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13. Tutoring Adjustment And Infants' Cognitive Gain

Sylvia SASTRE-RIBA

Abstract. Within the neuroconstructivist approach to cognitive development, tutoring is considered as a complex and essential form of human interaction in an educational context. Types, dynamics, and effects of tutoring (infant–infant and adult–infant) are heterogeneous and potentially have various effects on cognitive development. The identification of such interactive patterns among the participants and their successive regulations is essential to understand tutoring phenomenon. Investigating these tutoring types, dynamics and effects requires the observation of otherwise hidden patterns of tutoring in real time from ecologically valid situations involving a range of participants. The application of THEME program for the study of tutoring yielded these most relevant results: (1) the identification of various types of tutoring; (2) the importance of a tutor's adjustment to the tutored activity and the infant's competence; and (3) the possible effects of interference, and the determination of a tutor's optimal response to it.

Keywords: Tutoring; cognitive development; interaction; adjustment; executive functions.

Contents

13.1 Introduction

13.1.1 Cognitive development understanding

Cognitive development understanding requires an interdisciplinary and neuropsychological investigation of the continuous interaction among genes, neuropsychological substructure, and social context [1, 2]. From this perspective, cognitive development is interpreted as a continuous and differential transformation of cognitive competencies during which a human mind emerges from a developing brain as Quartz and Sejnowski reported [3]. Individual action and interpersonal interaction are essential components of this transformational process because they favour the progressive action organization as well as their cognitive consequences, demonstrate the emergent mechanisms and facilitate inferencing the intellectual structure. In sum, cognitive development would be a continuous redescription [4] of structures and cognitive functions during human life span, in which the subject has an active role. In this process, cognitive capacities are constructed and reconstructed step-by-step. Our interest focuses not only on the human intellectual capacity but also on its functioning, control and different manifestations.

Cognitive functioning is facilitated to a large extent by executive functions that coordinate various processes to achieve goals, flexibility [5] and the regulation of cognition [6], what is referred to as "executive control". Executive functions enable problem solving, creativity, and information processing. Concretely, such functions favour: 1) action as result of decision-making (intentionality), and 2) the selection and maintenance of information in the mind (representation), and 3) logical organization, decision-making, and planning [7]. Executive functions change with age, have differential expressions depending on types of development, may explain important aspects of typical and atypical development, and are crucial for successful social and academic performance.

Actual research on differential cognitive development focuses on the analysis of the microgenetic functioning of executive functions [8], in particular, inhibition, activation, planning, and shifting mechanisms. Cognitive development is no longer conceived as the activation of structural units - as Piaget postulated [9] - but is viewed as dependent on the inhibition of one structure or non-pertinent competence, the resistance to interference and the efficiency of activation.

The first years of life are essential in this redescriptional change because of their important role in the developmental process; in particular, occur concrete changes in the structure and functioning of the frontal lobe, changes in the prefrontal cortex related to myelinizaton, dendritic and cellular growth, new synaptical connections, and the activation of neurochemical systems [11-13]. These structural and functional brain's changes are associated with relevant gains in infant's first cognitive competencies and executive functions [7, 13 and 14], and in the organization of logical action and knowledge [15-17].

It is not only *nature* that produces developing minds; also social interaction pass beyond and modulate the neurobiological functioning, cognitive development is not only individual neither social, but both in a closed interrelation [18]. We postulate a tripolar subject–object–subject framework in which interpersonal interaction occurs in relation to a common object [18-20]. The flow of information in such interactions is not unidirectional, i.e., from the more competent (adult) participant to the less competent (child) as Vygotskian perspectives postulated, but bidirectional and dynamic, with continuous feedback among participants (e.g., child–child, child–adult). The patterns of information flow determine the modality of such processes, while the characteristics of the participants (e.g., their age and cognitive competence) and the form of their exchanges produce various modalities of interaction, as imitation or co-construction [18].

Tutoring is a modality that has particular relevance to the early years of human life [20]. Tutoring implies the existence of different competencies among participants (e.g., expert versus non-expert) and different roles [18] during interaction. Furthermore, as previous research has shown [21-23], tutoring varies according to: 1) the "action project" management (an infant's or an adult's action management), 2) an adult's adjustment to child competency and activity, 3) the focalization of an adult's proposal on the action results or process, and, 4) the proactive (during) or retroactive (after a result) maintenance by an adult of an infant's activity.

