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Sandrine Depeau, Kamila Tabaka, Pierre Dias, Sylvestre Duroudier, Colin Kerouanton, Arnaud Lepetit, Sonia Chardonnel, Isabelle I. André-Poyaud, Boris Mericskay, Eva Moffat

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1. Introduction

The place of children and their use of space are becoming important issues in urban research. Urban densification and changing city lifestyles raise questions about the well-being of families living in cities, and especially of their children. Studies based on children's mobility have been growing rapidly over the last twenty years. Since Hillman's study (1990) describing the reduction of children's mobility over two or three generations, this field of research has continued to develop since the mid-2000s, enhancing the idea that independent mobility in urban contexts is a fundamental process in a child's development, as a part of autonomy. However, this regression is often observed from a generational (transversal) viewpoint, and not a longitudinal way. It remains poorly documented regarding its relationship with biographical changes and daily-life contexts. In addition, the process of autonomy is rarely studied in its descriptive dimensions and would need to be further defined in relation to urban child

issues. Moreover, is independence of travels sufficient to describe children's autonomy process in urban space? Autonomy should be understood as a multi-dimensional process prone to transitional events in the development of children. The aim here is to show how each of the dimensions of the child's autonomy evolves according to the contexts of life and the periods of school life using a longitudinal approach. This one remains still underexploited as it proves very costly in terms of human resources and time. However, transition from elementary to middle school is seen as a “normative transition” (Bronfenbrenner, 1986), a period of reshuffling of territories and times within the family. Also, what does the transition from elementary to middle school imply in terms of autonomy, in other words, in terms of independence of movement, of places frequented and of perception of coping skills? To answer the question of how children's autonomy is developed at certain turning points, this article comes from a multi-methodological survey over two years¹. Thus, after a theoretical context and a methodological description, mentioning the participants, the field contexts, and the data collection, we present the results, which are discussed in the concluding section.

2. Theoretical context

Since Hillman's pioneering work (1990), spatial mobility studies have even built up an understanding of the changes in children's and families' relationships to space, and more specifically of children's spatial autonomy and their sedentary lifestyle over several years. Children's relationship to space and particularly their ability to move around, are sources of observation for many social issues involving a variety of data collections ranging from large national surveys (Gonzales et al., 2020) to field-specific surveys (Carver et al., 2014).

From a developmental and educational viewpoint, many studies have shown the role of independence of movement in spatial cognition (Rissotto & Tonucci, 2002; Depeau, 2003; Mackett et al., 2007), feeling of safety (Hillman, 2001), risk of accidents, and the sense of community (Pretty et al., 1996; Prezza & Pacilli, 2007). To explore growing ecological issues, numerous studies have highlighted the role of children's active travel modes (walking, cycling) in reducing the environmental impact of motorized transport (Kearns et al., 2003; Depeau, 2008). In particular, they aim to identify the levers for changing parental behavior, especially when it comes to driving (Tranter & Pawson, 2001; Carver et al., 2013). Yet, as a result, children's travel independence is often reduced to the sole use of active travel modes. Several factors are frequently studied to explain children's independence and well-being (Depeau, 2017), including social factors, such as the role of parents and peers (Valentine, 1997) and the permitted activity places, which are often assimilated to the home range (Anderson & Tindall, 1972; Hillman, 1997; Valentine & McKendrick, 1997), and spatial or urban structure factors, focusing mainly on traffic conditions, road networks, levels of urbanization, amount of vegetation (Larsen et al., 2009). All these factors are considered in their static state on very different spatio-temporal scales, offering a snapshot at time *t*. But very few are considered as part of a dynamic process, namely the autonomization itself. Despite the extensive literature, children's autonomy in urban environments must be distinguished from travel independence. Since the research of Hillman et al., children's independence has mainly been defined as “licenses... [that] children obtain from their parents to get around predominantly on foot on their own” (Hillman et al., 1990: 20)

and measured in different ways : the type of place(s) frequented alone or with peers, independent travel, distance traveled, time spent outdoors without supervision, playgrounds frequented alone (Depeau, 2003). Further, a growing range of indicators are being measured using mixed methods (Christensen et al., 2011) that combine more objective measures based on digital tools and connected devices. These allow more accurate measurement of times and distances traveled as well as the nature and functions of visited places (Kytä et al., 2018), and subjective measures such as the perception of danger, environmental preferences.

However, this otherwise necessary variety of methods may contribute to a confusion between “autonomy” and “independence” because they do not involve children in the same way. In this context, independence is most often understood as a behavioral dimension of autonomy. It implies the classic outdoor independence indicators related to daily travel and types of visited places reporting daily routines that contribute to children’s environmental familiarity (Depeau, 2003), including habitual daily mobility. Beyond the observed behaviors, autonomy also means including psychological mechanisms that are rarely considered for questions of travel, such as self-regulation, self-confidence and coping strategies. That is why, in this article, autonomy is characterized by the child’s perceived ability to deal not only with unexpected situations, but also with unfamiliar environments (Depeau, 2003). Finally, factors that can only be collected from the children’s narrative and which cover the original definition of Piaget (1932), supposing the capacity to decide for oneself, especially in the case of new situations. In addition, autonomy is also dependent on the process of socialization that contributes to learning how to move, particularly during the period when schools and territories change. And these periods of transition are also constitutive of life-course events of socialization to mobility (Scheiner, 2018) and conceptualized as “normative transition” in the ecological model of development (Bronfenbrenner, 1986). Associated with chronosystem in this last model, they complete other context scale levels in explaining child development. Thus, the ways in which children move around and the types of places they visit are explained as much by the social context of permission (mesosystem), as by urban amenities, transports services, and other urban facilities associated with the daily life of families (exosystem), and finally by a normative transition (chronosystem). One way of understanding the role of the macrosystem (cultural values) is to look more specifically at the period in children’s school careers that leads to changes in the context of their daily lives. This transition is all the more fundamental, not only because it impacts both the child and their family, but also because it induces a set of territorial, social, and psychological changes (e.g., busy timetable, not sharing the same timetable or extra-curricular activities as friends, etc.). These changes in the child’s spatial and social context can transform his/her behaviors and relationship to autonomy. Thus, depending on the field of study, the effects of the transition to middle school are not explained in the same way. For some researchers, this transition coincides with a period of social transformation (new social relationships), which induces forms of withdrawal but also emotional instability, particularly with regard to self-concept (Marsch, 1989). On the other hand, for others, this transition enables a shift towards more independent travel due to the extent of the territory (travel distance), new social relationships, and changes in time-schedules (Matthews, 1992, Hart, 1979, Valentine, 1997a). However, most research focuses more on independent age groups (cross-sectional design) than it does longitudinally. Despite broad intergenerational knowledge of the evolution of

daily travel, showing a regression in children's travel independence in recent decades (Hillman et al., 1990; Pooley et al., 2005; Kytä et al. 2015, Shaw et al., 2015), longitudinal approaches are still scarce. Some were undertaken over short time periods to test what effects an educational program or intervention has on behavior change (Carver et al., 2014, Foley et al., 2021). Other studies using longitudinal methods have mainly examined physical activity and sedentary behavior throughout the day and in all seasons in order to understand not the children's autonomy but the factors behind childhood obesity (Muhajarine et al., 2015).

Questions/hypotheses

In this study, we observe how children's autonomy (travel behaviors and self-assessment) evolve during a "normative transition" from elementary school to middle school. It is hypothesized that children's autonomy increases with age but variably depending on the context. It is assumed that children in middle school are more likely to travel independently, and their places of activity are more varied and extended. In comparison, elementary school children go to places more routinely, and for supervised activities. Finally, given the greater range and diversity of travel in middle school, it is hypothesized that the children will feel more able to cope with unexpected, new, and unfamiliar trips. These differences could vary according to the urban contexts.

