the toddlers' choices about when to look at the caregiver were influenced by their own behavior, as if they wanted to know how the caregiver would react to what they had done. We discuss these results in terms of the learning of socially promoted action opportunities for meal-related spoon use.

KEYWORDS

affordances, caregiver–child interactions, coordinated attention, education of attention, field of promoted action

1 | INTRODUCTION

The activities of daily life revolve around stable clusters of skills that have been selected within a given populated environment (Reed, 1996). Self-feeding—the ability independently to feed oneself with a utensil—is among the important daily skills in early development (Babik, Movva, Cunha, & Lobo, 2019; Connolly & Dalgleish, 1989; Gesell & Ilg, 1937). How do children learn, for example, to use a spoon? An ordinary spoon affords many actions, many of which (such as banging or throwing) are not related to the spoon's intended use as a tool to aid the ingestion of food (e.g., Ye, Cardwell, & Mark, 2009). Nonaka and Goldfield (2018) reported that toddlers explored different ways to hold spoons, and also exhibited considerable variability in the purpose for which spoons were used during mealtime. Examples included mouthing a spoon, running their fingers over it, banging two spoons against each other, bouncing the end of a spoon on the table, twisting a spoon with fingers, passing it from hand to hand, rolling it on a surface, shaking, dropping, and throwing the spoon, as well as using the spoon to probe or poke at food, loading food onto, transporting food to another place, and using the spoon to smear food onto a surface. These examples illustrate the many actions opportunities, or *affordances*, that are available when children encounter with spoons. As will be obvious to the adult reader, most of these affordances are irrelevant to or even counterproductive with respect to eating a meal. How does the child transition from exploration of generic spoon-related affordances to those affordances that optimize food ingestion, that is, to affordances that are appropriate at mealtimes?

We examined this question in relation to the fact that toddlers are rarely alone when they eat; typically, caregivers are present. Thus, for toddlers, mealtime comprises a social interaction. The social nature of mealtime means that toddlers have the opportunity to use their interaction with the caregiver to learn about spoon use. In particular, caregivers may provide information about how the

 © 2020 Wiley Periodicals, Inc.

toddler can learn to distinguish "what I *can* do with a spoon" from "what I *should* do with a spoon." In daily life, multiple affordances always exist (Wagman, Caputo, & Stoffregen, 2016), and selection from among available affordances in a given situation often is constrained by social norms (Heras-Escribano & de Pinedo, 2016; Rietveld, 2008).

1.1 | Social interaction and skill development

For humans, situated skill learning commonly involves multiple individuals and social norms (Gibson, 1950; Mauss, 1973; Valsiner, 1984, 1997; Reed, 1993). Recent research indicates that coordinated social interaction between young children and caregivers has a foundational role in the development of language, cognitive, and motor skills, helping to create developmental cascades into different domains of function (Adolph, 2019; Chen, Castellanos, Yu, & Houston, 2019; Corbetta, Williams, & Haynes, 2016). Yet, the interpersonal ecology of young children's development of daily skills is so commonplace that its significance seems yet to be fully appreciated. Nonaka and Goldfield (2018) reported that in the early stage of self-feeding at home, mothers carefully controlled what was within reach of young children, thereby creating a spatial arrangement within which playful behavior was tolerated; what Nonaka and Goldfield called *a field of safe exploration*. In addition, caregivers sometimes selectively varied the child's set of action opportunities, by changing the arrangement of objects on the table. Such subtle interactions, in which caregivers shaped the child's spontaneous activities, have received little attention from researchers, possibly because they are difficult to manipulate experimentally.

To understand how young children become attuned to a set of action opportunities relevant to a specific situation, an account is needed of how young children and caregivers coordinate their attention toward these relevant aspect of the situation in the setting where such interactions actually take place (Boyer & Bril, 2001; Zukow-Goldring, 1997). Recently, a growing body of evidence suggests that manual actions on objects are critical to the establishment of joint attention (Rader & Zukow-Goldring, 2010; Yu & Smith, 2013, 2017). In one study in an experimental object play setting, for example, Yu and Smith (2017) found that both toddlers and parents attended to their partner's object manipulations, and joint attention emerged through the coordination of gaze with manual actions on objects, indicating that such coordinated attention by way of manual actions on objects characterizes parent–infant everyday interaction. In the context of the development of self-feeding skill, one possibility is that manual actions by caregivers on tabletop objects previously reported by Nonaka and Goldfield (2018) may have a direct consequence in the subsequent selection of spoon-using action by novice spoon feeders. It is also possible that such interactions, if repeated, may help young children to become attuned to a set of action opportunities relevant to a specific context of mealtime. By this line of reasoning, the assistive action by caregivers observed may predict the subsequent selection of spoon-using action by novice spoon feeders. Another possibility is that attention paid by novice spoon feeders to caregivers during mealtime may exhibit some kind of lawful relation with their spontaneous selection of spoon-using action. Investigations into these subtle, non-obvious interactions between caregivers and novice spoon feeders that occur in a natural environment may deepen our understanding of the significance of a populated environment in learning to use a utensil for self-feeding.

1.2 | Current study

Using an observational methodology, we explored relations between the actions of caregivers and the actions of novice feeders' as children learned to use a spoon for food ingestion. We examined video recordings of 12 child–caregiver dyads at lunchtime in a natural setting. Our aim was to gain insight into the three-term relation between caregivers' actions, toddlers' gaze at caregivers, and toddlers' spoon use. We were interested in two types of social interactions. First, we asked whether different forms of spoon use (i.e., food-oriented or not) by novice spoon feeders were influenced by the actions of a caregiver (speech, touching the child, or touching an object). Second, we asked whether toddlers' spoon use choices were related to their prior or concurrent choices about whether to look at the hands or face of the caregiver. Using a longitudinal database of video recordings, we focused on the month in which the first successful independent spoon feeding was observed. In this period, children are capable of using a spoon to transport food to the mouth, but still display variable forms of spoon use. We asked how caregiver–toddler interactions might affect the likelihood that toddlers would focus their actions on meal-relevant affordances of spoons, and away from meal-irrelevant affordances. We predicted that novice spoon feeders would look at caregivers' manual actions on tabletop objects. Thereby, we predicted that caregivers' actions on objects would be associated with an increased likelihood that toddlers would actualize meal-relevant affordances of spoons.

