

# Creation and Discussion of Design Criteria for Dynamic Tripod Operation Spoon in Toddlers

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## ABSTRACT

Spoons are one of the more delicate tools that toddlers are exposed to at their early stages. As children grow older, their gripping posture and the way they handle it vary. If a fine motor skill such as dynamic tripod operation can be introduced when children are learning to use utensils, it will provide sufficient opportunities for practice and further help develop their ability to manipulate pencils later in life. However, current literature and related products only emphasize the static grip posture with no practical suggestion for the dynamic operation of fingers, making the design inconclusive. Hence, in this study, the spoon was divided into four determinants regarding its structure: spoon tip, spoon neck, spoon handle, and overall factor. The nine design criteria were established by compiling the spoon design factors and proposals for dynamic tripod assistance from the literature. Analytic Hierarchy Process (AHP) and expert interviews were used to analyze the significance of each structure and criterion. According to expert assessment, the degree of importance of the structure was in the order of spoon handle (50.01%), spoon tip (33.71%), overall factor (8.77%), and spoon neck (7.51%), with spoon handle and spoon tip being more important in terms of operation. As for the design factors, handle diameter (41.04%), handle cross section (22.98%), and spoon tip depth (9.87%) were the top three design criteria that were evaluated by the tree structure conversion, providing a scientific basis for industrial designers to develop related products.

**Keywords:** Operating spoons with dynamic tripod, Ergonomic product design, Spoon design criteria

## INTRODUCTION

The development of fine motor skills lies in the sound development of physical fitness, sensory perception of the nervous system, cognition ability, and personality of social-emotion. Particularly, when children enter school age, around 30% to 60% of the fine motor operations have already been acquired (McHale & Cermak, 1992). Related studies shown that fine motor practice can also stimulate the cortical layer of the brain, promote neural development (Chen, J. R., & Wu, F. K., 2012). For this reason, fine motor practice has gradually been emphasized in recent years.

Among the multiple tools for training and learning, the spoons are one of the fine motor tools that toddlers are exposed to in their early years. In 1954,

Gesell, a child psychologist, proposed the maturational theory about the physiological development. With finger differentiation, toddlers gradually grasp with their fingertips, and use upper extremities manipulate more freely. With the improvement of palm-finger coordination, fine motor control gradually shifts from wrist to finger manipulation, proceeds to dynamic tripod grip practice and finally results in learning how to use a spoon to scoop small amounts of liquids in mouth (Kamosita Kenichi, 2020). Many subtle manipulations have been identified in the literature from adult spoon scooping (Yasuda, T et al., 2017). Through these subtle movements, a small amount of food is scooped by interfinger manipulation, thus achieving eating efficiency (Kamosita Kenichi, 2020). In terms of fine control with the dynamic tripod, it was found in the literature that if one can operate the fine tool with lower finger pressure and postural changes, there will be more power for fine adjustment of the tool (Falk, Tam, Schellnus, & Chau, 2011). Thus, the dynamic tripod embodies mainly small operations that require hand force control, coordination, and manipulation skills to make the task more delicate and efficient.

Although lack of dynamic tripod manipulation practice poses no immediate risk, yet it has a profound effect on school-age writing. The inadequate construction of finger muscles and grasp posture makes it easy to hold the pencil in the wrong position during school-age learning, leading to skimming and diagonal writing as well as myopia (Prunty, M et al., 2013) The literature has also found that practicing a dynamic tripod grasp along with flexible use of the knuckles before penmanship can reduce the occurrence of compensatory problems such as incorrect posture and excessive force (Benbow, 2006). However, scarce literature mentioning what is involved from “static tripod grip” to “dynamic tripod manipulation”, which reflects in insufficient strategies for decisionmaking when it comes to developing dynamic tripod learning tools. Hence, in this study, we compiled the key design factors by means of literature analysis, followed by studying the dynamic tripod operation and suggestions to construct the key design criteria. Then, the weights of each determinant and design factor were established through AHP and expert interviews. This study is expected to present the following three factors that affect how toddlers learn to use spoons: (1) the ranking of the structural of spoon, (2) the data about the design criteria of dynamic tripod, (3) the notes about dynamic tripod.

## **DISCUSSION AND SUGGESTIONS ON DESIGN CRITERIA**

When it comes to how the design type makes an impact on operation efficiency, scooping stability, there have been many papers that provide corresponding auxiliary types and discussions on the use of dynamic tripod operation tools. Therefore, with a view to constructing guidelines for spoon design, this study focused on two parts, namely, “spoon design form” and “dynamic tripod learning and auxiliary suggestions.