Figure 1 presents the dimensions of the autonomy process in public spaces (independence and coping with ability) in a double thematic scope (travels and uses of places), and it lists the indicators, particularly those explained in the further sections (highlighted in orange in the Figure 1).

Figure 1: Autonomy definition and operational descriptors

Autonomy		
Dimensions Thematic scopes	Independence	Ability to make a decision on your own
Travels	- Travel modes used - Accompaniment modes - Travelled distances - Times spent in travel	- New travel situation - Unexpected travel situation
Uses of places	- Types of place - Times spent on site - Socio-spatial settings	

3. Methods

3.1. Field contexts

Rennes Metropolitan Area under mobility observation

The Mobi'kids study compares two municipalities located in the Rennes metropolitan area (Brittany region, Western France): the main urban center, Rennes city, and a small suburban town, situated 15 km southern: Orgères (cf. Table 1 : their population characteristics).

Table 1: General description of the population structures of Rennes and Orgères (INSEE, 2018).

General view of analysed areas' population	Rennes (city)	Orgères (town)
Inhabitants	217,728	4,729
By professional categories		
Employees/workers	22.5%	30.6%
Intermediate professions and managers	29.2%	30.4%
People without professional activity or retired	26.2%	13.6%
By household type		
Single persons	53.4%	24.3%
Other households without families	6.1%	0.8%
<i>Families types (by INSEE) :</i>	<i>41%</i>	<i>75%</i>
Couples with children	14.5%	28.2%
Couples without children	18.6%	38.4%
Single-parent families	7.8%	8.4%
By age		
0-14 years old	13.5%	21.7%
15-29 years old	32.8%	15.5%
30-60 years old	32%	43.4%

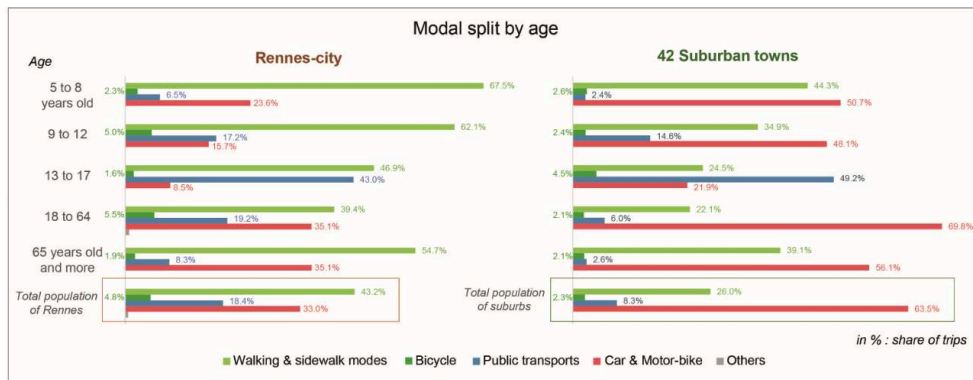
Being the regional capital city, Rennes has strong demographic growth dynamics (two-thirds of inhabitants are under the age of 45) and in its economic sector (+2.2% of average growth over the last decade, Audiar, 2021). Over the last twenty years, the city has densified due to collective housing development, which is gradually replacing individual housing. At the same time, the preservation of large and small green spaces and agricultural plots near the city has maintained both a social and functional mix and guaranteed access to nature in the city.

Orgères was mainly built for individual housing. The municipality's population has been expanding for several decades, driven by the construction of several new, family's residential lots. Surrounded by green fields and central green, sport and leisure spaces, its main urbanized area is located in the center. The town has two elementary schools (private and public) and a middle school.

General mobility context for 9-12 years old children in Rennes Metropolitan area

The last Household Travel Survey (HTS) carried out for the Rennes region in 2018 offers a general overview of the inhabitants' daily mobility, including children over 4 years old, and highlights in particular the role of car use in the city's suburban areas (cf. Fig. 2 A and B). In this data, we can select the Rennes metropolitan area (43 municipalities), with Rennes-city itself and a group of all its suburban municipalities (42 towns), but it is impossible to distinguish the sole inhabitants of Orgères.

Figure 2: The modal split by age-groups in two areas-types of Rennes Metropolitan Area (Rennes HTS 2018)

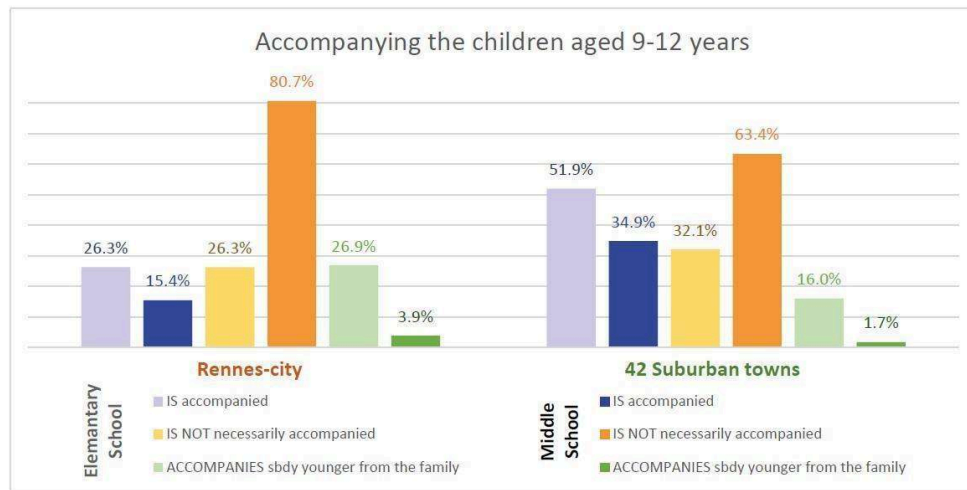


The car use share (the part of trips made by car, in %) decreases as children grow up, whereas it remains high for the adult city-inhabitants, without exceeding 40% of their daily trips. The suburban children aged 9 to 12 years daily travel by car (48%), but it decreases by a half for those aged 13-17 years (22%). Children aged 9 to 12 years can also be seen as “beginners” in the use of public transport (respectively 17% and 14.6% of trips for city and suburban children), whereas it is especially high for suburban older teenagers (49% of trips versus 42% for city teenagers).

While on average, children of 9 to 12 years walk on almost two-thirds of trips in Rennes-city (62%), it twice less in suburban areas (35%). Children under 9 and adults over 65 are the groups who walk the most in both areas, and children aged 9-12 years are the major bike users in Rennes-city (5%). This tendency is inverted for suburban areas: 2.5% for the 9 to 12-year-olds, and 4.5% for 13 to 17-year-olds, while this is only 1.6% for city teenagers.

The results in Figure 3 present the accompaniment modes of 9 to 12-years-olds show that, in general, suburban children are potentially accompanied twice as often as those living in the main city (respectively, 52% for elementary school versus 26%, and 35% in middle school versus 15%).

Figure 3: The modal split by age-groups in two areas-types of Rennes Metropolitan Area (Rennes HTS 2018)



3.2. MOBI'KIDS PARTICIPANTS

The MK research survey received assistance from the Mobility Service of Rennes Metropole and the Education Department of the City of Rennes in order to select survey areas and to reach out to the relevant elementary school authorities. Three elementary schools in Rennes city-center and two in Orgères agreed to participate in the research. Meetings with the respective school principals and grade teachers concerned were held to discuss the research protocol, time commitment, and the willingness of the children's families to participate in the study.