These types of tutoring, ordered from the adult management of activity (more adult guidance) to the infant's management of activity (lower adult's management), and from the more to less adult's adjustment are identified and defined through pattern extraction using the THEME program [24] as the following types: directive, integrative, maintenance, and laissez-faire (more information in [20, 21]). Because all of these tutoring types could be differentially related to cognitive gain and close cognitive progress [21, 22], the knowledge of an infant's action logical organization related to the impact of the tutoring types is important, as well as the role of inhibition (as an infant's "interference resistance") in front of some discordant information obtained (intrapersonal) or non-pertinent schemes of action, or in front of a non-adjusted adult proposal (interpersonal).

The manifestation of an infant's differential inhibition to an adult's proposals—adjusted or non-adjusted—would allow us to infer the infant's capacity to resist the interference as a result of the differentiated, selective, and effective inhibition. The manifestation of undifferentiated inhibition demonstrates the existence of "non-resistance to interference"; all of these factors demonstrate the efficacy or lack of efficacy in the infant's early executive functioning. There is little scientific evidence of what happens regarding alternative developmental courses. Some courses could be determined by functional brain differences, e.g., intra-uterine metabolopaties or nutritional problems, or by other functional and structural differences, e.g., resulting from Down Syndrome [25, 26]. In all cases, data related with these functional or structural matters improve our knowledge.

Our research is thus focused on infants' capacity to capture and benefit from the information obtained through their logical activity in relation to objects, and the information proposed by an adult. The comprehension of this question centers on understanding "how does the infant do" and "what does the infant do" in an interactive context during the first years of life. The research focuses on the action logical organization, the action content and on the own executive functions of the individual and the interference or facilitation provided by the adult's proposals (between individuals). Research must be applied to alternative developmental courses during the first three years of life, to identify differences in action logical organization [27, 28], executive functioning, and the effects of types of tutoring on those factors [22]. Our hypothesis was that different courses of development are associated with brain structural differences and differential models of efficacy in the previous-mentioned functions. A methodology adjusted to research objectives and data characteristics was necessary.

13.1.2 What a differential study of cognitive development can investigate

The subject of "knowing" is complex and multifaceted. It is commonly assumed to encompass hidden structures in individual and interpersonal functioning during early childhood cognitive development. From our point of view, it involves the following matters:

1. *An infant's activity on objects.* According to Langer [29], to act is to know, but acting is not sufficient for knowing, because acting must be intentional and logically

organized to obtain cognitive products. Furthermore, simple actions are embedded in more complex actions, in which goal achivement requires other steps that depend on higher-order factors [30]. We must know, step-by-step, the content of the infant's intentional activity, its action project and the flow of actions, results and their consequences on the activity redescription, as well as the role of executive functions in achieving such results (concretely: inhibition and activation regarding their correlates on control and planning, flexibility or perseveration). As Langer [29, 31] and Pastor & Sastre [27] reported, the logical classification of operations and functions will be used to operationalize the content of action.

2. *Executive functions.* Action planning and control are determined by the differential application of executive functions. The most relevant functions with respect to cognitive control, planning, and flexibility are inhibition and efficient activation (or shifting). Inhibition is related to control and planning that: (a) stops the execution of a dominant action or the processing of irrelevant information, (b) selects representations and pertinent actions in an action procedure, and (c) favours consequent shifting or efficient activation after a stop-signal. In summary, inhibition allows the emergence of a new or modulative (shifting) scheme and resistance to interference, and is thus associated with mental flexibility. Shifting is the result of efficient inhibition and activation. It appears after the stopping of one potential interference of irrelevant information (or action), and is accompanied by a pertinent activation. The unsuitable manifestation of shifting is associated with perseveration. Perseveration appears when efficient inhibition is lacking but the activation of a dominant action is continued repetitively and without modification [32]. Then, it is also associated with non-appropriate cognitive functioning. All of these executive functions must be studied with reference to an infant's ability to resist interference (non-pertinent information) and goal maintenance (action project).

