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T-patterns integration strategy in a longitudinal study: a multiple case analysis

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ABSTRACT

This work analyzes stability and change of T-patterns related with on-task persistence and social interaction of preschool-age children. Stability and change are considered as natural setting indicators of time allocation processes and social dynamics with teachers and peers, within the fields of educational neuroscience and developmental science. In contrast with descriptive observations, developmental scales or ratings, T-pattern analysis clarifies and allows predictions on otherwise hidden behavioral patterns and their stability and change processes in natural settings. Here, T-pattern analyses were applied on observational behavior profiles of three preschool children, their teacher and their interacting peers in classroom and playground natural settings, to identify the structure and dynamics of daily activities in a multiple case study strategy about persistence and social interaction processes, considering teachers' and peers influence on children's behavior. Behavioral data were obtained with the Observational System of Social Interaction in a nomothetic, following and multidimensional observational design. Main results include the identification and description of patterns, their stability and change over time, and their subsumed structure regarding setting, child, and diachronic information. Two main behavioral patterns identified were: (1) teacher's attempts at redirecting child behavior to on-task were followed by on-task and off-task alternation loops, and (2) peers or teacher not responding to child social emissions, predict the kid going off-task. This constitutes a methodological contribution to Educational Neuroscience's efforts to describe real-world group contexts and predict the use of time in preschool contexts by children, their subsumed behavioral patterns and the influence of peers and teachers.

1. Introduction

Developmental epigenesis is an integrative approach in which the main assumption is that genetic, neuronal, functional, behavioral, environmental and cultural subsystems interact as mutually influential levels of analysis [1]. This framework overcomes historical dichotomic debates in developmental studies, such as the nature-nurture, continuity-discontinuity, maturation-experience, and others, suggesting that explanations at one level may complement and coexist with explanations at another level. This framework is coincident with the dynamics of establishing methodological bridges between neuroscience and education, where Blakemore and Frith [2] have pointed out the need for longitudinal studies to account for response patterns stability and to identify those factors that alter their consistency.

The present work has not been published previously, and it is not under consideration for publication elsewhere. Its publication is approved by all authors and explicitly by the responsible authorities of the preschool where data were taken. If accepted, it will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright holder.

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This work is framed in the field of Educational Neuroscience (EN), providing evidence at functional and behavioral levels to highlight interactions between levels of analysis. These efforts can potentially contribute to a significant transformation of educational practice, to foster disciplinary interaction, research, methodology and knowledge, and providing robust foundations, both to respond to difficulties and to develop academic and social skills in teachers and students [3, 4].

Special emphasis to Developmental Science and its perspectives of synthesis and epigenesis (Gottlieb, 1996) are given, along with its links with experimental psychology and Educational Neuroscience. The Developmental Science approach in terms of multiplicity of levels of analysis may contribute to the enrichment of a critical dialogue and promote the construction of bridges from different angles placing emphasis on the methodological aspects, which are possible to transfer between contexts of research, therefore building a multi-method strategy [3, 5, 6].

One aim of Developmental Science is the study of the stability, change and individual differences of children. Preschool settings are good environments to develop academic and social abilities with peers and teachers [7, 8]. There are also other motivational and educational goals at school such as teaching children to progressively maintain more time in academic activities (on-task behavior) as they grow and gain more schooling experience. But in fact, there is evidence that most children in preschool allocate their attention on socialization activities and on leisure (off-task behavior), and they have trouble keeping their attention exclusively on a single task, therefore showing lots of changes in their behavior over short periods [9]. In this paper (see Table 1), *eor* is an indicator that a student's attention is not focused on the instructional activity (*eac*), nor play or social interaction (*esp*); in other words, it is one of the off-task behaviors where a student completely disengages from the learning environment and academic activities to engage in unrelated behaviors [10, 11].

Focus of this work is on children under four years old in the preschool setting because these are critical and sensitive periods where there is greater malleability. Also, neuropsychological evidence show that attentional capacities may differ through childhood [12, 13], though most evidence is still from standardized tests and cross-sectional designs. So, information about longitudinal trajectories and most of all, about the way those processes could be seen in daily adaptative behavior may highlight valuable aspects of this phenomena. Teacher and parent reports have been useful to assess executive control in an everyday context for preschoolers from 2 to 5 years old, especially if behaviors are operationally described [13, 14], but this evidence would be strongly supported with trained-observers, in real-time observation [15].

Moreover, at school it could be expected that teachers were able to redirect children off- task behavior back to the academic activities, and this goal should be accounted for. There are several works on such topics [16], but information about the structure of the interaction and relevant events that could predict more precisely such processes is needed. This work focuses on the study of social interaction in preschool contexts and specifically in peer interaction and teacher-children interactions with a strategy based on the identification of T-patterns, which has been a methodological strategy highly valued in recent decades in a variety of fields of knowledge [17].

The assumption underlying the T-Pattern Detection and Analysis (TPA) method is that complex human behaviors have a temporal structure that cannot be fully detected through traditional observational methods or mere quantitative statistical logic [15, 18]. By detecting T-patterns, or “temporal patterns”, structural analogies can be identified across very different levels of organization. This represents an important shift from quantitative to structural analysis.

The TPA perspective provides a new approach to analyze “intensive repeated measures” [19], which can detect microprocesses that used to be hidden to the more conventional analysis. It could be also a promissory methodological tool to contribute to the still unsolved conceptual and methodological problem of describing the complexity and dynamics of the integrative approach of developmental epigenesis on the interaction and mutual influence of different subsystems or level of analysis [1].