The participants were families: parents with children aged 9-13. They were initially recruited and assessed in spring 2018, then surveyed again in follow-up phases during autumn 2018, and (for some) in spring and autumn 2019. As the Table 2 shows, a total of 86 families (79 with 1 child and 1 parent recruited; 5 families with 2 siblings and 1 parent; and 2 families with 2 parents and 1 child) agreed to participate during the primary school period (T1), and 56 families continued to take part in the survey the year after (T2) when children had moved to middle school.

Table 2: Total number of families and children in the two phases of Mobi'kids data collection (T1 - elementary school, T2 - middle school, 2018 and 2019)

	Rennes	Orgères	Total
Elementary School T1 (Families)	42	44	86
- Children	44	47	91
Middle School T2 (Families)	27	29	56
- Children	30	30	60

Regarding gender distribution, the sample comprised approximately equal numbers of boys and girls from elementary and middle schools. During the first period (elementary

school), Children and parents participants were respectively 10 years old and 42.5 years old on average.

3.3. PROCEDURES

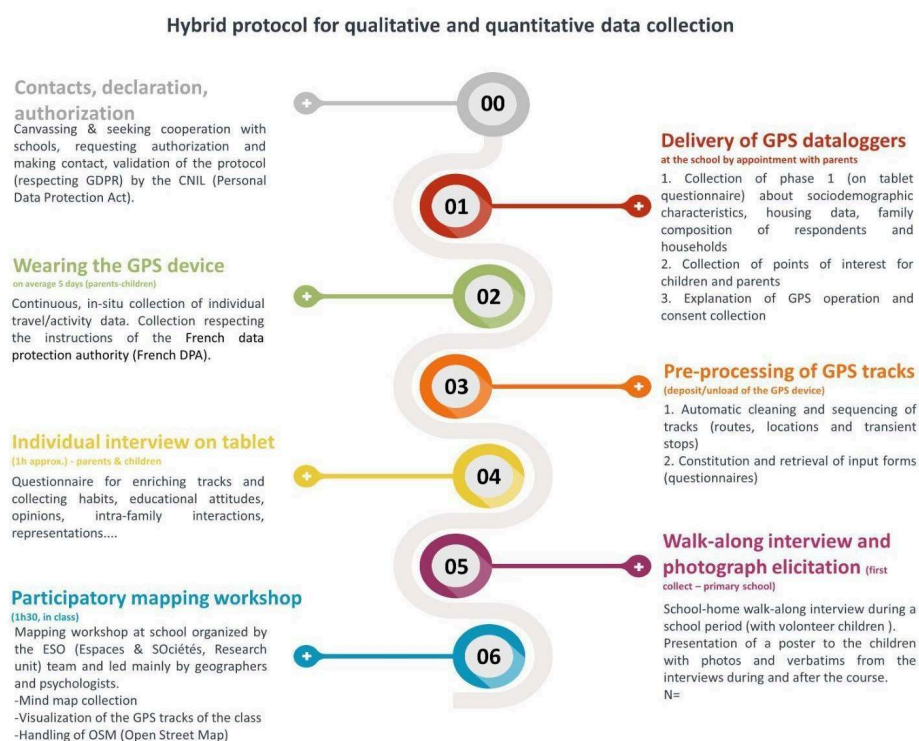
The data collection was organized into four main steps (cf. Fig. 4). The preliminary phase (00) of making contact resulted in the return of the participants' consents. The children and their parents who agreed to participate in the study were met at a first appointment (Step 1) to deliver the data loggers (one for each family member interviewed), and to schedule an appointment for a prompted recall interview. This allowed us to collect the points-of-interest for children and parents, as well as some socio-demographic and household characteristics, i.e., housing type, residential occupancy type, previous residences, etc.

The participants were then asked to wear a GPS data logger (a device custom-designed by a research program partner) over five consecutive week days, including both school and non-school days (Step 2). These GPS devices recorded second-by-second GPS position data with a median spatial location error of 2.5 meters. Then, after recovering the data-logger (Step 3, supported by Alkante private partner), the collected data were sequenced by an algorithm to distinguish the two main geospatial objects representing trips and activity-station places (Wolf et al., 2001; Spaccapietra et al., 2008). Places are defined as groups of GPS points located within a 50 m radius for at least 300 seconds (5 min), or less than 300 seconds if the data-logger was put on standby automatically. Trips are defined as groups of successive GPS points between two places.

After this, each child participant and his/her parent participated in a face-to-face individual interview at home (Step 4), using a touchpad with the MobiBack application (Depeau et al., 2019). This enriched the sequenced trips and places data with semantic attributes of daily life organization and subjective questions: mobility, free-time, children's autonomy and socialization, as well as parental recommendations. Finally, some volunteer children were also involved in an additional walk-along-interview (Step 5) and some also participated in a participatory mapping workshop (Step 6). The results presented here only include those for the first four steps. This survey, as well as the applied rules for data security and their anonymization, were approved by the French Data Protection Agency in compliance with General Data Protection Regulation. All data collection and analysis were contingent upon the child's assent and their parent's consent.

This protocol was repeated twice (and three times for the children attending the fifth grade of school): a first round when the child was in primary school (T1), and a second round at his/her first year of middle school (T2).

Figure 4: Description of the Mobi'kids data collection protocol



3.4. MEASURES AND DATA PROCEDURES: CAPTURING THE CHILDREN'S SPATIAL INDEPENDENCE AND AUTONOMY

Children's spatial autonomy is studied through three measures: their travel independence, their use of outdoor places (types of visited places), and their perceived coping abilities.

In order to discuss the MK database regarding the last HTS context, the following indicators were computed at an aggregate level, according to the spatial location (Rennes or Orgères) and the school level (elementary or middle school).

A data cleaning and structuring process was established in several steps and adapted to each type of indicator processing.

Travel Independence measures

The MK dataset (GPS tracks and enriched data) first required a data quality assessment protocol (Duroudier et al., 2020). This procedure allowed the spatial data outliers to be filtered out (11.3%). Finally, among all the cleaned data (6,428 trips), this analysis kept only the children's trips (2,308 in total, cf. Table 3).

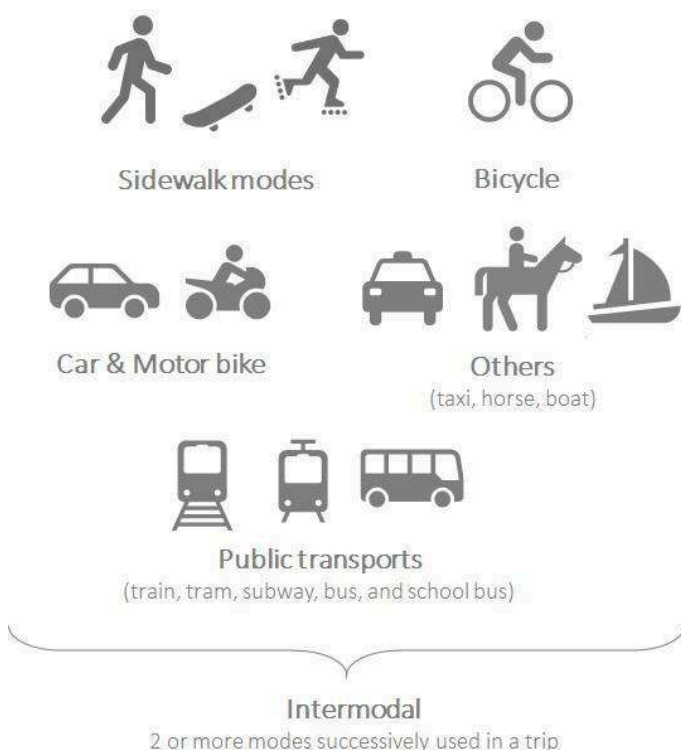
Table 3: Number of children's trips in the MK database, by municipality and school level

	Elementary school (T1)	Middle School (T2)	Total
Orgères	943	409	1352
Rennes	556	400	956
Total	1499	809	2308

To better identify possible changes in children's weekly planning and the share of weekly school time in their schedule, we distinguished between weekdays (from Monday to Friday, including Wednesday, a half-school day in France), and weekend-holidays.