3. *Interaction.* Because infants do not act alone, it is necessary to investigate the interactive context during the flow of task activity. According to Haan & Johnson [1], genetic factors and *interactions* with external factors contribute to the developmental process, even when an infant is still in the protective environment of the womb. Table 13.1 shows the components of an interactive situation that we studied from a tripolar perspective, in which we postulated the bi-directionality of interaction, the active and regulating role of the infant, and the importance of object determinants.

Consequently, we studied the following issues. First, we aimed at determining which types of tutoring are optimal in cognitive management, what do an infant and adult do during interactive activity, and which are the possible modulating parameters of tutoring. We had studied these parameters in previous research that identified tutoring types [21, 33] through the patterns detected by the THEME program [34]. The present study aimed at corroborating these findings in relation to executive functions and different participants. Tutoring types were identified using relevant parameters extracted from previously studied categories [20] related to:

- *Action project*: This was defined as the action goal maintenance that generates, organizes, and maintains activity, and attributes its meaning. This tutoring type can emerge from an infant, an adult, or both. The subcategories were the type, content, signification, and attention characteristics of an infant's activity.
- *Activity management*: This concerned the determination of which participant is the agent of activity (infant or adult) to understand the beginning and management of projects and actions realized.

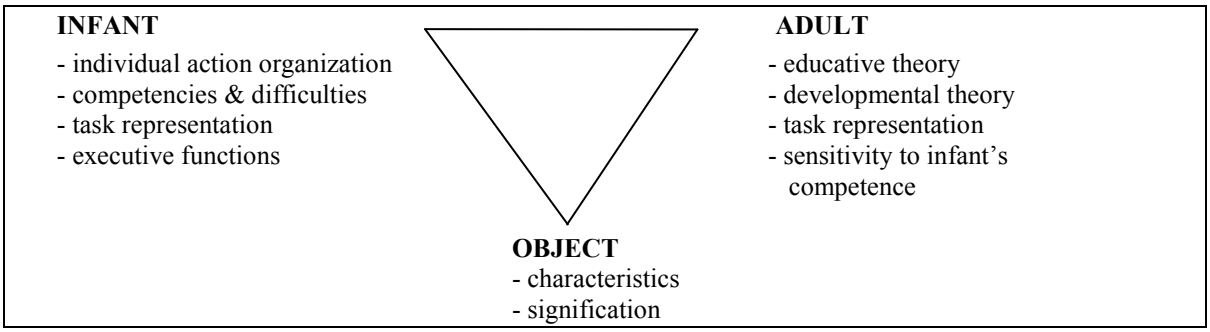

Table 13.1 Components of the interactive activity

- *The adult's focus*: It consisted of determining whether an adult focused on the result of an infant's activity or on the process of obtaining it.
- *Maintenance*: This concerned whether an adult's proposals accompanied the process or the result of an infant's action. The subcategories were proactive (during activity) and retroactive (ending activity).
- *Adjustment*: This involved the proximity between an adult proposal and an infant's action project and/or his/her competence. Intersubjectivity and common representation of task was needed. The subcategory was adult information.

Second, the discovering of immediate infant gains during the interactive relationship related on the tutoring modalities is detected. These gains are referred to the micro-categories of "knowing result". Third, the understanding of infant's ability to resist the interference produced by lack of adjustment of the adult proposals, related to the types of tutoring. It is contained on the "type of activity" and "inhibition/activation" components [35].

All of these components and conditionings were necessary to the research goal; they were collected by the components of the mixed system analysis of field formats, as explained in the procedure paragraph. The understanding of the behavioural mechanisms of human activity; their content and effects, are not always evident and easily perceived. Furthermore, interaction relationships are subject to problem analyses concerning temporal organization (verbal or nonverbal, intra- or inter-individual). In this respect, time is central to the behavioural organization determining the methodology to apply.

13.1.3 Methodology decision

According to the previous concepts, methodology must allow to capture reality through the continuum in which is produced and its meaning. Methodology must allow to structure reality according to their behavioural units and it must allow the reality's simplification in order to interpret it. The methodology was designed to measure the elements set out in Table 13.2.

Consequently, the methodology consisted of the following points:

1) To infer intra- and inter-individual processes conferring psychological meaning: (a) the systematic observational methodology [36] for the reliable capture of reality in their continuum, extracting and codifying behavioural units and their sequential components; (b) the micro-genetic analysis of the reality content. This analysis was: (i) functional, extracting content and showing its emergence and sequential organization; (ii) intensive, i.e., based on a large number of reality observations; and (iii) sequentially realized.