T-pattern detection studies have been conducted in very different scientific domains, such as school [20], communication [21] and sports [22, 23]. Since observational records of human behavior have a temporal and a sequential structure, an analytical tool that describes this structure can enhance the understanding of the target behavior(s). In social interaction for example, T-pattern analysis can reveal the hidden yet stable structures that underlie the interactions that determine what occurs in a competition.

On the other side, it is possible that the trajectories of different behavioral patterns imply lineal or non-lineal changes, stability or non-stability over time. For example, there is evidence that behavioral persistence implies low rates of episode changes, long episodes defined by the time allocated to on-task behavior [24]; and it could be expected that children allocate more time to on-task behavior over time. But what can TPA tell us in this regard?

Developmental changes of most behavioral patterns could be different for the same child at different moments, and also may be different between different children at the same time. Factors that could influence such differences are critical in Developmental Science and they can be identified through TPA.

Finally, in developmental, clinical and educational psychology, the information arising from TPA could be useful to give feedback to teachers and parents as an evaluative tool for prevention and intervention programs [25].

There are not many works in Developmental Science research with T-Patterns that integrate information from different temporal samples, in different settings (classroom and playground) and from different participants in the field of Developmental Science [26]. Most of the work has been directed to describe the changes that over time children exhibit in terms of their social adjustment. One example is the work of Rubin et al. [7], in which they describe the "orderly" form of behavioral organization in terms of approximation and avoidance that children exhibit in new contexts, and the relationship with peers is not the exception. Thus, this paper is aimed to strengthen longitudinal research, with an essential emphasis on the fact that data derive from systematic field observation, with mutually exclusive and exhaustive categories, and with high control in the quality of data. In addition, for being part of the Coyoacan Longitudinal Study CLS (Santoyo, 2007), it connects with what has been referred to as archival research [27, 28], as useful transformation trying to answer new research questions. Finally, it is possible to detail more precisely the different trajectories and development profiles which, without a doubt, strengthens the work in Developmental Science and extends the multiple uses of TPA to Educational Neuroscience.

Therefore, the goal is to identify and contrast the behavioral patterns that children exhibit according to context and experience, focusing on the study of academic persistence and in peer-to-peer and teacher- children interactions with a T-pattern identification strategy.

2. Method

2.1. Observational design

Data for this paper are a subset of the Coyoacán Longitudinal Study (CLS) files [29], which is a larger Project examining social development in Mexican children [29]. Such data was obtained with observational methodology [30], which has proven to be a robust scientific method for analyzing interactive situations in natural settings [31, 32].

A longitudinal, nomothetic, following (inter-sessional and intra-sessional), multidimensional observational design was used [33, 34]. The study was longitudinal since it took one wave of data collection every six months for 18 months, in order to have three measures

Table 1
Dimensions, categories, definition and codes of the Observation System of Social Interaction (OBSSI). Based on Santoyo et al. [35]. Codes for the *Peers* category are specific for the observations of the class reported in this study because they represent the particular people available for interactions during the data collection.

Dimensions	Category	Code	Definition
Social agents	Teacher	*pr*	Corresponds to teacher code
	Peers	*ceaa1, mna1, faa1, jla1, elea1, ro1a1, isa1, doa1, ola1, ac1a1, mia1, ira1, ro2a1, soa1, pma1, cra1, ada1, cebb1, amb1, an2b1, kab1, olb1, cab1, fogb1, gmb1, krb1, adb1, elsb1, jub1, sfb1, erc1, gac1, gic1, arc1, armc1, src1, alc1, jg1c1, jo2c1, mgc1, dic1, dac1, ib2c1, tec1, sec1, koc1, xi1c1, ji2c1, mioa2, afa2, jva2, jpa2, dna2, poa2, vea2, cra2, elia2, ala2, aja2, leb2, mib2, meb2, ega3, mca3, kla3, coa3, aga3, fra3, mob3, rob3, asa3, adb3, mjc3, koc3, mac3, cra3, mcc3, bea3.*	Each code identifies a peer.
Zones or Locations	Zones	*m1, m2, m3, m4, out, ch, arb, res, aro, a, l, p, pas, esc, ere, cas*	*m1* corresponds to table and chair of target; *m4* corresponds to teacher' table in classroom. The other codes correspond to specific areas of playground.
Beginnings	Emission	*eiep*	Physical and/or verbal behavior that is directed by the target student towards others and it is not immediately preceded by an interaction initiated by another child. The code of the child towards whom the action is directed is noted down.
	Reception	*eipr*	Physical and/or verbal behavior initiated by another student that is directed at the target child and not immediately preceded by any social behavior by the target child. The peer's code is noted down.
Behavioral Episodes	Academic activity (on-task behavior)	*eac*	Behavior displayed by the target child in response to specific instructions from the teacher in relation to the learning goal at the time and situation. It may involve contact with material depending on the task.
	Social interaction	*espe, espr*	Simultaneous or successive physical and/or verbal behavior targeting the target child or other children in which there is mutual dependence. The letter 'e' following *Esp (Espe)* indicates initiation by the target child. The letter 'r' *(Espr)* indicates initiation by a peer.
	Free activity	*eal*	Behavior displayed by target child involving academic material selected by the teacher, but without a specific learning goal. It involves different levels of contact with the material depending on the needs of the child.
	Isolated play	eja	Behavior displayed by the target child involving objects and/or toys, without the participation of others. The type of play is identified by what the child is doing and/or the rules he is applying.
	Other responses	*eor*	Behavior displayed by the target child that is not covered by the other categories in OBSSI.
	Group play initiated by target child	*ejge*	Play situation initiated by the target child that establishes mutually dependent interactions between the target and another child, in accordance with the rules of the game.
	Group play initiated by a peer	*ejgr*	Play situation initiated by another child that establishes mutually dependent interactions between the target child and another, in accordance with the rules of the game.

through time from the same sample. It was nomothetic because different children and the teacher were observed. Following was intersessional because at least six sessions in each of three observation waves, both in classroom and playground, were studied; and intrasessional because a frame-by-frame record of the behaviors was performed in all sessions. This study is also multidimensional because different dimensions of behavior were considered, each of which correspond to different aspects of interactive behavior included in the observation instrument.