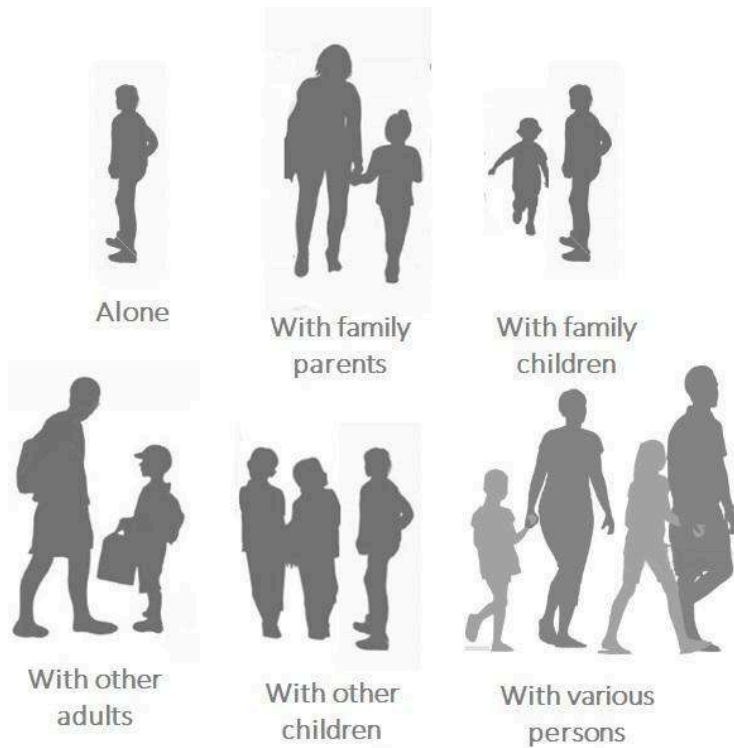
Travel Independence (TI) is measured by the transport modal split and the accompaniment. For each trip, the data were gathered on: the travel mode(s), whether the children were or not accompanied, and by whom (with a maximum of five different modes and/or accompaniment types for each trip). The travel modes can be passive, i.e. car passengers, or active ones, i.e. walking and cycling), knowing that the public transport use includes both the passive and active travel modes. As 17 travel mode types were used in the MK survey, in order to compare them with the HTS data, they were aggregated into six major modes (Figure 5).

Figure 5: Travel modes groups distinguished for analysis



The travel accompaniment type describes the degree of freedom and/or possible social interaction experienced by children during their trip. Among the six accompaniment modes, being alone vs. being with an adult characterizes the two opposing modalities of independence (cf. Figure 6).

Figure 6: Travel accompaniment modes distinguished for analysis

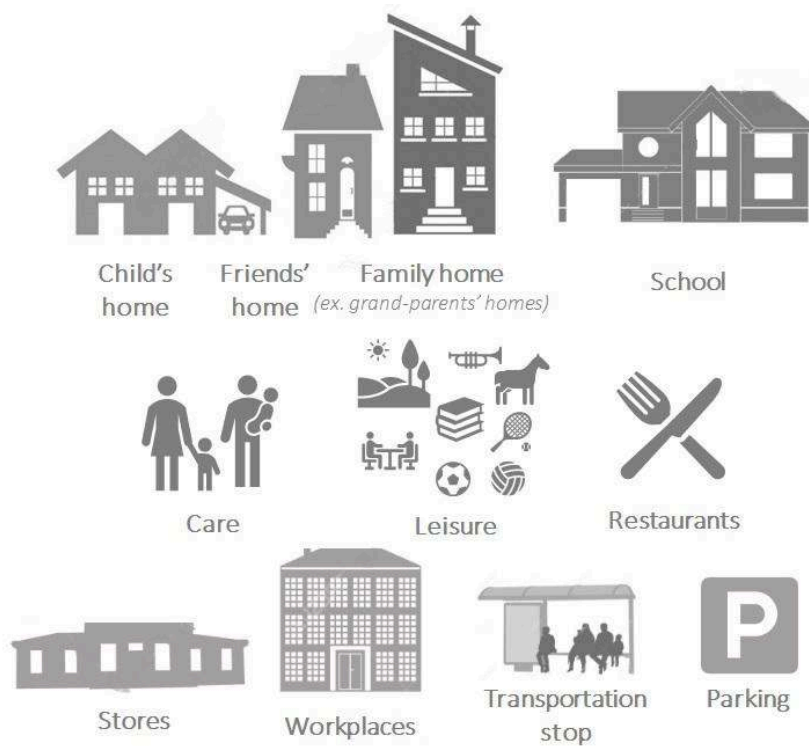


The children's travel independence is assessed by the average percentages of transport modal and accompaniment shares among all trips at the individual level. Making possible the comparison between children having different numbers of trips, percentage values are computed at the individual level among subtotals, distinguishing the average measures by the school level, the type of day and locality.

The visited places

The categories of visited places are other descriptors used in measuring children-environment relationships. Besides the school-time, exploring the types of places visited during the week vs weekends allowed us to understand the part played by the socializing dimensions of these spaces. Staying at home or in private places does not have the same meaning as frequenting public places, which are more open and mixed. The MK survey considers 12 generic types of places, defined *ex-ante* because recorded in public databases (cf. Figure 7).

Figure 7: Places' types distinguished for analysis



Moreover, other non-structurally programmed places could also constitute spaces of socialization and these “informal settings” obviously cannot be defined ex-ante but can be explored afterwards.

For the sake of anonymity, all the home places (44.3% of all visited places) were removed. As a result, only nine major categories were used for the mapping of visited places.

To describe the independence dimension, the places selected from the previous trip-accompaniment (where children go alone or with their peers vs trips with parents), were compared according to the diversity and their functions.

Frequentation and duration metrics allowed complementary measures of children's independence, enabling us to observe their routines in time and space. A set of maps was designed in order to represent visited places, and time spent there. For this, the database of places visited by the children was cleaned/filtered (for unreliable spatio-temporal quality, zero time spent in the place, and high duration of the bottom percentile) (Table 4).

Table 4: Number of children's places in the MK database, by municipality and school level

	Elementary school	Middle School	Total
Orgères	662	333	995
Rennes	448	312	760
Total	1110	645	1755

To simplify the representation of children's visited places, and to avoid duplication of the same individuals in these places, an aggregation procedure was carried out. A first pass of the DBSCAN algorithm (Ester et al., 1996), survey by survey, allowed us to gather the points (at least two) within a radius of 30 meters. However, this clustering is not always efficient in large places (e.g., a college which is more than 100 meters wide) when the distance between two points for the same place is too large. Therefore, a second one was carried out via the ST-DBSCAN algorithm (Birant & Kut, 2007). A radius of 130 meters as a parameter (130m is large enough to detect places with an unprecised location) was retained and completed by another differentiation criterion integrating the variable "type of place".

In order to map the time spent in places visited by children, either accompanied by adults, or visited alone and/or with peers, a processing chain was adopted. The merging of the duplicate locations required averaging the time spent at a place. For the places visited only once, the raw value was kept. For better legibility of the represented information, the ST-DBSCAN algorithm was applied again for all the individuals so that the often-visited places would be represented only as entities with identical geographical coordinates.