2 | METHOD

2.1 | Participants

Twelve toddlers (eight females, four males) and four adult female caregivers participated in the study. The mean age of the toddlers was 10.44 months at the beginning of observation and 20.01 months at the end of the observation period (*SD* = 2.62 months). All were enrolled in or worked at a day-care center (the Yamaboushi Nursery Center, Hyogo, Japan). Data were extracted from video recordings of toddlers as they ate lunch with the assistance of a caregiver. These recordings were made longitudinally over a period of 10 months from June 2017 to March 2018. At the beginning of observation, none of the toddlers used a spoon during feeding. From our observations across 10 months, we identified the date of the onset of independent spoon feeding, the details of which are described in the

subsequent section. The mean age of the toddlers at the onset of independent spoon feeding was 17.88 months (*SD* = 1.09 months). All parents and caregivers gave informed consent prior to being filmed.

2.2 | Procedure

A researcher visited the nursery monthly, placing digital video cameras in front of each table so as to record the toddler eating a meal with the caregiver. To avoid distraction, the researcher left the room before the toddlers came in. The toddler sat in his or her usual chair facing a table, and the caregiver sat around the corner of the same table next to the toddler (Figure 1). Each month, lunchtimes of four consecutive days were videotaped. Each child was observed at least 2 days within the same week for every month. Using the collected video data, the onset of independent spoon feeding was identified for each toddler. Independent spoon feeding was defined as the multiple occurrence of food ingestion with a spoon independently manipulated by the toddler. This onset was not meant to be the strictly defined moment after which the toddlers can eat with a spoon independently. Rather, the onset was used to extract the situation of early use of spoons in self-feeding where the toddlers exhibit still unskilled and variable level of performance. We also note that since there was 1-month interval between observations, there could have been a time difference up to 1 month between the observed and the actual instance of first independent food ingestion using a spoon. In this period, the child sometimes was fed by the caregiver (using the caregiver's spoon), and sometimes was fed independently, through finger feeding, or through the child's use of their own spoon. Caregivers held a spoon, which they used either to transport food from a larger dish to a small dish in front of the child, or directly to feed the child (Figure 1). In addition, caregivers used their spoon to manipulate the contents of the child's dish.

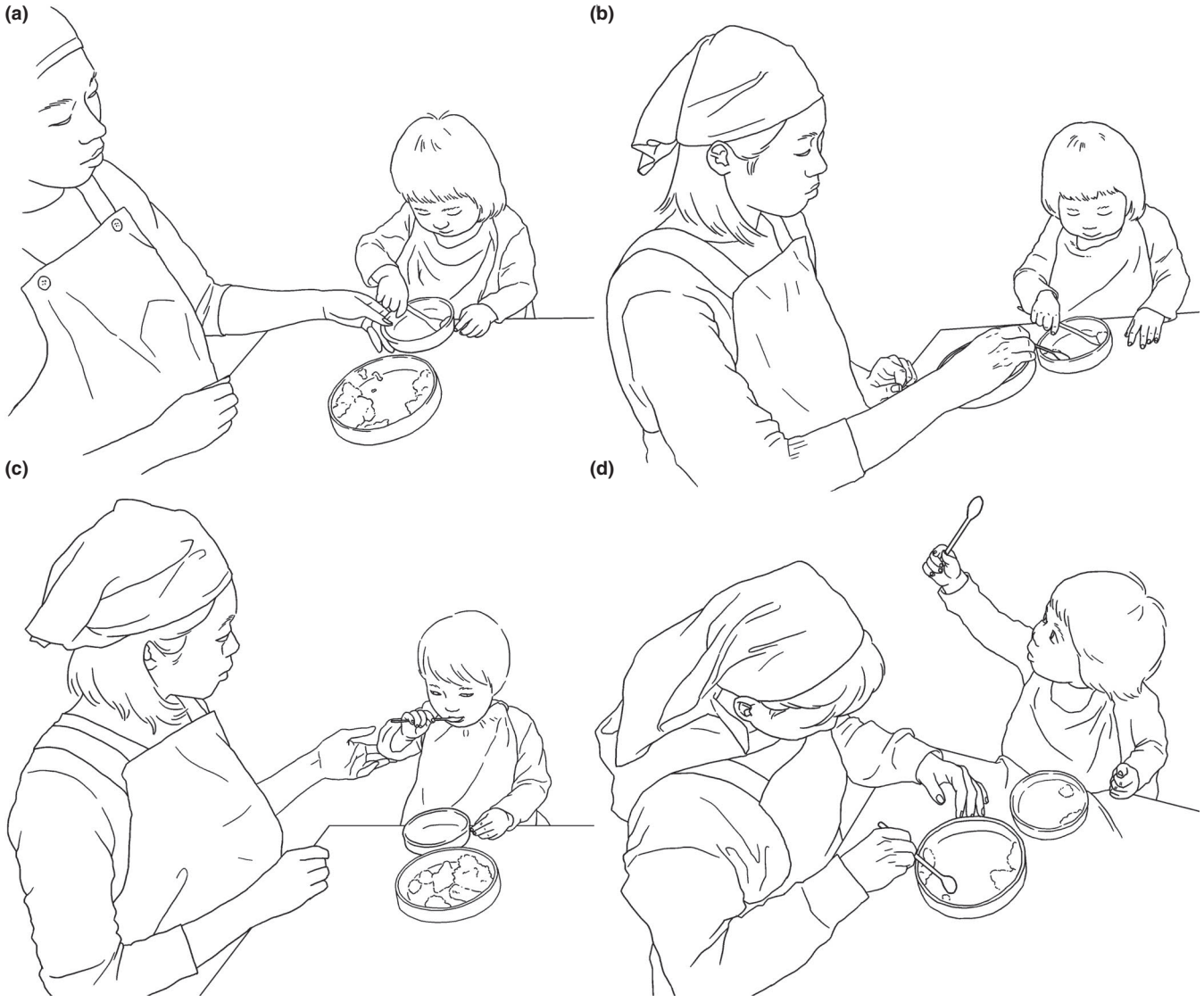

FIGURE 1 Some examples of toddler's spoon-using action and caregiver's assistive action. (a) Toddler's spontaneous food contact during caregiver's action on the dish on the table. (b) Toddler's spontaneous food contact during caregiver's action on the food in the dish. (c) Toddler's food ingestion assisted by caregiver's action on the toddler's elbow. (d) Toddler's playful spoon use not oriented to food

We selected a single segment of video from each the first two meals after the onset of independent spoon feeding. The beginning of self-feeding typically is characterized by unexpected events and interruptions. To ensure that the situation was comparable across children, we selected feeding bouts that satisfied three conditions: (a) the toddler held their own spoon, (b) the caregiver was present at the table, and (c) less than 1 min passed between instances of the toddler using their spoon to contact the food. From each meal, we selected the longest bout that satisfied above criteria. Overall, we analyzed 24 video clips that met all three criteria. The duration of these clips was 3.82 ± 2.03 min.