Observation was direct (the level of perceptibility was complete), non-participatory and active.

2.2. Participants

The observational records of three focal preschool-age children and their interactions with their teacher and with 13 children in their classroom and 17 children available at playground were analyzed. Children's ages were in the 2.5 to 3.5 years old range, and they were all located in the same class by the moment of the first wave of data collection.

2.3.1. Observation instrument

Participants' behavioral data were collected based on the *Observational and Behavioral System of Social Interactions (OBSSI)* [35], which was designed specifically to study social interaction in elementary school and preschool settings. This instrument combines a field format and a system of categories for each dimension in the observation instrument [36]. The field format system consists of four dimensions: social agents, beginnings, behavioral episodes, zones or locations. Based on each dimension, a system with exhaustive and mutually exclusive categories for the acts that participants exhibit in educational settings was designed.

Then *OBSSI* makes it possible to identify events and situations that constitute behavioral patterns. In Table 1 the behavioral categories of *OBSSI* and their codes are presented.

2.3.2. Record instrument

The sessions were recorded using the software program SDIS-GSEQ [37]. Systematic recording with mixed codes (literal and numeric) was used. The data were type IV [38].

2.4. Procedure

2.4.1. Data collection and codification

Three preschool-age children, two girls (*coa3* & *kla3*) and one boy (*ega3*), their teacher and their 17 peers (13 of them in the same class, 17 in the playground), were observed in a natural setting (a preschool in Mexico City) on a longitudinal basis of three data collecting sessions

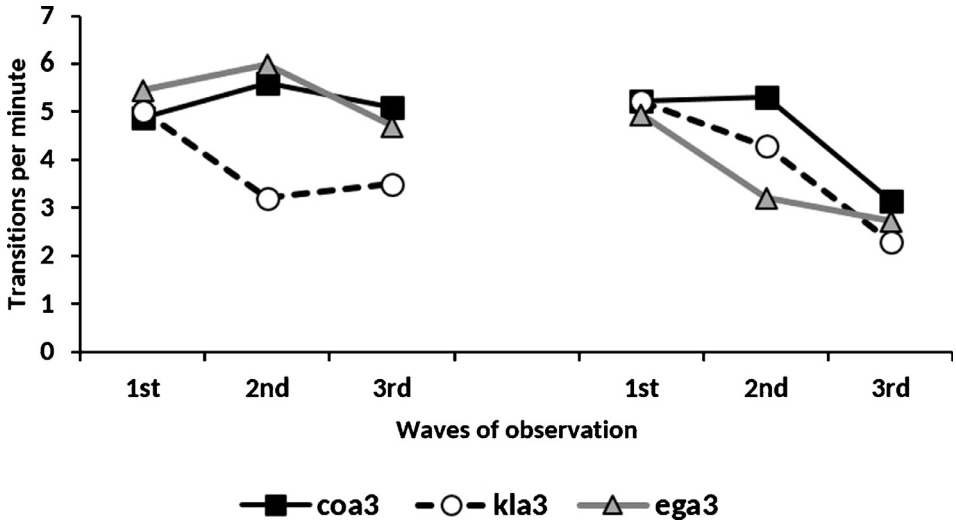

Fig. 1. Behavioral transitions. Changes of activity per minute for the three participants in classroom (left) and playground (right). Three waves of data collection, every 6 months, constitute the whole longitudinal study.

with six month intervals over the course of 18 months, with explicit permission of school authorities and parents. The research protocol was approved by the Ethics Committee of the University of the first author (CONACYT 178383/12/11/12; PSIC-UNAM/12/15/2017UNAM).

A total of six observation sessions in the classroom, and six observation sessions in the playground for each participant were analyzed. Duration of sessions was 15 minutes each in the classroom, and 10 minutes each in the playground. A systematized recording was used.

The recording performed with SDIS-GSEQ software consists of sequences of actions (Table 1). The sequences are pinpointed by a starting point and an end point. Following Bakeman [38], the used data were type IV (concurrent and time-based), that is consistent with the multidimensional nature of the design. The parameters of frequency or occurrence, order and duration were organized in a progressive order of inclusion. The maximum informative power of the duration parameter justifies the consistency of the results obtained [39].

The OBSSI generates a time- based sequential record in which observers write the order of occurrence of events. Moreover, it allows the study of contextual factors at the site where a behavioral pattern emerges (i.e., places or zones in the classroom and in the playground) and identifies the person who initiates an exchange. The use of this system made it possible to categorize participants' activities, social exchanges, peers involved in social interactions (specific children or teacher), direction (who initiates the episode) and location of exchanges.

Data were transformed later into Theme format, allowing detection of temporal patterns in the data sets (see Manual of THEME 6 EDU).

2.4.2. Control of data quality

In this study there have been two observers overseeing the corresponding records. The observers followed a theoretical-practical training process as described in Santoyo et al. [35].

In order to determine inter-observer concordance, Cohen's kappa coefficient [40] was obtained through GSEQ software version 5.3.2. The values were higher than .75 in all data blocks, which by the reference values set by Landis & Koch [41] means there was a substantial agreement.

To estimate the extent to which our results could be generalized to other situations, the generalizability coefficient, initially designed by Cronbach et al. [42] was used, through the application of the analysis of variance techniques. Global data from the preschool sample in the CLS obtained a 0.95 generalizability coefficient [43], which suggests that data from individuals and sessions can be reliably generalized based on the category system, number of participants, and number of programmed sessions.