### **Literature Analysis on Spoon Design Form**

According to the structural analysis on the spoon tip, the shape of the spoon tip that resembles that of the utensil will increase the efficiency of the task

**Table 1.** Causes and effects of spoon operation (compiled by this study).

Structure	Design Criteria	Independent Variables (Cause)	Dependent Variables (Effect)	Literature
Spoon tip	Spoon tip shape	Spoon tip shape	Efficiency of task	Abe, S et al., 2013
	Spoon tip depth	Flat/deep spoon tip	Efficiency of task	M. E. Groher & M. A. Crary, 2016
Spoon neck	neck angle	Bending angle of spoon neck	Efficiency of task	van Roon et al., 2003
Spoon handle	Handle diameter	Size of handle diameter	Efficiency of task Finger pressure	Leiras et al., 2014
Overall factors	Spoon weight	counterweights for spoon handle	Efficiency of task	Li, T et al., 2019
	Spoon length	Spoon size	Efficiency of task	Liu, B. S et al., 2008

(Abe, S et al., 2013). The flattened spoon tip allows the spoon to enter the mouth easily for children with poor lip closure to put food in their mouths (M. E. Groher & M. A. Crary, 2016). Based on the structural analysis on the spoon neck, bending the spoon towards the user can properly assist cerebral palsy patients in scooping food into the mouth (van Roon, D et al., 2003). While analyzing the structure of the spoon handle, adults prefer the smaller 15 mm diameter spoon to 25 and 40 mm on account of the operation task of scooping and placement of the finger. It is more comfortable in terms of finger pressure as well as subjective evaluation (Claudia Leiras et al., 2014). According to the overall analysis, the length of the spoon should be increased by 30 mm to facilitate support and handling (Liu, B. S et al., 2008) In terms of weight, studies have indicated that the weight of the product affects the position of the spoon grasped (Li, T et al., 2019).

Based on the results of the above literature analysis, six design criteria (Table 1) were summarized, namely, spoon tip shape, spoon tip depth, spoon neck angle, handle diameter, spoon weight, and spoon length.

### Operation Learning and Proposals for Dynamic Tripod

Based on literature analysis, we found that in addition to the scooping action, there are many subtle manipulations involving in the process of scooping (Yasuda, T et al., 2017) Fine tuning is the main function of the mature dynamic tripod, which can be used to scoop small amounts of food with fingertips to improve eating efficiency (Kamosita Kenichi, 2020). The literature on pencil grasp learning suggests that excessive restrictive aids are discarded during the gradual transition from static to dynamic operation. The literature also suggests that cross-sectional shape affects operational efficiency (Goonetilleke, R et al., 2009). Other related literature also mentions that the exterior material also affect the operation of users (McCoy, 1984).

In this study, we found that the three design criteria, namely, handle cross section, assisted operation and product material, will affect the dynamic tripod operation. The design criteria of each structure are summarized in the following (Table 2).

**Table 2.** Establishment of nine design criteria for dynamic tripod learning tasks.

Items to Explore	Spoon Design Form	Dynamic Tripod Operation Learning
Spoon tip	(1) Spoon tip shape (2) Spoon tip depth	-
Spoon neck	(3) Spoon neck angle	-
Spoon handle	(4) Handle diameter	(7) Handle cross section (8) Auxiliary operation
Overall factors	(5) Spoon weight (6) Spoon length	(9) Product material

**Table 3.** Basic information on expert interviews (compiled by this study).

Expert No.	Job Title	Seniority	Expertise
Expert(A)	Pediatric occupational therapists	13 (Y)	Children's attention / emotion
Expert(B)	Pediatric occupational therapists	21 (Y)	Child development
Expert(C)	Pediatric occupational therapists	5 (Y)	Child development

In this study, nine design criteria for the dynamic tripod spoon for children were summarized with references to (Table 2). The above design criteria will be analyzed by AHP to determine the more important design criteria.

## CREATION OF DESIGN CRITERIA FOR TODDLER

Three early pediatric occupational therapists with more than five years experience were invited to join this study between February and April 2022. A brief introduction of their expertise is shown in (Table 3). The methodology of this study was divided into two parts: (1) AHP and (2) Expert interviews.

## RESULTS

### Percentage of Weight and Ranking in Learning to Manipulate Spoons for Toddler

This study was conducted in two parts. To begin with, the structure of the spoon was divided into spoon tip, spoon neck, spoon handle, and the overall factors, while the importance of each structure was investigated as shown in (Table 4). Then, the design criteria for each structure were evaluated and the degree of importance of the structure and design factors were calculated by AHP, as shown in (Table 5).

In this study, the weight values of each structure were presented as percentages in hierarchy 2. Based on (Table 4). The importance of spoon structure on the operation was ranked in the order of spoon handle (50.01%), spoon tip (33.71%), overall factors (8.77%), and spoon neck (7.51%), with spoon handle topping the list. Among the child occupational therapists, Expert B concluded that when operating a spoon with a dynamic tripod, the spoon tip plays an important role as it acts as a medium of contact between food and

**Table 4.** Weights and rankings of the spoon structure for toddler's operating spoon.

Component	Hierarchy 2 Weight Assigned by the Experts							
	Expert A		Expert B		Expert C		Total Weight	
	Weight	Rank	Weight	Rank	Weight	Rank	Weight	Rank
(1) Spoon tip	20.45%	2	56.09%	1	24.31%	2	33.71%	2
(2) Spoon neck	4.56%	4	7.36%	4	9.19%	3	7.51%	4
(3) Spoon handle	65.45%	1	22.08%	2	62.96%	1	50.01%	1
(4) Overall factors	9.55%	3	14.48%	3	3.55%	4	8.77%	3

the mouth. Experts A and C believed that the spoon handle offers direct contact of the dynamic tripod which is of higher importance. Thus, we suggest that these two structures should be prioritized when designing a spoon.