2.3 | Data coding

Caregiver–toddler interactions were coded from video clips recorded with one frontally oriented camera. All coding from the video clips was completed in frame-by-frame mode using a video coding software *Datavyu* (www.datavyu.org) that allows for frame by frame analysis of the timing of onsets and offsets of specific behaviors (i.e., 30 frames per second were visible and available for coding). A primary coder scored (1) the toddler's spoon-using actions, (2) the caregiver's assistive actions, and (3) the toddler's visual attention (gaze) to the caregiver. For the toddler's spoon-using action (Figure 1), the coder noted the onset and offset of each of three types of episodes: (1a) toddler's spontaneous use of a spoon to contact food, (1b) toddler's use of their spoon to ingest food (emptying food from the spoon into the mouth), or (1c) playful spoon use (e.g., the toddler hitting the dish with a spoon). The toddler's spontaneous use of a spoon to contact food could lead to either food ingestion or to other actions. Taking this fact into account, we operationally defined the offset of the toddler's spontaneous use of a spoon to contact food in either of two ways; when the toddler's spoon ceased to be in contact with food (in the cases where food ingestion did not follow), or at the moment just prior to food ingestion (in the cases where food ingestion followed). For the caregiver's assistive action (Figure 1), the coder noted three types of episodes: (2a) the caregiver's movement of items on the table (e.g., food, dish), (2b) the caregiver's actions touching the toddler, or (2c) the caregiver's vocalization addressed to the child. We did not analyze the contents of the caregiver's vocalizations, but only the onset and offset of these vocalizations. Finally, for the toddler's visual attention (gaze) to the caregiver, the coder noted the onset and offset of two types of episodes: (3a) the toddler's eyes were directed at the face of the caregiver, and (3b) the toddler's eyes were directed at the hand of the caregiver including anything held in the caregiver's hand. When the child's eyes were not directed at the face or hand of the caregiver but were directed elsewhere (e.g., other objects on the table), the coder simply noted "other." The "other" category was not analyzed. A second researcher independently coded 25% of the time-segmented data. Between coders, the agreement was above 90%. Kappa inter-observer reliabilities ranged from 0.86 to 0.96. For each coded video segment, we calculated the percentage of the total duration of each behavior (% time) by dividing the total duration of each behavior by the duration of the video segment, the mean duration of each occurrence of the behavior, and the mean rate of food ingestion per minute.

2.4 | Data analysis

The time stamped raw coded data were exported from Datavyu to Generalized Sequential Querier (GSEQ; Bakeman & Quera, 2011). The sequential analyses were used to explore the following specific questions concerning the temporal contingencies between the child's spoon use, the caregiver's assistive action, and the toddler's gaze at the caregiver. A previous study found that when the toddlers started using spoons in self feeding at home, mothers frequently steady dish while the toddlers were touching food with a spoon (Nonaka & Goldfield, 2018). The study also found that the caregivers often adjust the position of the bowl on the table, or adjust the layout of food on the dish so in such a way to invite the toddler's food-oriented spoon use. To capture the immediate effects of the caregiver's assistance on the toddler's spoon-using behavior, we examined the toddler's spoon use during or immediately after the caregiver's assistive action. Specifically, we tested (a) how much more or less likely compared to chance the onset time of the toddler's spontaneous spoon use (either food contact or other playful use) occurred during or immediately after the caregiver's assistive actions defined above. Next, we looked into where the toddlers were directing their gaze when the caregivers were assisting the toddlers in one way or another; and tested (b) how much more or less likely compared chance the toddlers looked at caregivers' hand or face during the caregiver's assistive actions defined above. In addition, we further looked into the sequential relation between the toddler's gaze directed at the caregiver and the spoon-using actions by the toddler. Specifically, we tested (c) how much more or less likely compared to chance the onset time of the toddler's spontaneous spoon use (either food contact or other playful use) occurred immediately after the toddler looked at the hand or the face of the caregiver; and (d) how much more or less likely compared to chance the onset time of the toddler's gaze directed at the caregiver occurred immediately after the child's food contact with a spoon, food ingestion with a spoon, or other playful spoon use. In the present analysis, we considered the action response that occurred within the time window of 2 s after the preceding action as the immediate action response. Thereby, for the temporal contingencies between the child's spoon use and the caregiver's assistive action, we counted the toddler's spoon use that occurred during or 2 s after the caregiver's assistive action. The choice of the time interval is based on a number of studies of human interactions which have found sensible and interpretable results with 2- to 5-s windows (e.g., Bakeman & Quera, 2011; Goldstein & Schwade, 2008; Tamis-LeMonda, Kuchirko, & Tafuro, 2013).

For each of these sequences, we first created two-dimensional contingency tables. The rows of the contingency tables were labeled with given (or preceding) actions, while the columns were labeled with response (or following) actions, as defined above. Accordingly, in these tables, each cell contained the frequency of the joint occurrence of given and response actions. Then, the observed joint frequencies, expected frequency by chance, and associated *z*-scores computed based on the difference between observed and expected joint frequencies were generated by GSEQ (Figure 2). The expected frequency for a cell in a contingency table is the probability of its response (column) action (p_c in Figure 2, the base rate of the response action) multiplied by the frequency of its given (row) action. The *z*-score reflects the degree to which the observed frequency of each sequence differs from expected frequency by chance. In other words, *z*-score reflects the degree to which one action occurred (or not) as a condition of another action, taking into consideration the base rate of the actions in the sequence (p_c and p_r in Figure 2). In doing so, the *z*-score "controls" for the total number of occurrences for each behavior and allows for the probability values to be reasonably assessed. The *z*-score is positive if the observed is greater than chance and negative if the observed is less than chance. If there is no association between given and response actions, then a *z*-scores would be distributed approximately normally with a mean of 0 and variance equal 1. Overall, a large *z*-score indicates a greater than expected occurrence (relative to chance) of that sequence (Bakeman & Quera, 2011).