2.4.3. Data analysis

The full data for each observational session record (3 children x 6 sessions x 3 waves of data collection x 2 contexts) were analyzed to identify T-Patterns in classroom and playground situations in a short longitudinal study to identify hidden temporal structures [15, 18, 44], using the THEME 6.0 program (THEME 6.0 Edu for academic use is available free for download at: www.patternvision.com).

Default search parameters were used in THEME (for more information, see the reference manual [45]. An additional excellent example for this could be at Amatria et al [46]). Only the following parameters were specified: a) frequency of occurrence of >20; b) significance level of 0.005 (0,5 probability of critical interval being due to chance); c) redundancy reduction setting of 90% (exclusion of T-Patterns when >90 % of occurrences of a new pattern start and finish with the same critical interval relationships of patterns already detected); d) deactivation of fast requirement at all levels e) selection of free heuristic critical interval setting.

The qualitative filters were: (1) maximum length (number of event-types in the terminal string of a pattern), (2) maximum level (number of hierarchical levels in a pattern), (3) prioritize the description of the relationship between eac (on-task) and eor (leisure) items (codes) and social interactions with peers and the teacher in classroom and playground contexts. The results were validated by simulation, through data randomization on five occasions, accepting only patterns for which the probability of randomized data coinciding with real data is zero.

4. Results

In first place the molar descriptive data of the rate of behavioral transitions and the behavioral preferences of the three target children in both scenarios are presented, and then the information resulting from TPA is included. This quantitative and sequential analysis give a first approach to the differential profiles.

Fig. 1 shows that the rate of behavioral transitions in the classroom of *coa3* and *ega3* show stability around five transitions per minute during the three observation samples; while the rate of transitions of *kla3* tends to decrease until it is around three transitions per minute. All participants showed a decreasing trajectory of transitions in the playground from 6 transitions to 3 transitions per minute.

Considering the total time of observation and the allocation of time

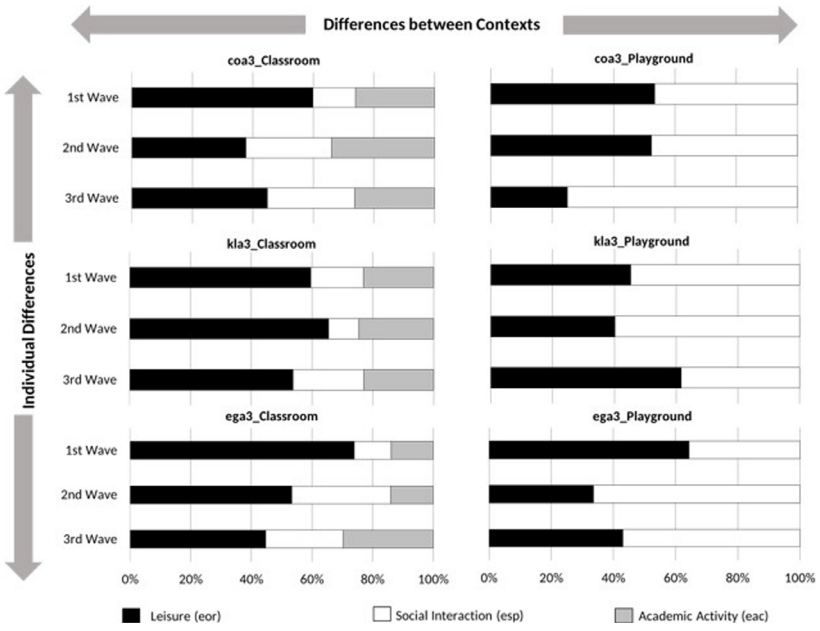

Fig. 2. Behavioral preferences in a longitudinal study. Percentage of time allocated to leisure behavior (*eor*), academic behavior (*eac*), and social episodes (*esp*) of participants (*coa3, kla3* & *ega3*) in classroom and playground in each wave of data collection. Differences between contexts (horizontal) and individuals (vertical) are exposed.

to the behaviors available in each context, a decreasing tendency in other responses (one type of off task-behavior) over time was found, almost 60% to 40% in the classroom and almost 53% to 30% in the playground for all participants (See Fig. 2).

Stability in the preference of on-task behavior (academic activity) was found over time. However, it was lower than 27% considering the whole set of categories (off-task behavior, including social interaction and other responses).

Fig.s 1 and 2 show a molar description of behavioral transitions and behavioral preferences of the participants. However, it is still necessary to describe the structure of such preferences in order to explain the interactions and patterns over time in different settings.

Results shown below are centered on the main aims of longitudinal research: stability and change of social interactions of preschool-age children in natural settings based on a TPA strategy. Examples of representative t-patterns that meet the criteria, parameters and qualitative filters specified in the data analysis section are included next.

In Fig. 3 an example of a complex pattern in the playground is presented. In this pattern, labeled in Theme output as [*ega3,*TP 2153], a high persistence on loops of *eor* shows that acts of emission (*eiep*) are not responded by peers producing recurrence of *eor* simple loops; when target receives teacher's verbalizations he/she does not react and the pattern concludes in *eor* activity. This pattern shows two events that are strongly related to persistence in leisure activities: the acts of emission not responded by peers, and the unsuccessful attempt of the teacher to redirect the activity. Also this pattern shows in the third wave of observation that teacher attempts to redirect behavior to on-task (*pr.eirp*), decreased.