To compare the importance of design factors successively, nine design criteria were established at hierarchy 3 through literature integration. Then, the weight of the design factors in each hierarchy of the structure was converted through tree structure analysis. (Table 5) shows that handle diameter (41.04%), handle cross section (22.98%), and spoon tip depth (9.87%) are the top three design factors that should be evaluated first when designing a spoon for children, who are supposed to learn how to manipulate it with dynamic tripod.

### **Suggestions for Spoon Design Criteria for Dynamic Tripod Operation in Toddlers**

In the semi-structural expert interviews, the experts provided specific recommendations and supplements for each criterion. The key points of the interviews and the data from the literature were summarized in (Table 6).

The above table shows that the three experts have different suggestions on "product length" design form. For the short-handled spoons, Expert A thought that they could help, while Experts B and C believed that the short-handled spoons were not recommended because of their special shape, which made it difficult to connect with ordinary spoons. Regarding the three design forms of handle diameter, handle cross section, and spoon tip shape, the experts made multiple specific design suggestions from the perspective of helping toddlers learn how to operate a spoon with dynamic tripod. However, these suggestions are mostly based on empirical judgment with no experimental scientific verification and hereby need to be further explored.

### **CONCLUSION**

In summary, this study draws the following four conclusions from the results of the Analytic Hierarchy Process (AHP), and suggestions from the expert interviews are as follows:

- (1) After being evaluated by three experts followed by conducting AHP on spoon structure concerning how toddlers operate with dynamic tripod,

**Table 5.** Weights and rankings of design criteria for toddler's operating spoon.

Design Criterion	Hierarchy 2			Hierarchy 3			Overall		
	Total Weight	Design Criterion	ExpertA	ExpertB	ExpertC	Total Weight	Rank	Total Weight	Rank
Spoon tip	33.71%	Shape	75%	25%	25%	40.95%	2	9.87%	3
Spoon neck	7.51%	Depth	25%	75%	75%	59.05%	1	9.19%	5
Spoon handle	50.01%	Neck angle	100%	100%	100%	100%	1	1.54%	8
		Diameter	20%	64%	75%	52.37%	1	41.04%	1
Over all factors	8.77%	Cross section	60%	26%	18%	34.60%	2	22.98%	2
		Guiding assistance	20%	10%	7%	13.03%	3	9.35%	4
		Weight	26%	43%	83%	52.83%	1	2.70%	6
		Length	24%	43%	15%	40.55%	2	2.42%	7
		Material	10%	14%	1%	6.62%	3	0.91%	9

**Table 6.** Suggestions for the design of the spoon operation with dynamic tripod.

Design Criteria	Suggestions From Literature and Experts	Supplements by Experts
Tip shape	Partial round, circular smooth (all)	(a) Conforms to mouth shape (A) (b) Special shapes not recommended (all)
Tip depth	Shallow is better (all)	(a) Steady gathering and loading (C)
Neck angle	Angularity is required in Z-axis direction (C)	(a) Do not level with the spoon handle (C)
Diameter	(a) Suggest enlargement and thickening (C)	(a) Size reduction by ability (all) (b) Refer to palm space (A, C)
Cross section	(a) Fit the shape of the hand (all) (b) Expanded contact with the plane (all) (c) Increase the grasp position guide (all)	(a) Size from large to small can support the palm space
Guiding assistance	(a) Ring shape is not recommended (all) (b) Large cross-section and groove auxiliary are recommended (B, C) (c) Referral egg-shaped/oval (C)	(a) Boosting motive in the form of toys (B) (b) Different sizes of concave guides (C) (c) Don't to be restricted (all)
Weight	(a) Weight influence on grasp position (literature) (b) Additional gravity at the operator's end (B)	-
Length	(a) 3-5cm convex grasp (B) (b) the handle length should be increased by 30 mm (literature)	(a) Short handle can assist (A) (b) Not easy to use spoons with short handles (B, C)
Material	(a) Try to augment the tactile feedback aid (B)	-

the components of spoon products were, in order of importance, spoon handle (50.01%), spoon surface (33.71%), overall factors (8.77%), and spoon neck (7.51%).

- (2) The conversion weights of spoon structure (hierarchy 2) and design criteria (hierarchy 3) showed that handle diameter (41.04%), handle cross section (22.98%), and spoon tip depth (9.87%) were the top three design factors to be assessed when designing a spoon for children to learn dynamic tripod operation.
- (3) The experts agreed that , oval and shallow depth spoon top is preferred. As for the spoon handle, a larger and thicker one is recommended, with flat and grooved elements added so as to guide the grasping position appropriately. However, in terms of assistance, it is necessary to consider that the operation of toddlers is not restricted, so it is not recommended to use restrictive assistance.
- (4) The experts made different suggestions about the “product length” in the design form. Expert A believed that a short handle can effectively assist the operation of dynamic tripod, while experts B and C thought that the short handle is a special model, that will easily lead to spherical grasp.

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