2) To objectify the micro-genetic inferences, respecting the flow of real activity and its organization, the THEME program analysis [24, 34] permits the discovering of hidden structures and intra- and inter-individual patterns of functioning and their components. It also permits to identify the transition between events and patterns.

-The flow of action and its organization	-The adult proposals' adjustment
-Number of participants	-The nature of exchanges
-The characteristics of each participant	-The cognitive prerequisites
-The role of each participant	-Motivational aspects
-The types of tutoring used	-The dynamics of interaction
-The differential effects of tutoring	

Table 13.2 Reality elements to capture

13.2 The application of THEME program analysis to the study of tutoring and cognitive development

13.2.1 Participants

We studied 24 infants with alternative courses of development: 15 typical infants and 9 Down Syndrome infants, at the age of 1–3 years old (typical) or a developmental level equivalent to 1–3 years old (Down Syndrome). All infants were drawn from the Neonatology Service of the Saint Millan's Hospital at Logroño. Their initial cognitive developmental level was tested and found to be equivalent to 1–3-years-old [37].

13.2.2 Material

The material presented to the infants is designed to study the variation-selection mechanisms (activation–inhibition–shifting). It consisted of a task oriented to nonverbal behaviour to allow infants to execute proto-substitution and proto-addition logical operations (Figure 13.1).

Figure 13.1 Material

13.2.3 Procedure

Infants' spontaneous activity was videotaped longitudinally for a 10-minute period. The infant sat in front of the material and beside a familiar adult who acted according to the instruction: "act only if the infant's action stops, in which case offer a motivating proposal". Data analysis was designed to detect the content and logical organization of the infants' actions, and the associated executive functions and interactive dynamics. Three levels of analysis are proposed, from the less to the more reality-abstracted, ending with statistical analysis on the third level.

1) First-level analysis: Reality description. It included: (a) The reality depiction, step by step, exhaustively and consistently [38] recorded on specific sheets, elaborated ad-hoc for the extraction of successive behavioural units and their content; (b) The mixed analysis system (field formats) for reality coding. This system was essential for the analysis, and included the relevant content-components extracted from the theoretical background and experimentally applied to reality: the infant's activity, logical content, executive functions,

and adult proposals and their adjustment. Table 13.3 shows the major components; (c) The inter- and intra-observer data quality control [38]. If the inter- and intra-observer concordance indices were satisfactory, we proceeded to the depiction and coding of all empirical data from the participants.

The product of this level of analysis was the generation of reality-depiction sheets, including the record of the acting content and the succession of actions.

	Macro-components	Micro-components	Codes
		infant	ch
	activity management	adult	ad
		both	com
Infant activity	type of activity	repetitive	re
		modified	mopa
	inhibition/activation	shifting	sh
		….	…
	action content	continent/content function	fcc
		…	
	knowing result	result	re
		…	…
	communicative demand	show result	mr
		…	…
Adult intervention	proposal	object	porel
		…….	
	adult information	related	infvarel
	(adjustment)	non-related	infvanrel
		…	…
	focus on	process	ca
		result	

Table 13.3 Some components of the mixed system analysis (adapted from [39])

2) Second-level analysis: Reality codification and first inferences. This level consisted of the extraction and codification of behavioural units (Type III data—sequential and time-based). Reliability was calculated by intra- and inter-observer concordance [37]. In this way, we proceeded to the micro-genetic extraction of action projects: their start and end, chaining and meaning organization, logical content, and adult proposals. Activity sequences were established according to the stability of the action projects that were developed (by infant or by adult). The product consisted of detailed tables showing the organization of intra- and inter-group activity and participants' management of such activity [38]. This was an important approach to the psychological meaning of activity, which must be objectified and integrated.

3) Third-level analysis: Hidden pattern extraction (THEME program) and corroboration of micro-genetical interpretation. Digitalised image of reality is coded in real time applying the mixed analysis system constructed on the first level analysis and now introduced into the *.vvt folder* (THEME coder) . Then, we proceed to pattern extraction ($\alpha = .01$). Figure 13.2 shows one frame of the THEME coder.