In Fig. 4 a complex pattern of *eac* and *eor* alternation of the participant *coa3* is displayed (labeled in Theme as [*coa3,*TP922]). Pattern begins with target emission (*eiep*) not responded by the teacher, then *eor* reoccurs, a second attempt from the teacher to redirect the activity produced alternation between *eac* and *eor* in two different moments, pattern finishes with *eor* activity. This pattern shows an example of teacher regulating academic activity with relative success because of the repetitive alternation between *eor* and *eac*. In fact *coa3* shows a similar pattern of behavioral transitions in the classroom than *ega3* (Fig. 1) but shows a moderately higher level of preference to academic activity in all the observation samples. However, it is not superior to 34% of total time of observation.

Fig. 5 [*kla3,*TP240] shows a pattern fading over time in the playground where the child emissions (*eiep*) were not responded by peers maintaining *eor* persistence, although *eor* appears related to isolated play. However, there is no stability in this pattern, because in the third observation wave it does not occur with the same frequency observed in the first and second observations. Such patterns help in understanding the decreasing tendency in behavioral transitions showed at fig. 1.

Fig. 6 shows a pattern from participant *kla3,* (identified by in the analysis by Theme with the label [*kla3,*TP753]) beginning in academic activity (*eac*) and frequently alternating with leisure activity (*eor*). Several levels of T-pattern were found, identified mainly at the end of the first and at the beginning of the second observation samples. This T-pattern represents a special example of academic persistence with the characteristic that it is alternating with brief periods of *eor*. In this case social emission directed to the teacher (*pr.eiep.espe*) was responded and *kla3* continued with *eac*. The pattern finished with a brief loop of *eor*. It is important to consider that *kla3* is the child with less frequency of transitions in the second and third waves of data collection (Fig. 1) and this pattern could explain the structure of such behavioral preference.

5. Discussion

Besides providing a robust means of observing and collecting data in natural settings, observational methodology provides a rigorous yet flexible framework for capturing behaviors that occur over a period of time that can then be subject to diachronic analysis. The use of THEME to conduct this kind of analysis of behavior and detect hidden structures is growing. It is a powerful means for detecting behavioral patterns that remain invisible to the naked eye [15].

Comparing T-patterns with molar data, we can better understand longitudinal information of separate children, different settings and dissimilar situations. This may allow interpretations to go further than describing the distribution of time and the transitions rates, by identifying key events that explain what happens around those transitions and suggest interaction mechanisms that control the behavioral organization.

Most evidence of attention development through childhood comes from standardized tests which lack of ecological validity [12], and from cross-sectional designs, which hide stability and change processes [47]. In contrast with those descriptive observations, developmental scales and ratings, TPA clarifies and allows predictions on several otherwise hidden behavioral patterns. Two examples that deserve noticing are: (1) A pattern in which teacher's attempts at redirecting child behavior to on-task, are not completely efficient as they are followed by the child

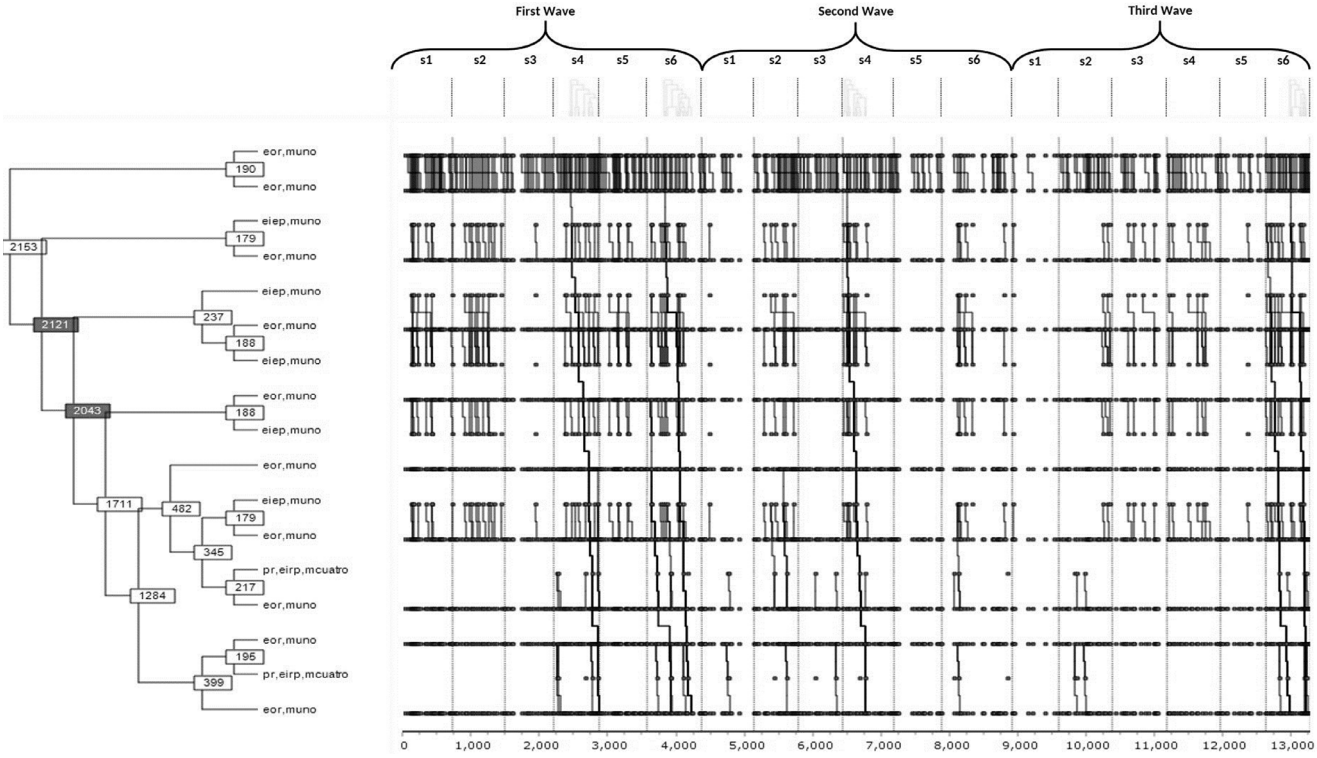

Fig. 3. [*ega3* TP2153]. T- Pattern of *ega3* at classroom. Loops of *eor* (leisure) recurrence. Emissions (*eiep*) not responded by peers are associated with high recurrence of *eor*. *muno* and *mcuatro* means the table and chair where target and teacher are located, respectively. Vertical dotted lines divide observation sessions (*s*) and brackets indicate waves of data collection in the longitudinal study. As it was noticed in figure 1, ega3 is the child that exhibits more behavioral transitions in all sessions.