To compare the occurrence of sequences with chance, the probabilities of each sequence (i.e., individual *z*-scores obtained for the 24 meals from 12 participants) were used as dependent variables in a random-effects model which treats the participant effects as random variations around a population mean with a single fixed effects of intercept. In this random-effects model, the intercept represents the estimate of mean *z*-score across the population which takes into account the correlation between observations made on the same child. We then tested whether the intercept was statistically different from zero by the analysis of variance using the *R* package *nlme* (Pinheiro & Bates, 2019). If the occurrence of the response action was not related to the occurrence of the preceding action, the mean *z*-score would hover around 0 and therefore not differ from 0. In addition, we computed 95% bootstrap confidence intervals and presented them in the corresponding figures, using the bias-corrected and accelerated (BCa) method (based on 1,000 bootstrap samples) which has been shown to be robust even when the distribution deviates from normality in small samples (Efron & Tibshirani, 1986). We computed the odds ratio of joint occurrence measured in percent time (i.e., rescaled time whose maximum time set to 100) between caregivers' action and toddlers' gaze at caregivers as the ratio between the likelihood that toddlers gazed at the caregiver while the caregiver was engaged in certain actions versus the likelihood that toddlers gazed at the caregiver while the caregiver was no engaged in those actions. In order to compare the difference in likelihood of toddlers' gaze between with and without caregivers' actions, Yule's Q static, an algebraic transformation of odds ratio that varies from −1 to +1 with 0 indicating no effect (Bakeman & Quera, 2011), was computed for each individual meal. Using the random-effects model with participant effects as random effects, we then tested whether the estimated intercept of the model (i.e., the estimated overall mean) was statistically different from zero by an analysis of variance. In all the analyses, if one of the actions which defines the joint occurrence of actions did not occur, we treated the value of the associated index (such as *z*-score or Yule's Q) as missing. For inferential tests the criterion alpha was 0.05.

R number of rows (givens)

C number of columns (responses)

x_{rc} **observed joint frequency** *r*-th row and *c*-th column of a $R \times C$ table

x_{+c} sum of the counts in the *c*-th column

x_{r+} sum of the counts in the *r*-th row

N number of counts total for the $R \times C$ table

p_c probability for the *c*-th column $= x_{+c} \div N$

p_r probability for the *r*-th column $= x_{r+} \div N$

e_{rc} **expected frequency**, by chance $= p_c \times x_{r+}$

z-score (adjusted residual) $= \frac{x_{rc} - e_{rc}}{\sqrt{e_{rc}(1-p_c)(1-p_r)}}$

odds ratio $= \frac{a/b}{c/d} = \frac{ad}{bc}$

Yule's Q $= \frac{ad-bc}{ad+bc}$

Given action:	Action response: Yes	No
Yes	*a*	*b*
No	*c*	*d*

FIGURE 2 Definitions for contingency table indices and statistics (Bakeman & Quera, 2011)

3 | RESULTS

3.1 | Descriptive statistics for toddler and caregiver actions

Descriptive statistics for the toddler and caregiver actions as well as correlations between each action and children's age are presented in Table 1. On average, the children began using a spoon to eat at 17.88 months of age (*SD* = 1.09 months). As mentioned before, this is the mean age of the toddlers at which the data were extracted for the subsequent analysis. In the segments extracted for observation (see *Procedure* for extraction criteria), the toddlers contacted the food with a spoon 30.67% of the time. The mean duration of each occurrence of food contact with a spoon was 5.40 s. Toddlers used the spoon playfully (e.g., hitting the dish with a spoon and mouthing the end of the spoon) 8.37% of the time. Playful spoon use was negatively correlated with age, indicating that playful spoon use occurred less for older children compared to younger children. The mean duration of each occurrence of non-feeding spoon use was 3.08 s. The caregiver acted on the objects on the table (e.g., putting food into the dish and adjusting the position of the dish on the table), 37.5% of the time. The caregivers acted on the toddler's body somewhat less frequently (13.38% of the time). The duration of the caregiver's action on the objects on the table exhibited a significantly positive correlation with toddler's age.

TABLE 1 Means and standard deviations (*SD*) of durations and frequencies of toddler and caregiver behaviors, and their correlations with age

			M (*SD*)	Correlation with age
Onset of self-feeding with a spoon (age in months)			17.88 (1.09) months	—
Toddler's spoon use	Spoon on food	% time	30.67 (9.98)%	n.s.
		duration	5.40 (1.97) sec	n.s.
	Food ingestion	rate/min	2.75 (1.06)/min	n.s.
	Other (playful) use	% time	8.37 (10.18)%	−0.405*
		duration	3.08 (2.97) sec	n.s.
Caregiver's action	On objects	% time	37.50 (9.07)%	0.417**
		duration	6.31 (2.44) sec	n.s.
	On toddler's body	% time	13.38 (8.89)%	−0.440**
		duration	3.98 (2.38) sec	n.s.
	Vocalization	% time	23.87 (24.69)%	n.s.
		duration	1.46 (0.37) sec	n.s.
Toddler's gaze at caregiver	Caregiver's face	% time	3.20 (3.34)%	n.s.
		duration	1.51 (1.02) sec	n.s.
	Caregiver's hand	% time	19.38 (9.16)%	n.s.
		duration	3.39 (1.17) sec	n.s.

*$p = 0.05$,
**$p < 0.05$.

By contrast, the duration the caregiver's action on toddler's body exhibited a negative correlation with toddler's age. Taken together, these two results show that the caregiver acted more on the objects on the table but less on the toddler's body for older children compared to younger children. The caregiver's vocalization varied considerably from meal to meal, but on average occurred 23.87% of the time. The mean duration of each occurrence of caregiver's actions was 6.31 s for actions on objects, 3.98 s for actions on the toddler's body, and 1.46 s for vocalizations. The toddlers looked at the caregiver's face only 3.20% of the time. In contrast, the toddlers looked at the caregiver's hand, and at objects held by the caregiver 19.38% of the time. The percentage of duration where toddler's gaze was directed at the caregivers was not significantly correlated with age.