Finally, in order to observe the main visited area, the map scale was adapted. Consequently, 37.6% of the places could not be shown here.

Coping With unexpected and unfamiliar Situations (CWS)

Children's perceived abilities facing unexpected or unfamiliar travel were investigated using a series of two questions formulated as scenarios (cf. Table 5) to let them imagine and answer how they would react and behave when coping with 1) the need for an unexpected school-home travel (CWS1); and 2) the need for an unfamiliar home-peer's home (CWS2). The questions were left open-ended in order to collect the child's speech (T1 & T2).

Such imaginary situations allowed to identify firstly the child's determination and coping strategies, and secondly the reasons that justify his/her position when faced with each imaginary situation.

The corpus of verbatim collected for the two presented questions and for the two survey sessions (T1 = elementary and T2 = middle school) underwent a systematic thematic analysis, consisting of a double-blind coding process resulting in 11 themes (cf. Table 5). Two of these reflected the child's perception of his/her ability or inability to make the trip alone: STOP vs. AGREE. Then, each part of the discursive answer was categorized by Boolean modalities (0 / 1) for all of those themes.

Table 5: Thematic categories of children's responses to CWS1 and CWS2

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CWS1	"You need to come back home alone from a place of activity and make this journey on which you are usually accompanied. How do you react? "	
CWS2	"You need to go to a friend's home that you have never been to before and the friend does not live in your neighborhood, but nobody can accompany you. How do you react and manage it?	
Category	Category explanation	Label
Declared incapacity	Explicitly <u>refuses</u> to make the trip	STOP
Declared capacity	Explicitly <u>agrees</u> to make the trip	AGREE
Experience	Has already had this experience, or is even used to making trips alone.	EXP
Positive emotions	Positive emotions, joy, serenity, determination, and no fear.	EMO+
Anxiety	Negative emotions, some anxiety, stress, fear, isolation, at the thought of making the journey alone.	ANX
Safety	Travel safety, be cautious, watch out for cars, safety conditions, possible assaults, do not talk to strangers.	SAFE
Social support	Outside help, mutual aid, possible, for example a friend, a relative of a friend, etc.	SOSUP
Planning	Travel planning, a need for information such as looking at bus schedules, a map, using a GPS, etc.	PLAN
Mode of transport	Discussed the mode of travel they would use.	MODE
Parental agreement/s support	Referral to parents or other relatives for their agreement, disagreement, or assistance.	PARENT
Distance	Reference to issues of travel distance, near vs. far, etc.	DI ST

To give this additional view of children's attitudes, the modalities of answers related to the coping strategies questions for each period of data collected (T1 & T2) were submitted to a Factorial Correspondence Analysis (FCA). This helped to identify a reduced number of explanatory dimensions (factors) of children's greater or lesser determination to travel alone (Table 6). The number of axes selected depends on the Kaiser criterion which indicates axes whose eigenvalue is greater than the average eigenvalue (by definition 1 divided by the total number of axes). Then, a Hierarchical Ascending Classifications (HAC) was carried out with Ward's method from the selected axes of the factorial analysis (Table 6). The number of groups of children and their composition depending on their perceived coping abilities (Table 6) could be distinguished. Here, the number of groups retained depends on the criterion of the elbow which allows to keep the groups that have simultaneously the highest inter-cluster and the smallest intra-cluster distance.

Table 6: FCA and HAC elements of CWS1 and CWS2 question analyses

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	T1 (Elementary school)	T2 (Middle school)
CWS1 <i>Traveling alone in unexpected school-home travel situations</i>	FCA: n=90, 5 factors: 74% variance HAC: 3 groups, 1st: 47 children (52%), 2nd: 15 (17%), 3rd: 28 (31%)	FCA: n=58, 3 factors: 59% variance HAC: 3 groups, 1st: 24 children (41%), 2nd: 12 (21%), 3rd: 22 (38%)
CWS2 <i>Traveling alone in unfamiliar home/peers' home travel situations</i>	FCA: n=90, 4 factors: 68,5% variance HAC: 4 groups, 1st: 13 children (14%), 2nd: 43 (48%), 3rd: 17 (19%), 4th: 17 (19%)	FCA: n=59, 3 factors: 64% variance HAC: 4 groups, 1st: 14 children (24%), 2nd: 17 (29%), 3rd: 8 (13%), 4th: 20 (34%)

The comprehensive presentation of composed groups will be shown later, while commenting on the results (part 4.1).

The HAC carried out for CWS1 (T1) resulted in three groups of children:

- The group of **willing** children who spontaneously agree, have the necessary experience, and are happy to do it.
- The group of **cautious** children who need to be assured of good safety conditions to make the trip.
- The group of **unwilling** children who are afraid and refuse to travel alone. They ask for social support and accompaniment.

The three groups of children for CWS1 (T2):

- The group of **transport-dependent** children whose agreement is conditioned by the mode of transport they will be able to use.
- The group of **own experience-dependent** children whose agreement is conditioned by their personal experience and the extent of travel planning that can be done beforehand.
- The group of **anxious** children who ask for social support, and trip accompaniment, especially by their parents.

The HAC carried out for CWS2 (T1) yields four different groups of children:

- The group of **experience-dependent** children who spontaneously agree to make the trip, thinking they have the necessary experience, and who are confident.
- The group of **social-support dependent** children who need help from others and to plan their travel.
- The group of children **held back by distance** who have **distance anxiety**. They are stressed by the distance of the trip to be made.
- The group of **unwilling** children who spontaneously refuse to make the trip alone without giving any particular reason.

The four groups of children for CWS2 (T2):

- The group of **transport-dependent** children whose motivation is conditioned by the mode of travel they could use.
- The group of **social-support dependent** children who need help from others and to plan their travel.
- The group of children **held back by distance (distance-anxious)** who attach importance to distance and feel stress about making a long trip alone.

- The group of **unwilling** children who spontaneously refuse to travel alone without giving any particular reason.

4. RESULTS

4.1. Children's ability to undertake unexpected and unfamiliar travel

To appraise the evolution of autonomy, the ability to make decisions under unknown and unfamiliar situations are first presented, then independent travels and finally the visited places.

For this, the groups of coping strategies identified in the method were described and drawn in the factorial design made from the thematic categories of children's responses to CWS1 and CWS2 to facilitate the comprehensive and comparative analysis between T1 and T2. These allow us to see how children appraise their ability to cope with unexpected and unfamiliar travels according to the transition period. These are depicted by the graphics for CWS1 (unexpected travel) in T1 (primary school) and in T2 (middle school) and for CWS2 (unfamiliar travel) (see Fig. 8 A & B and Fig. 9 A & B).

During the primary school period, we note that children can be divided into three distinct groups, ranging from the spontaneous volunteers (axis 1 - social support) to the unwilling children who refuse to travel alone, and in between, the cautious group who hesitate and who are more representative of axis 2 (travel preparation).

When children are in middle school, this nuance disappears and they volunteer more. Indeed, the group of anxious children is opposed (axis 1 - experience) to the group of children who feel able to undertake an unexpected school-home trip by themselves. Furthermore, children's spontaneous acceptance is also dependent on their experience-based ability to use some transport modes (axis 2 - positive emotion). This last recalled experience also contributes to a positive affirmation of their response.