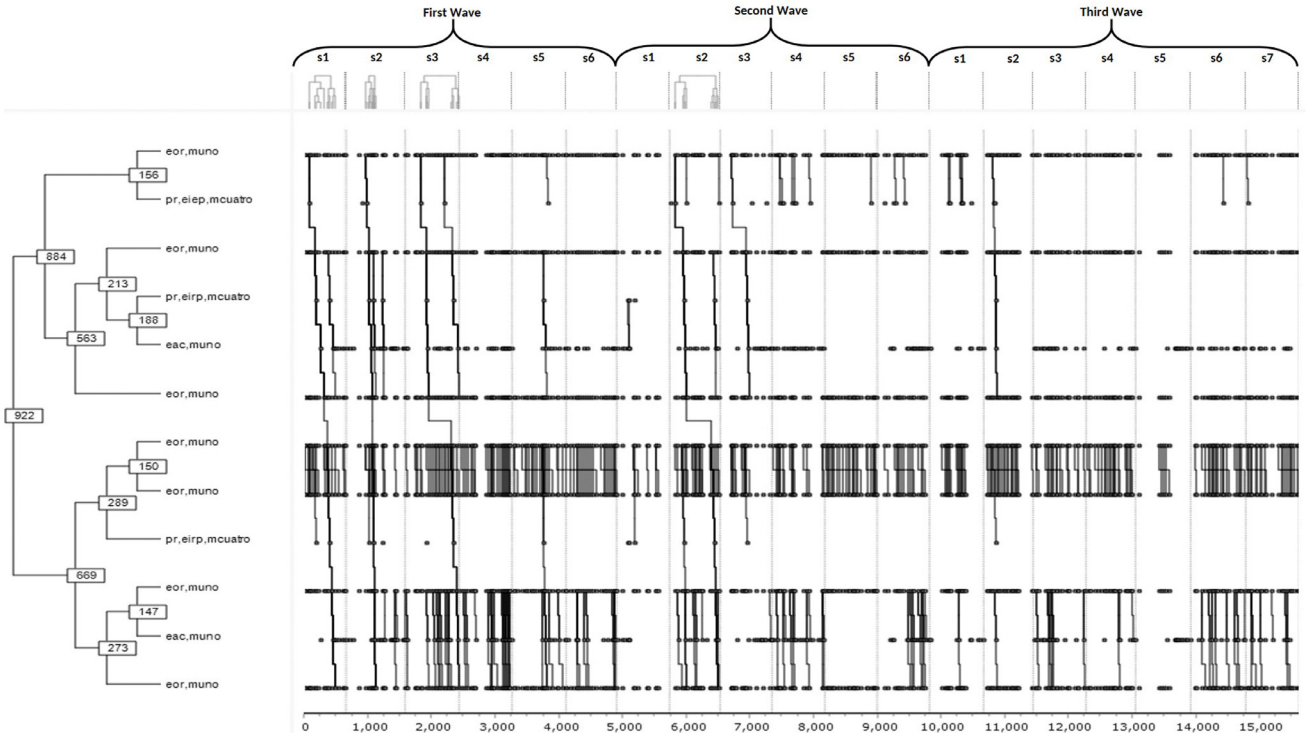

Fig. 4. [*coa3* TP922]. T Pattern of *coa3* at classroom interacting with teacher (pr), *eor* and *eac* alternating. *muno* and *mcuatro* mean the table and chair where target and pr are located. Vertical dotted lines divide observation sessions (*s*) and brackets indicate waves of data collection in the longitudinal study.