3.2 | Caregiver–toddler action sequences

To investigate whether the infant's spoon use was influenced by the caregiver's actions, we computed the *z*-scores of the difference between the expected frequency and the observed frequency of infant's spoon-using actions during or within 2 s after the caregiver's assistive actions. Following a caregiver's assistive action, the toddlers were more likely than chance to contact the food with a spoon, and were less likely to play with a spoon (Figure 3). In particular, an analysis of variance with a random-effects model confirmed that toddlers were significantly more likely than chance to contact food with the spoon during or after the caregiver's action on the objects on the table, as shown by the "objects" bar in the left panel of Figure 3, $F_{(1,12)} = 14.83$, $p < 0.01$. Toddlers were marginally less likely than chance to play with the spoon during or after the caregiver action on the toddler's body, as shown by the "body" bar in the right panel of Figure 3, $F_{(1,12)} = 4.10$, $p = 0.07$. The occurrences of other sequences did not differ from chance.

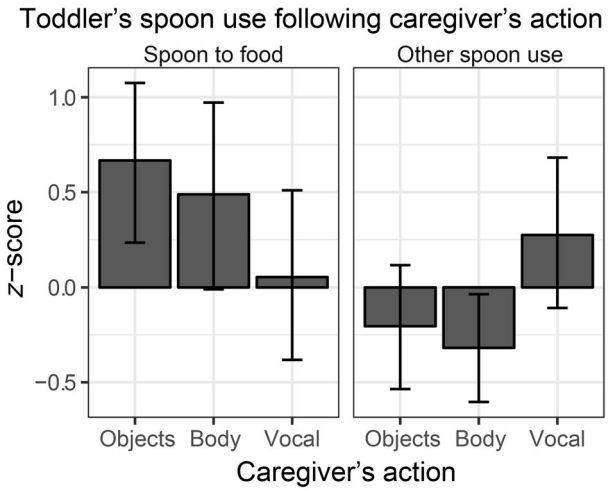

FIGURE 3 Spoon-using action selected by toddlers during or within 2 s after a caregiver's assistive action. Error bars indicate the bootstrapped 95% confidence intervals

3.3 | Toddler's gaze directed at the caregiver

As we mentioned previously, when looking at caregivers the toddler's gaze was heavily skewed toward the hand of the caregiver. We

further looked into what the caregivers were doing when the infants looked at them. When all the data were pooled, the odds of the toddler looking at the hand of the caregiver when the caregiver was acting on the objects on the table was 8.33 times greater than when the caregiver was not acting on the objects on the table (Table 2). When Yule's Q static, which transforms the odds ratio to a normal distribution, was computed for each observed meal and subjected to a random-effects analysis of variance, the toddlers turned out to be significantly more likely to look at caregivers' hand while the caregiver was acting on the objects than while the caregiver was not acting on the objects (Table 2), $F_{(1,12)} = 374.38$, $p < 0.0001$. We also examined what the caregiver was doing when the toddler's gaze was directed at their face. We found that toddlers were 12.11 times more likely to look at the caregiver's face when the caregiver was vocalizing than when the caregiver was not vocalizing (Table 2), whose statistical significance was confirmed by a random-effects analysis of variance on Yule's Q static, computed for each observed clip, $F_{(1,12)} = 11.29$, $p < 0.01$.

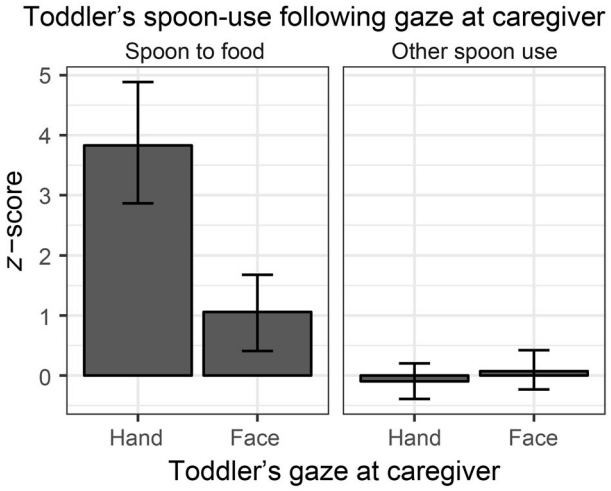

FIGURE 4 Spoon-using action selected by toddlers within 2 s after toddlers directed their gaze at the caregiver. Error bars indicate the bootstrapped 95% confidence intervals

3.4 | Gaze-action sequences in toddlers

We further examined the temporal sequence relating the toddler's gaze and their subsequent action choices. First, we identified points at which the toddler looked at the caregiver. Then, we examined the 2 s periods following these looks. Within 2 s of looking at the caregiver, did the toddler use the spoon for a feeding-related purpose (e.g., to contact the food), or did the toddler use the spoon for a non-feeding purpose? Figure 4 shows the *z*-scores associated with the toddler's use of the spoon up to 2 s after directing their gaze at the caregiver. We found that, after looking at the caregiver's hands, toddlers were more likely than chance to contact food with a spoon, as shown by the "hand" bar in the left panel of Figure 4, $F_{(1,12)} = 34.37$, $p < 0.0001$. When caregivers used their spoon to act on food in either of the dishes, the toddlers were often observed to look at the caregiver's hand that held the spoon, after which the toddler directed their own spoon to the food. Toddlers also were more likely than chance to contact food with a spoon after looking at the face of the caregiver, as shown by the "face" bar in the left panel of Figure 4, $F_{(1,12)} = 10.44$, $p < 0.01$. The occurrences of other sequences did not differ from chance.

In addition to sequences in which actions followed the toddler's gaze, we also examined the reverse, that is, we examined how toddlers own spoon use influenced their subsequent looking choices. We examined toddlers' gaze as a function of the type of preceding action. Because we were interested how actions influenced gaze, in this analysis we considered three types of actions: (a) The toddler's use of their spoon to contact food, (b) the toddler's use of their spoon for ingestion, and Other. As mentioned in the Method section, we operationally defined the offset of "toddler's spoon contact with food" so as not to include food ingestion, so as to distinguish the moment of spoon contact with food in the dish from the moment when the function of ingestion was fulfilled. After executing each of these action types, where did the toddler choose to look? Table 1 shows that, overall, toddlers more often chose to look at the caregiver's hands, rather than looking at their face. By contrast, toddlers made different choices after using their spoon. Up to 2 s after using their spoon to ingest food, toddlers were more likely to look at the caregiver's face, as shown in the "ingestion" bar in the right panel of Figure 5, $F_{(1,12)} = 4.82$, $p < 0.05$. Toddlers were also more likely to look at the caregiver's face within 2 s after having used their spoon for non-feeding purposes, as shown by the "other" bar in the right panel of Figure 5, $F_{(1,12)} = 4.83$, $p < 0.05$. The occurrences of other sequences did not differ from chance. Overall, these results indicate that there were some predictable patterns in the timing with which the toddler directed their gaze toward the caregiver.