After pattern extraction, we statistically analysed the components according to the research objectives, particularly oriented towards identifying whether there were significant differences between the groups (i.e., typical versus Down Syndrome infants).

The results consisted of hidden structures of functioning, including patterns of the tutoring types, adjustment, and infants' interference resistance to adult proposals.

Figure 13.2 THEME coding frame

13.2.4 Results

Only the results of the third level analysis derived from the THEME program are presented; the results are grouped into the three issues studied: (a) tutoring types, (b) logical content, and (c) resistance to interference [38]. This extraction was started by the generation of a coefficient of concordance, with α= 80% as the acceptable threshold.

13.2.4.1 Tutoring types

Previously established tutoring types [21] were supported. Patterns obtained were constituted by the same categorical elements, with a frequency of regularity of almost the 85%. Table 13.4 shows the types of tutoring extracted according to the parameters described. Figure 13.3 shows one of the representative patterns obtained.

A brief description of each tutoring type is now given, from less to more adult-oriented management of activity.

i. *Directive tutoring* was defined because the adult's managed activity. Infants followed adult proposals, incorporating these proposals into their own activity. Adult proposals were not adjusted to infants' actions, but to their own activity.

ii. *Integrative tutoring* was evidenced when adults managed an activity facilitating the infants participation in the adult' action project. Adult proposals were adjusted to the infants' level of competence, but did not favour infants' initiatives.

iii. *Maintenance tutoring* was evidenced by patterns composed of behaviors concerning infants' management activity, with adults' proposals adjusted to infants' action projects and competence. Adults offer new information that helps infants to excel their own initiative.

iv. *Laissez-faire tutoring*. This assumed that there was no adult intervention while infants were acting on objects; therefore there were no proposals or expressions of maintenance. Activity management was thus entirely infants' responsibility.

Action project	Focus on	Maintenance	Adjustment	Tutoring type
adult	result process	proactive retroactive	no	directive
adult to child	result process	proactive retroactive	yes	integrative
child	result	proactive retroactive	yes	maintenance
child	no result no process	no proactive no retroactive	no	laissez-faire

Table 13.4 Types of tutoring

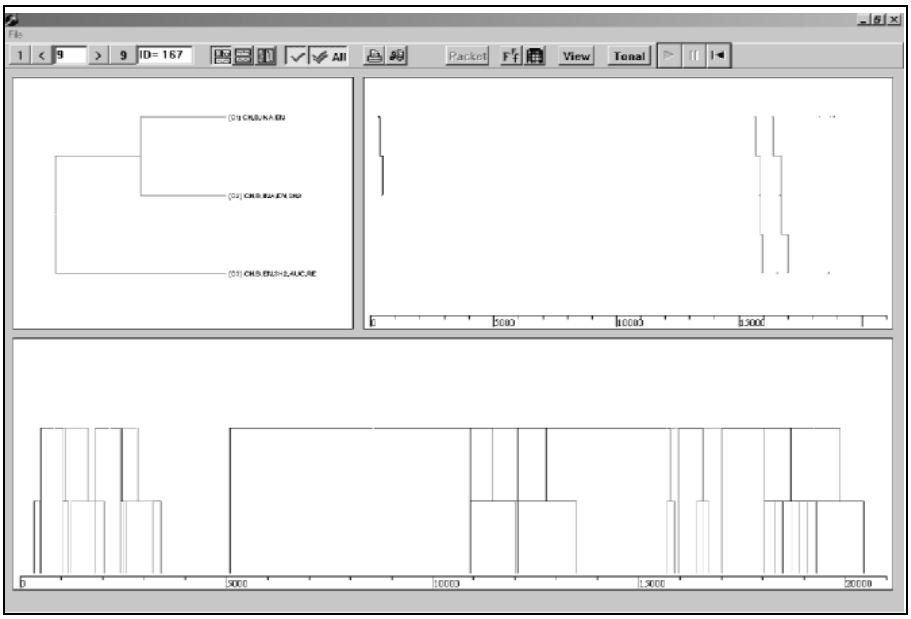

Figure 13.3 Example of a THEME pattern and their participation on the flow of activity

Among the Down Syndrome babies, the more frequently occurring tutorial type was directive tutoring; among the typical babies, the more frequent type was maintenance tutoring. This suggests that infants' development may depend in part on the extent to which adult proposals assist them.