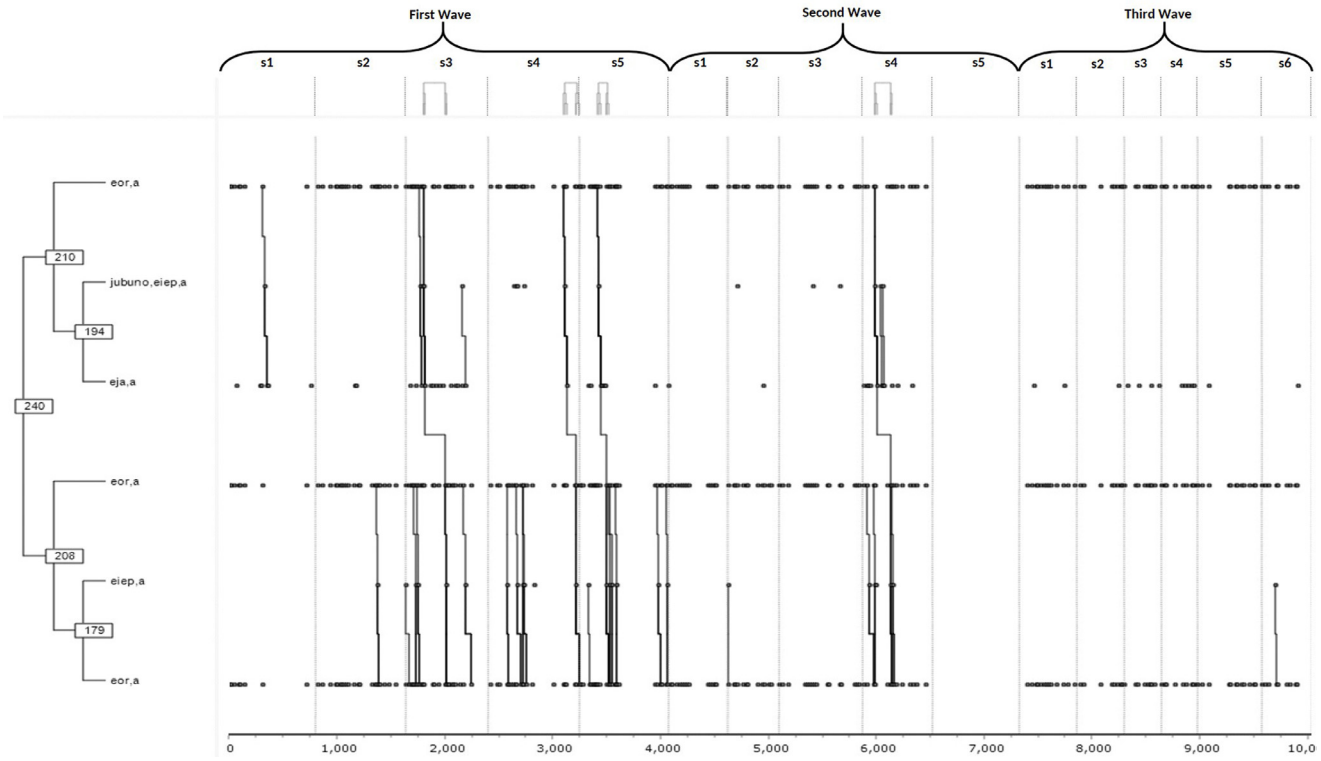

Fig. 5. [*kla3* TP240]. T Pattern of *kla3* at playground. Leisure behavior (*eor*) alternating with *eja* (isolated play). Emissions (*eiep*) without peer response are associated with *eor* (*a*) means a specific area code in playground. Vertical dotted lines divide observation sessions (*s*) and brackets indicate waves of data collection in the longitudinal study.

engaging in loops of alternated on-task and off -task. (2) Another pattern in which the child makes repeated social emissions but those are not responded by teacher or peers, and then the focal child abandons the academic behavior and goes off- task. The main contribution of the T- Patterns perspective to analyze "intensive repeated measures" is crucial for studying changes within individual microprocesses [48], in order to describe thoroughly mutual influences between intra- individual change, context influences and inter- individual differences.

One finding in all three cases is the stability of T-Patterns in *eac* (on-task). There is recurrence intra and inter sessions over the three semester samples. On the other side, *eor* (leisure) T-patterns show changes over time mainly in the third wave of collection data in both settings.

Teacher (*pr*) attempts to regulate on-task behavior (*eac*) are properly described for TPA, where some of the teachers' interventions provoke a change of activity to the desired educational goal (redirect behavior to on-task). A special feature about this pattern is worth noting: when the teacher does not attend children's initiatives (*pr.eiep*), they suspend on-task activity and fluctuate in *eor* loops. Other results show teacher's relatively successful interventions where changes from *eor* to on-task behavior were induced, but with a kind of limitation due to a cycle of alternations between *eac* and *eor*. Although *eor* loops are dominant in children's patterns in both settings, classroom and playground.

Individual differences between the three cases were identified and described in the T-pattern examples. For example, *ega3* and *coa3* showed high *eor* persistence, but child *kla3*, who showed less frequency of behavioral transitions, also presented a different effect on the pattern structure displaying more frequently the alternating recurrence of *eor-eac* and better time allocation to academic behavior. On the other side, *ega3* is the child that exhibited more behavioral transitions (Fig. 1) and also spent less time on academic activity (*eac*) during the first and second observation samples.

The decreasing trend of behavioral transitions in the playground for all children is showing a possibility to spend more time on social interaction and play, such patterns are not found in the classroom where a motivational competition between the social, leisure and academic activities is more prevalent. The problem is that these children spent less time on academic behavior. The high recurrence of *eor* loops, or *eor-eac* loops could explain such situations, but social interaction is important in order to understand what is happening in the classroom, because most precursors of *eor* bursts are emissions not responded by the teacher or peers.

Teacher role on *eor* (off- task behavior) recurrence is very important. In some situations, the attention is directed to *eor* events and then *eor* could be reinforced [49], but in other situations, as we see for example with *coa3* (Fig. 4), teacher action redirects child behavior with relative success. A detailed analysis of the different patterns for each child in the classroom could help to identify the opportunities to improve teacher strategies, programming feedback for the different exemplars detected [25]. In addition, the combined use of observational methodology and TPA make it possible to create feedback on process instead of only feedback on the results.

Stability and change of T-Patterns on an 18 months basis were found. Such information is very informative and useful in order to better understand developmental tendencies. For example, the *eor* persistence in the classroom shows great stability over time for some children (*ega3* and *coa3*), but a changing profile to alternating acts of *eor* with *eac* was identified for child *kla3*.

Globally, these results suggest that TPA is an innovative and precise tool for detecting hidden events that can affect interactive processes. For example, in the preschool classroom, some acts of the teacher -like not being responsive to target kids' initiatives- may inadvertently elicit more off- task loops. This is true also in the example of peer to peer interactions.