TABLE 2 Joint occurrences in percent time (and odds ratios) between caregiver's action and toddler's gaze at caregiver. Data from all 24 meals were pooled

	Toddler's gaze directed at	
Caregiver's action	**Caregiver's hand**	**Caregiver's face**
On objects	14.82 (8.33)	0.53 (0.32)
On body	0.74 (0.21)	0.29 (0.63)
Vocalization	0.65 (0.63)	1.07 (12.11)

4 | DISCUSSION

In an observational study, we examined video recordings of toddlers eating with the help of a caregiver. We focused on meals in which individual toddlers were first learning how to use a spoon, that is, learning affordances of spoons that are relevant to eating. We asked how caregiver–toddler interactions might guide the attention of these novice spoon feeders to spoon-related affordances that were relevant to the mealtime context. Our analysis

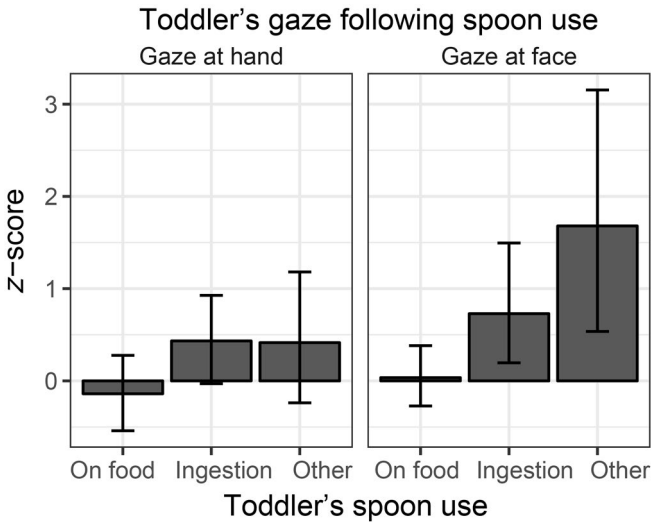

FIGURE 5 How toddlers directed their gaze at caregivers (at their hands vs. at their face) within 2 s after toddlers' spoon-using actions. Error bars indicate the bootstrapped 95% confidence intervals

revealed several related results. First, caregivers often manipulated objects on the table (i.e., food and dishes), and toddlers were more likely (than chance) to use their spoon to contact food immediately after watching these caregiver manipulations. Second, toddlers looked more often at the caregiver's hand (or spoon-in-hand) than at their face. In addition, there were differences in the timing of when toddlers chose to look at the caregiver's hand versus her face. Third, toddlers tended to look at the caregiver's hand when the caregiver was manipulating objects on the table, and after these looks, toddlers were more likely than chance to contact food with their spoon. Finally, the toddlers' choices about when to look at the caregiver were influenced by their own behavior, as if they wanted to know how the caregiver would react to what they had done. More often than chance, toddlers chose to look at the caregiver's face immediately after executing one of two actions; using their spoon to ingest food, or using the spoon in ways that were not related to feeding (i.e., play). We discuss these results in terms of the learning of socially promoted affordances for meal-related spoon use (e.g., Reed, 1996; Veissiere, Constant, Ramstead, Friston, & Kirmayer, 2019).

4.1 | Caregiver–toddler interaction and toddlers' affordance selection

Our results suggest that there was an intricately structured intention-sharing process between novice spoon-feeders and their caregivers. Caregivers manipulated objects on the table more frequently than they physically interacted with the toddlers. The results suggest that caregivers adjusted the layout of objects so as to promote spoon-related affordances that were relevant to the mealtime situation. Such attentive adjustment by caregivers of the action opportunities for novice spoon feeders is consistent with what was reported in mother–toddler interaction in a home setting (Nonaka & Goldfield, 2018). That study reported caregivers used a variety of assistive actions on objects during meals, such as adjusting the toddler's food in such a way to promote its "scoopableness," or steadying the dish so that the dish would not be destabilized by the child's inexpert spoon use (Nonaka & Goldfield, 2018). Our results reveal that caregiver's actions on objects on the table served a dual role—(a) to make available to toddlers food-related affordances of the spoon, and (b) to guide toddlers' attention toward those food-related affordances. The second role was facilitated by the fact (as revealed in our results) that toddlers frequently chose to look at the caregiver's hand. This latter role is consistent with recent studies which have documented a role of manual action in the management of joint attention (Rader & Zukow-Goldring, 2010; Yu & Smith, 2013, 2017). Similarly, Yu and Smith (2017) reported an experimental study in which individual differences in how toddlers attended to objects that they held in their own hands predicted how much time toddlers and their parents spent in joint attention. Our findings add to this literature by revealing that caregivers' manual actions on objects guided toddlers' attention in the specific context of mealtime setting. There appeared to be a reciprocal caregiver–toddler coupling in which the caregiver's manual actions provided guidance about what toddlers should attend to, and in which toddlers respond with their own choices for selective attention, and for actualization of affordances that had been promoted by the caregiver.

4.2 | Differential looking at the caregiver's face and hands

Toddlers were significantly more likely to look at the caregiver's hand (19.38% of observed duration) than at the caregiver's face (3.20% of observed duration). This result is consistent with the previous studies on infant's gaze in different contexts (Deàk, Krasno, Triesch, Lewis, & Sepeta, 2014; Franchak, 2019; Rader & Zukow-Goldring, 2010; Yoshida & Smith, 2008; Yu & Smith, 2017). For example, in real-life locomotor play, 12-month-olds spend only 4% of the time looking at caregivers' faces and 15% of time looking at caregivers' hands and bodies (Franchak, 2019). These findings are similar to the figures obtained from the present observation despite difference between the studies in task and posture. Franchak (2019) also reported that when sitting across from caregivers and playing with toys, 12-month-olds tried to keep both toys and caregivers' faces in view simultaneously, whereas by 24 months, children tended to center toys in view at the expense of caregivers' faces. Franchak's findings are important, but what remains to be known is exactly *when* children look at caregivers' faces or hands during ongoing dynamic interactions with the caregiver. The present result goes beyond those earlier studies by indicating that not only the frequency but also the timing of "face looking" and "hand looking" differed. We first identified times when the toddlers looked at the caregiver's face or hand, and we determined what the caregiver was doing when toddlers chose to look at them. We found that when the caregiver manipulated objects

on the table, toddlers were more likely to choose to look at those manual actions. Separately, we found that toddlers often looked at the caregiver's hand before using their own hands to use their spoon in meal-appropriate ways.