Figure 8A: Ellipse projections of groups in primary school (T1) on their two explanatory axes for unexpected travel

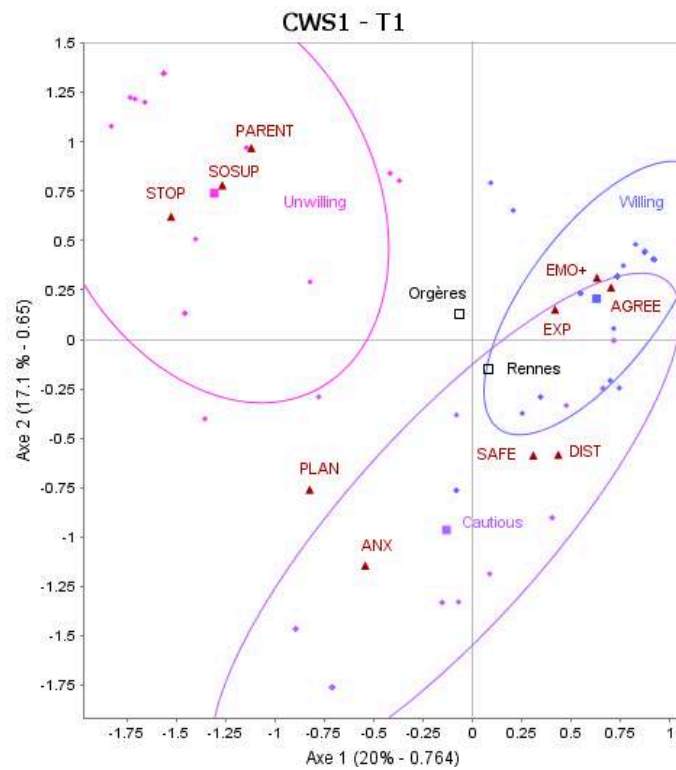
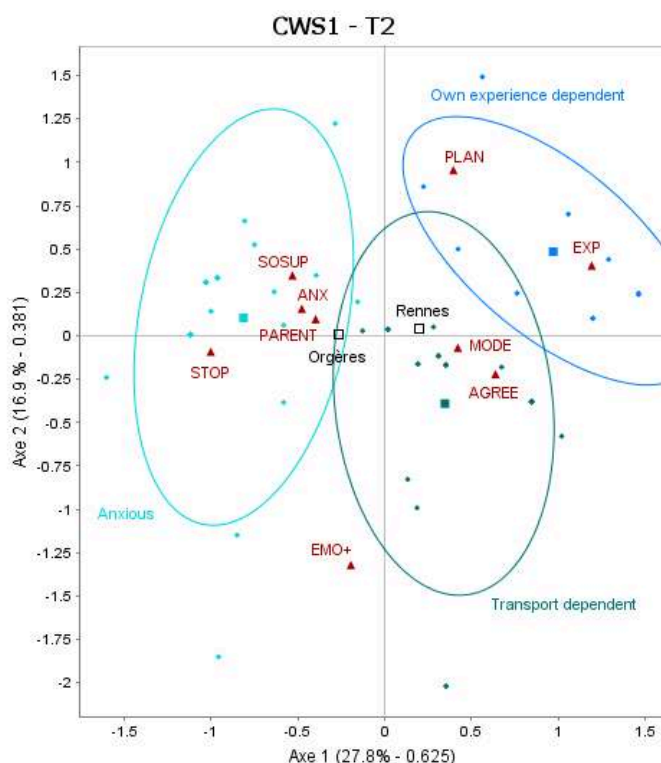


Figure 8B: Ellipse projections of groups in middle school (T2) on their two explanatory axes for unexpected travel



Key:

T1 - axis 1: social support / axis 2: the preparation type

T2 - axis 1: experience / axis 2: positive emotions

Red triangles - Active variables of strategies

Squares - Additional variables of urban site

Colored ellipses - different groups with the central value shown as a colored square

When comparing children's groups facing unfamiliar home-peer's home travel (CWS2), (see Fig. 9 A & B), in T1 (primary school) and in T2 (middle school), we observe relatively stable levels of responses. The unwilling children and those who are afraid of distance are opposed to volunteers who need social or transport-related support as shown by axis 1 (predisposition for T1, and determination for T2). Moreover, the separate volunteer groups stand out on axis 2 (distance for T1, and social/transport-related support for T2).

The security issue does not distinguish the 6th-grade children's position regarding this travel scenario for middle school, unlike primary school children. This type of trip does not result in greater ease of travel for middle-school children. The difference lies in their willingness to make this type of trip drawing on their knowledge of public transport networks, rather than on their lived experience as they did in primary school.

Figure 9A: Ellipse projections of groups in primary school (T1) on their first two explanatory axes for unfamiliar travel

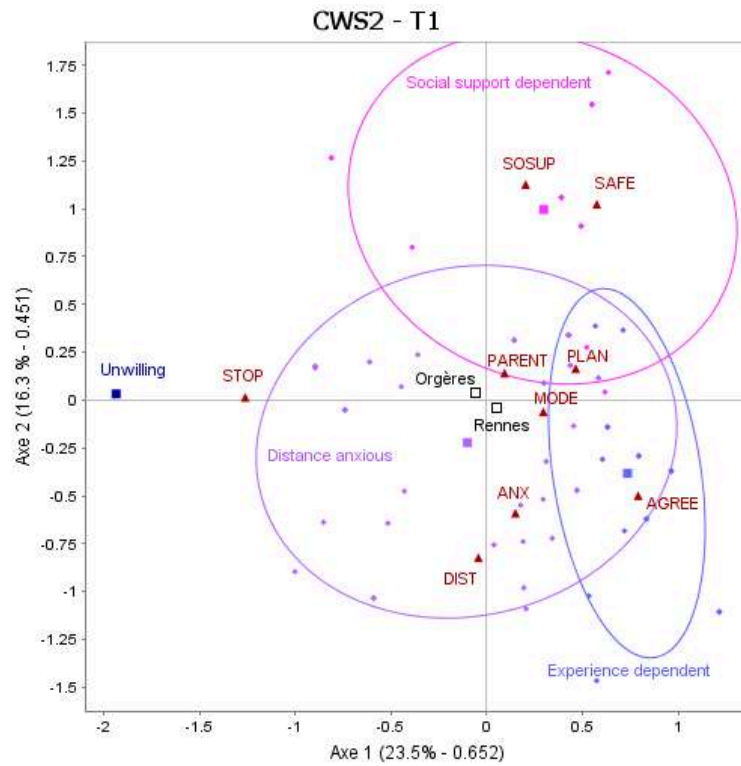
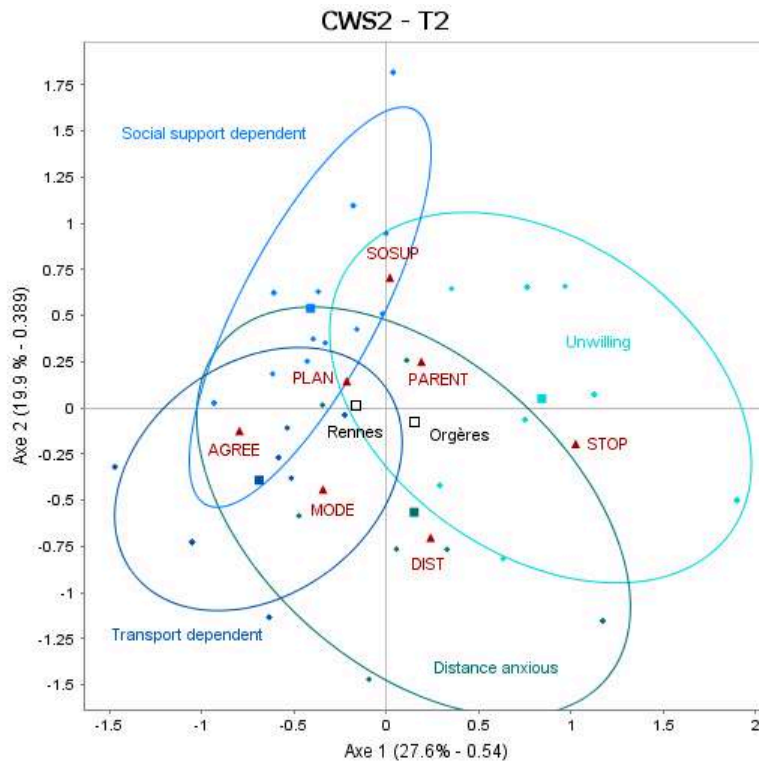