13.2.4.2 Immediate gain in action

To determine the relationship between tutoring type and infant development, we have summed all the codes referred to as "gain", constituting the patterns obtained and corresponding to each kind of tutoring. The results are set out in Table 13.5.

Tutoring type	Cognitive gain
Maintenance	n= 28
Integrative	n= 16
Directive	n= 2
Laissez-faire	n= 0

Table 13.5 Gain and non-gain frequencies

The ground with higher gain was produced with "maintenance tutoring", i.e., adult proposals are related to the infant and accompanied by proactive and retroactive adult's maintenance during infant activity. On the other hand, directive tutoring showed some gains as the result of the copy of non-adjusted adult proposals, but not as the product of infants' initiative and elaboration.

We also represent, the emergence of executive functions on infants' activity to determine their effect on cognitive control and flexibility. As Table 13.6 shows, there are significant differences between the groups with respect to the levels of shifting, i.e., efficient inhibition and activation on typical babies, and perseveration, i.e., inefficient inhibition among the Down Syndrome infants. This result suggests that adults' adjusted proposals play a significant role in the favouring of cognitive development and in stimulating flexibility rather than perseveration.

Efficient inhibition/activation	**Typical/Down Syndrome infants**
Shifting	$p = .032$
Perseveration	$p = .050$

Table 13.6. Inter-group differences in efficient inhibition/activation ($\alpha = .05$).

13.2.4.3 Infants' resistance to interference

Resistance to the interference produced by adult's non-adjusted information was extracted from the data; the resulting significant differences are set out in Table 13.7. The data show more adult's non-adjusted proposals and less resistance to interference among Down Syndrome babies. This is an important finding for educators who wish to minimize the effects of their non-adjusted proposals, they have to be particularly sensitive to alternative courses of development because they may increase the potential for adult intervention, if not adjusted, to add to the structural and functional difficulties of Down Syndrome infants from the early stages of their development.

	Tutoring types			
Infants	Adjustment	Non adjustment	Interf. resistance	Goal maintenance
Typical infants	$p = .001$	---	$p = .003$	Yes
Down Syndrome infants	---	$p = .002$	---	No

Table 13.7. Significant inter-group differences in adjustment and resistance to interference ($\alpha = 0.5$)

13.3 Conclusions

The THEME program has produced significant evidence of the types and dynamics of tutoring, and of the organization, content, and associated executive functions of action sequences. It has shown the importance of the adjustment of adult proposals to infants' action project and competencies in the task of optimising their cognitive development.

We have identified various types of tutoring associated with both adult and infant management of activity. Infant management appears to be enhanced with maintenance tutoring, which is in correspondence with a greater level of cognitive improvement. A reduced level of infant's gains accompanies adult management activity - directive tutoring.

These types of tutoring are also characterized by the level of adult proposal adjustment to an infant; the more adjusted proposals are likely to be associated with maintenance tutoring and the less adjusted proposals with the directive or laissez-faire tutoring. In this

respect, adult adjustment depends on the type of tutoring and the existence of an infant's project of action (goal maintenance). On the other hand, infants' gains are related to infants capacity to generate action project, flexibility (executive functions), type of tutoring, and the adjustment of adults' proposals based on feedback from the situation.

There are significant inter-group differences in efficient inhibition/activation mechanisms: the main one is not centred on a stop-signal but on perseveration, which is more frequent among Down Syndrome infants and which is associated with less combination and redefinition of efficient inhibition/activation function (shifting). Such infants also show a lower capacity to generate or modulate new action schemes, where flexibility on action organization is lower.

Deriving educational implications from these findings is necessary to help infants in their cognitive development. This is particularly important with respect to alternative courses of development because, adding to the individual structural differences on the competence to organize and control cognitive acting, it appears the influence of non-adjusted adult's intervention.

Results show that the infants' group with more structural and functional difficulties receives a more non-adjusted type of tutoring that involves less resistance to interference. It suggests that their developmental process could be impaired.

In sum, early educative intervention must be redefined: it should not only be centred on formal consistency, but also should be particularly sensitive to (1) infants' initiation of logical organization of the content and executive control of their actions, and (2) adult adjustment to infant competencies. Not to redefine such intervention may contribute to a continuing deficiency in the tutorial process.

13.4 Acknowledgements

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