The temporal sequencing of events was different in the period immediately following toddlers' own spoon use. After using their own spoon to ingest food (a meal-related affordance), toddlers were more likely to look at the face (but not the hand) of the caregiver. However, the same was true immediately after toddlers had used the spoon to actualize affordances that were not meal related (i.e., playing with the spoon). It was as if toddlers were monitoring the response of the caregivers to their own spoon-using actions; testing to see whether the caregiver would indicate approval (e.g., for meal-related spoon use), or non-approval (e.g., for playful spoon use).

Taken together, our findings suggest that toddler's choices about how and when to look at the caregiver were systematic. Our interpretation is that toddlers chose to watch how the caregiver used the spoon as an indicator of possibilities for their own spoon use, and that, having selected and tried to actualize specific spoon-related affordances, toddlers sought feedback from the caregiver about the appropriateness of both their performance and their choice of spoon-related affordances (Neisser, 1988, p. 43).

In previous research, caregivers have been shown to respond differentially to different child activities, and the types of caregiver responsiveness followed different developmental trajectories, suggesting that young children played an active role in eliciting caregivers' behaviors that may be increasingly meaningful and relevant to them as their needs change and as they develop more sophisticated competencies (Bell, 1979; Bornstein, Tamis-LeMonda, Hahn, & Haynes, 2008; Lewis & Rosenblum, 1974; Karasik, Tamis-LeMonda, & Adolph, 2014). Because of such high level of specificity in the moment-to-moment exchanges between children and caregivers, it seems quite natural that young spoon feeders have motivations to explore the response caregivers display to different forms of spoon use. The current study is novel in revealing that toddlers selectively looked at the face and hands of the caregiver to obtain particular types of information about their own behavior; about behaviors that they might do (when watching the caregiver use the spoon), and about behaviors that they had done (after the toddler's own spoon use). Naturally, we must be cautious in drawing conclusions from any observational study. In addition, we cannot generalize from the mealtime use of utensils to broader developmental processes, or even to learning about other tools. It is important to point out, however, that many phenomena of skill acquisition have non-obvious causal relations to their typical surroundings (Gottlieb, 1998; Turvey & Sheya, 2017), including typical cultural surroundings (Gibson, 1950; Mauss, 1973; Veissiere et al., 2019), which are so commonplace that they can only be discovered through the careful observation of a natural environment where such development literally *takes place*. The current study has described the normally occurring reciprocal coupling between the actions of caregiver and novice spoon feeders that surround the emerging skill that, we hope, may serve as hypotheses to test in a more rigorous experimental setting in the future.

5 | CONCLUSION

The results of our observational study document the nature of social interaction in the emergence of skills to perform daily routines in a preferred manner in a populated environment, which supplement findings from experimental research.

ACKNOWLEDGMENTS

This research was supported by grants from JSPS KAKENHI Grant Numbers JP18K12013 and JP18KT0079 from the Japan Society for the Promotion of Science, awarded to Tetsushi Nonaka. We are grateful to Kazuko Yoshimoto and the staff at the Yamaboushi Nursery Center for giving us the invaluable opportunity for the observation of lunchtime. We thank Lila Nagai for her help with coding and Minami Matsumura for the drawings of Figure 1. An earlier version of this article was improved by the suggestions of two anonymous reviewers.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy restrictions.

ORCID

Tetsushi Nonaka https://orcid.org/0000-0003-2011-8818

REFERENCES

Adolph, K. E. (2019). An ecological approach to learning in (not and) development. *Human Development*, *63*(3–4), 180–201. https://doi.org/10.1159/000503823

Babik, I., Movva, N., Baraldi Cunha, A., & Lobo, M. A. (2019). Development of self-feeding behavior in children with typical development and those with arm movement impairments. *Developmental Psychobiology*, *61*(8), 1191–1203. https://doi.org/10.1002/dev.21798

Bakeman, R., & Quera, V. (2011). *Sequential analysis and observational methods for the behavioral sciences*. Cambridge, UK: Cambridge University Press.

Bell, R. Q. (1979). Parent, child and reciprocal influences. *American Psychologist*, *34*, 821–826. https://doi.org/10.1037/0003-066X.34.10.821

Bornstein, M. H., Tamis-LeMonda, C. S., Hahn, C. S., & Haynes, O. M. (2008). Maternal responsiveness to young children at three ages: Longitudinal analysis of a multidimensional, modular, and specific parenting construct. *Developmental Psychology*, *44*(3), 867–874. https://doi.org/10.1037/0012-1649.44.3.867

Boyer, I., & Bril, B. (2001). Structuring a child activity: A comparative study of mother-child interaction in a complex bimanual task. In J. van der Kamp, A. Ledebt, G. Savelsbergh, & E. Thelen (Eds.), *Proceedings of the International Conference on Motor Development and Learning in Infancy* (pp. 55–58). Amsterdam, the Netherlands: IFKB.

Chen, C. H., Castellanos, I., Yu, C., & Houston, D. M. (2019). Parental linguistic input and its relation to toddlers' visual attention in joint object play: a comparison between children with normal hearing and children with hearing loss. *Infancy*, *24*(4), 586–611. https://doi.org/10.1111/infa.12291

Connolly, K., & Dalgleish, M. (1989). The emergence of a tool-using skill in infancy. *Developmental Psychology*, *25*, 894–912. https://doi.org/10.1037/0012-1649.25.6.894

Corbetta, D., Williams, J. L., & Haynes, J. M. (2016). Bare fingers, but no obvious influence of "prickly" Velcro! In the absence of parents' encouragement, it is not clear that "sticky mittens" provide an advantage to the process of learning to reach. *Infant Behavior and Development*, *42*, 168–178. https://doi.org/10.1016/j.infbeh.2015.05.001

Deàk, G. O., Krasno, A. M., Triesch, J., Lewis, J., & Sepeta, L. (2014). Watch the hands: Infants can learn to follow gaze by seeing adults manipulate objects. *Developmental Science*, *17*, 270–281. https://doi.org/10.1111/desc.12122

Efron, B., & Tibshirani, R. (1986). Bootstrap methods for standard errors, confidence intervals, and other measures of statistical accuracy. *Statistical Science*, *1*(1), 54–75. https://doi.org/10.1214/ss/1177013815

Franchak, J. M. (2019). Looking with the eyes and head. In J. Wagman & J. Blau (Eds.), *Perception as information detection: Reflections on Gibson's ecological approach to visual perception* (pp. 205–221). New York: Routledge.