Forthcoming work must be directed towards explaining social abilities and social adjustment on a longitudinal basis, where social effectiveness, social responsiveness and reciprocity could be the main focus in order to explain socio emotional development at preschool and

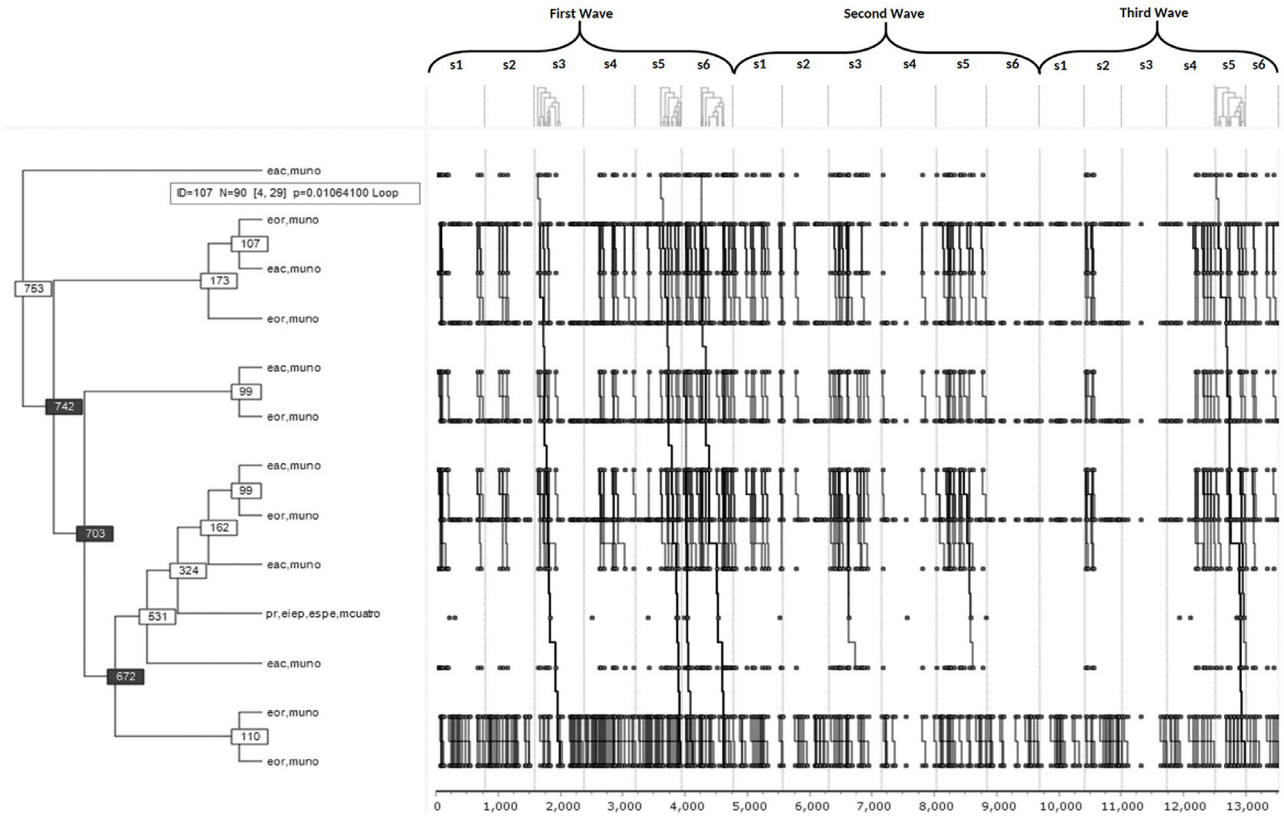

Fig. 6. [*kla3* TP753]. T Pattern of *kla3* at classroom. Academic episodes (*eac*) are related to *eor* and *eac* alternating cycles. Emissions of *kla3* to teacher were responded (*pr.eiep.espe*) and there is a relation with *eac eor* alternations. *muno* and *mcuatro* means the table and chair where target and teacher are located, respectively. Vertical dotted lines divide observation sessions (*s*) and brackets indicate waves of data collection in the longitudinal study. As an illustrative function, text box in the left upper side, shows some of the parameters for the node identified by label 107 (ID = 107), which shows that it occurs 90 times, that the critical interval at the node is [4, 29] with p = 0.01064100, and that it is a Loop.

elementary school settings. TPA also makes it possible to explore and identify some events that can be of interest to applied researchers and preschool teachers. Future studies can consider the role of specific peers as inducers of disruptive behaviors in the classrooms. In addition, TPA may be useful to the study of persistence and attention loops.

Future developments must consider TPA as a methodological strategy which may contribute to large-scale observational studies investigating attention allocation in preschool and elementary school settings during instructional activities as a first step in providing observational evidence to inform interventions that aim to better engage students [11].

According to Bruer [50], bridges between neuroscience and education based on scientific data should be established with the aim of integrating different levels of analysis including methodologies of empirical basis and technological integration. However, Goswami [5] cautiously warns about the possibility of investing precious resources in scientifically spurious applications. In this study, we explore structural patterns searching for solid bridges supported by systematic, valid and reliable methodological advances, of Educational Neuroscience as a translational research approach [28]. In such perspective, TPA may play an important connecting role. In addition, the integration of qualitative and quantitative elements, that is the essence of mixed methods, is a relevant benefit in this multiple case analysis, that opens new promising perspectives. Some of those may include the designing of new strategies where complementary methods could be used, like polar coordinates, quantitative models of target behaviors, and TPA with different qualitative filters established by researchers. Such strategies could offer different complementary perspectives of different processes toward a structural analysis of development, motivation and attention areas [16].

Disclaimer

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Ethical standards agreement

We have read and have abided by the statement of ethical standards for manuscripts submitted to the journal of physiology and behavior.

Declaration of Competing Interest

The authors declare that this research was conducted in the absence of any aspect that could be considered as a potential conflict of interest.

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