Figure 9B: Ellipse projections of groups in middle school (T2) on their first two explanatory axes for unfamiliar travel



Key:

T1 - axis 1: predisposition / axis 2: remoteness

T2 - axis 1: determination / axis 2: human and transport-related support

Red triangles - Active variables of strategies

Squares - Additional variables of urban sites

Colored ellipses - different groups with the central value shown as a colored square

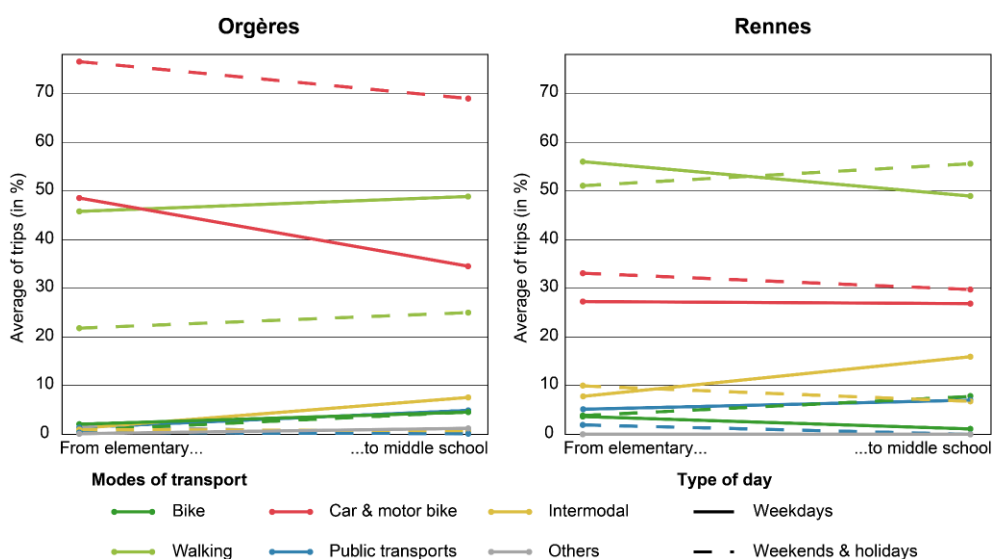
To go further, the children's ability to do unexpected and unfamiliar travel differently according to socio-spatial conditions were analyzed. Knowledge of or experience with a mode of transportation (especially buses, but also bicycles) appears to further condition children's perceived ability to make an unexpected and unfamiliar trip when they are in middle school. Moreover, urban living conditions also explain the perceived ability to travel alone in unfamiliar situations. Indeed, children in middle school who spontaneously volunteer to make unexpected school-home trips alone are more likely to live in Rennes ($X^2(2) = 11.3$; $p < .01$; $V = .43$), in collective housing ($X^2(6) = 19.48$; $p < .01$; $V = .42$). Similarly, children who are more likely to make a trip alone, as long as they have support, are those whose parents are urban homeowners. Those who feel anxiety are characterized by parents who have recently moved to an urban environment. Children whose parents are homeowners in the suburbs tend to refuse to travel alone ($X^2(9) = 26.24$; $p < .01$; $V = .43$). Finally, during middle school, the housing environment conditions children's ability to cope with the idea of traveling alone. Children living in urban areas are more willing to undertake unexpected school-home travel (compared to children living in suburban areas) and unfamiliar home-peer's home trips by requiring transport-related and/or social support to do so.

4.2. Independent mobility

As a first view of children's behaviors from the MobiKids survey, figures 10 and 11 present first exploratory results about the average proportions of modal and accompaniment splits between children. These mainly show evolution trends in both the type of accompaniment and the classical opposition in the travel modes between the suburban context of Orgères and the central urban context of Rennes, strengthened in the middle school period.

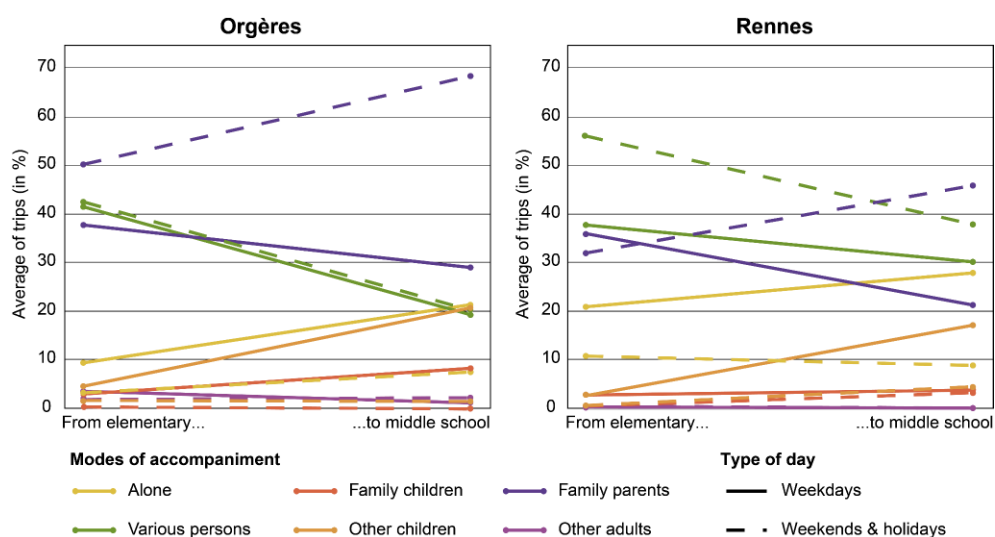
Concerning the travel modal split of children (Fig. 10), the first result highlights the share of driven trips during weekdays by Orgères children than Rennes ones: 48% and 34% on average. On the contrary, if children have numerous walking trips in both cities, they generally walk in similar proportions with about a half of travels. Secondly, children in Rennes count more multimodal and public transport trips, which is also increasing at the middle school level. Thirdly, at the middle-school level in Orgères and during weekdays, travels by car are decreasing, while walking tends to be more used than the car.

Figure 10: Mobi'kids children's average modal split of trips by location, school level, and type of day



Concerning travel accompaniment (Fig. 11), elementary school children of both urban contexts mainly move with their parents or with various accompaniments. But these types of accompaniment are mostly decreasing at the middle school level, especially in Orgères for weekday trips with various accompaniments and in Rennes for weekday trips with parents. Secondly, children from Rennes also seem to travel alone more frequently than in Orgères at the elementary school level, while this alone mobility increases in Orgères at middle school up to the level of children from Rennes. However, the independent trips appear limited during weekends and holidays. Thirdly, between elementary and middle school, the share of other children's accompaniment during the week rises and reaches 21% in Orgères and 17% in Rennes.