Gesell, A., & Ilg, F. L. (1937). *Feeding behavior of infants*. Philadelphia, PA: Lippincott.

Gibson, J. J. (1950). The implications of learning theory for social psychology. In J. G. Miller (Ed.), *Experiments in social process: A symposium on social psychology* (pp. 149–167). New York: McGraw-Hill.

Goldstein, M. H., & Schwade, J. A. (2008). Social feedback to infants' babbling facilitates rapid phonological learning. *Psychological Science*, *19*(5), 515–523. https://doi.org/10.1111/j.1467-9280.2008.02117.x

Gottlieb, G. (1998). Normally occurring environmental and behavioral influences on gene activity: From central dogma to probabilistic epigenesis. *Psychological Review*, *105*(4), 792–802. https://doi.org/10.1037/0033-295X.105.4.792-802

Heras-Escribano, M., & de Pinedo, M. (2016). Are affordances normative? *Phenomenology and Cognitive Sciences*, *15*, 565–589. https://doi.org/10.1007/s11097-015-9440-0

Karasik, L. B., Tamis-LeMonda, C. S., & Adolph, K. E. (2014). Crawling and walking infants elicit different verbal responses from mothers. *Developmental Science*, *17*(3), 388–395. https://doi.org/10.1111/desc.12129

Lewis, M., & Rosenblum, L. (Eds.). (1974). *The origins of behavior: Vol. 1. The effect of the infant on its caregiver*. New York: Wiley.

Mauss, M. (1973). Techniques of the body. *Economy and Society*, *2*, 70–88. https://doi.org/10.1080/03085147300000003 (Original work published 1935 in *Journal de Psychologie Normal et Pathologique*, 32, 271–293).

Neisser, U. (1988). Five kinds of self-knowledge. *Philosophical Psychology*, *1*(1), 35–59. https://doi.org/10.1080/09515088808572924

Nonaka, T., & Goldfield, E. C. (2018). Mother-infant interaction in the emergence of a tool-using skill at mealtime: A process of affordance selection. *Ecological Psychology*, *30*(3), 278–298. https://doi.org/10.1080/10407413.2018.1438199

Pinheiro, J. C., & Bates, D. M. (2019). *nlme: Linear and nonlinear mixed effects models, version 3.1-141*. Retrieved from https://cran.r-project.org/package=nlme

Rader, N. V., & Zukow-Goldring, P. (2010). How the hands control attention during early word learning. *Gesture*, *2*, 202–221. https://doi.org/10.1075/gest.10.2-3.05rad

Reed, E. S. (1993). The intention to use a specific affordance: A conceptual framework for psychology. In R. H. Wozniak & K. W. Fischer (Eds.), *Development in context: Acting and thinking in specific environments* (pp. 45–76). Hillsdale, NJ: Erlbaum.

Reed, E. S. (1996). *Encountering the world: Toward an ecological psychology*. Oxford, UK: Oxford University Press.

Rietveld, E. (2008). Situated normativity: The normative aspect of embodied cognition in unreflective action. *Mind*, *117*(468), 973–1001. https://doi.org/10.1093/mind/fzn050

Tamis-LeMonda, C. S., Kuchirko, Y., & Tafuro, L. (2013). From action to interaction: Infant object exploration and mothers' contingent responsiveness. *IEEE Transactions on Autonomous Mental Development*, *5*(3), 202–209. https://doi.org/10.1109/TAMD.2013.2269905

Turvey, M. T., & Sheya, A. (2017). Non-obvious influences on perception-action abilities. *Psychonomic Bulletin & Review*, *24*(5), 1597–1603. https://doi.org/10.3758/s13423-016-1223-2

Valsiner, J. (1984). Construction of the zone of proximal development in adult-child joint action: The socialization of meals. In B. Rogoff & J. V. Wertsch (Eds.), *Children's learning in the "zones of proximal development"* (pp. 65–76). San Francisco, CA: Jossey-Bass.

Valsiner, J. (1997). *Culture and the development of children's action: A theory of human development*. New York, NY: Wiley.

Veissiere, S. P. L., Constant, A., Ramstead, M. J. D., Friston, K. J., & Kirmayer, L. J. (2019). Thinking through other minds: A variational approach to cognition and culture. *Behavioral and Brain Sciences*, https://doi.org/10.1017/S0140525X19001213

Wagman, J. B., Caputo, S. E., & Stoffregen, T. A. (2016). Hierarchical nesting of affordances in a tool use task. *Journal of Experimental Psychology: Human Perception and Performance*, *42*(10), 1627–1642. https://doi.org/10.1037/xhp0000251

Ye, L., Cardwell, W., & Mark, L. S. (2009). Perceiving multiple affordances for objects. *Ecological Psychology*, *21*, 185–217. https://doi.org/10.1080/10407410903058229

Yoshida, H., & Smith, L. B. (2008). What's in view for toddlers? Using a head camera to study visual experience. *Infancy*, *13*, 229–248. https://doi.org/10.1080/15250000802004437

Yu, C., & Smith, L. B. (2013). Joint attention without gaze following: Human infants and their parents coordinate visual attention to objects through eye-hand coordination. *PLoS ONE*, *8*, e79659. https://doi.org/10.1371/journal.pone.0079659

Yu, C., & Smith, L. B. (2017). Hand-eye coordination predicts joint attention. *Child Development*, *88*(6), 2060–2078. https://doi.org/10.1111/cdev.12730

Zukow-Goldring, P. (1997). A social ecological realist approach to the emergence of the lexicon: Educating attention to a modal invariants in gesture and speech. In C. Dent-Read, & P. Zukow-Goldring (Eds.), *Evolving explanations of development: Ecological approaches to organism-environment systems* (pp. 199–250). Washington, DC: American Psychological Association. https://doi.org/10.1037/10265-006

How to cite this article: Nonaka T, Stoffregen TA. Social interaction in the emergence of toddler's mealtime spoon use. *Developmental Psychobiology*. 2020;00:1–10. https://doi.org/10.1002/dev.21978