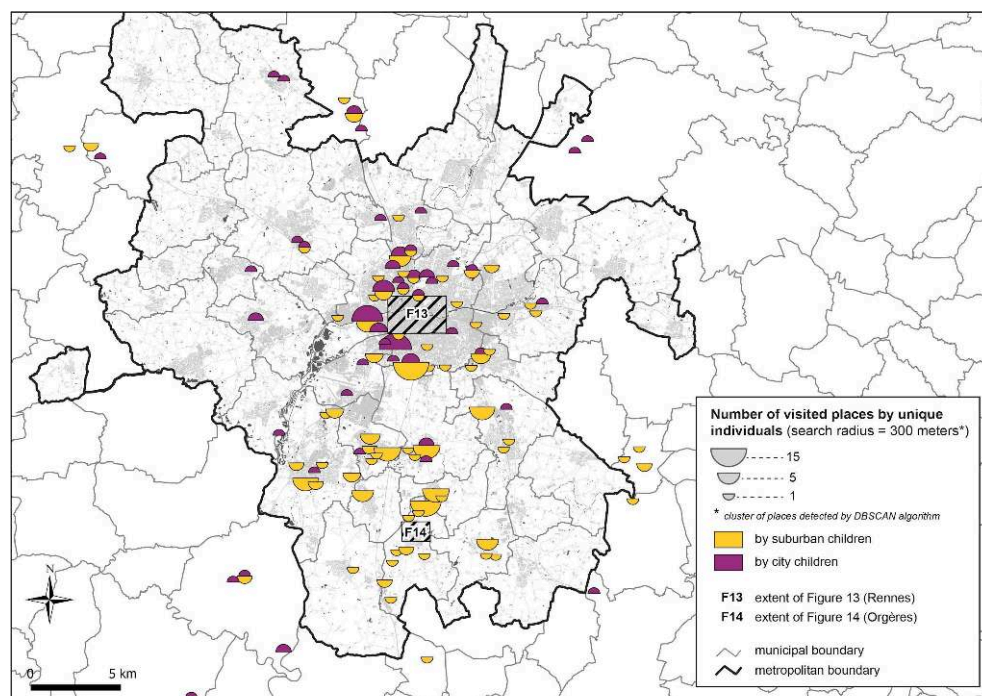
Figure 11: Mobi'kids children's average trip accompaniments by location, school level, and type of day



4.3. Children's visited places

First, we should note the differences between Rennes and Orgères in the range of places visited by children. The general map at the metropolitan scale (Fig 12) shows the extent of the places visited by children in Rennes vs Orgères and in particular the polarization effect of these places according to the two municipalities (mainly to the northwest for both).

Figure 12: Metropolitan map of the places visited by children with the size of scale of each surveyed urban site



Authors: Kerouanton, C., Lepetit, A., Depeau, S. Sources: IGN BD TOPO 2021; © OpenStreetMap contributors, ODbL License; Rennes Métropole, ODbL License; ANR MOBIKIDS Survey 2018-2019

This first map also displays the size of the scale used for the following set of maps of Rennes and Orgères (hatched boxes 13 and 14). Indeed, these next maps point precisely the communal polarization effects of children's visited places in Rennes and Orgères during the recording of the GPS tracks at the 5th (T1) and 6th (T2) grades (for the sake of legibility, the whole metropolitan map could not be presented on the maps).

Here below, two types of visited places can be noted: places where children go alone or with friends (PAP), and places where children are accompanied by adults (PAD). On each map, the colors distinguish the survey periods: coral-red for the elementary school period and turquoise blue for the 6th grade period. The shape of the symbol refers to the municipality of residence of children: circle for the places frequented by the children of Rennes and diamonds for places of the children of Orgères. The size of the symbol varies proportionally to the average time spent in a place by each child.

Evolution of places visited by children (where they go alone or with adults) in Rennes

In general, Figures 13 show that PADs are on average more often frequented, more spread out and concern a higher proportion of children in the 4th-5th grade than in the 6th grade. They are also more concentrated in Rennes city-center. Leisure places and stores are the main places where they go and spend time with adults. This raises the question of the interweaving of parent-child trips more than that of children's autonomy. Indeed, these are two types of places where children and parents can share their spent time.

The PAPs are more spread out and slightly more varied when children are in 6th grade than when they are younger. Leisure and transportation places are the two most important categories pointing to entry into the 6th grade. This last category also marks new travel patterns for children living far from the school, which confirms the previously observed results for travel modes. The extent of PAPs also depends on the larger size of secondary school catchment areas. Thus, middle school becomes an important PAP, although it continues to be a PAD (no doubt because of the distances involved). Conversely, elementary school is a place to which more children seem to be accompanied on average even if, unlike Orgères, it also remains a PAP during the 4th and 5th grades. Although the transition to middle school leads to a higher proportion of visited places (and some new ones such as stores or healthcare places), the PAPs are still very strongly associated with daily activities such as school and extracurricular activities.

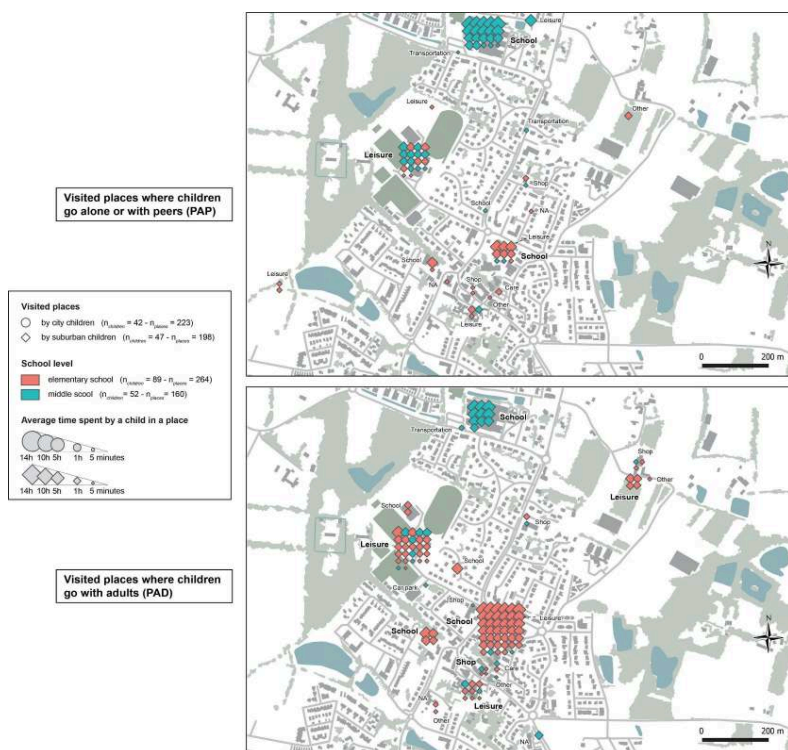
Figure 13: Distribution of places visited by children from Rennes: in non-accompanied trips (top: alone or with other children) and in trips with parents (bottom), during two school level periods (T1 and T2)



Changes in places visited by children (where they go alone or with adults) in Orgères

Comparing the PAP and PAD maps (Fig. 14), differences in the proportion of children and the average time spent seem to be higher when children are in 5th grade. Thus, school is the main PAP for children attending 6th grade, whereas it was mainly a PAD for primary school children. In both municipalities, the main PAPs during the transition to middle school are: middle school (north Orgères) and the leisure center (west Orgères). Surprisingly, the PAPs are more diversified when children are in the 5th grade than when they are older (6th grade). And even the use of informal venues seems to be more characteristic of primary school children. In addition, stores where children go as frequently with adults as alone are on average more visited by 5th grade-children. Furthermore, if the leisure places (such as sports complex and the media-library) are places where primary school children are on average more accompanied, they become places of independence for a significant proportion of children attending middle school. Moreover, as in Rennes, places of transportation appear within daily visited places when children in the 6th grade. The central places (close to the school and located in the town center) where a few children go alone during 5th grade are more visited when they transition to 6th grade. Nuances in the density of urban amenities and town structure help to explain the lower proportion of places that children visit alone or with adults in Orgères. While children from Orgères go to Rennes city, Orgères is not a place where children from Rennes have activities.

Figure 14: Distribution of places visited by children from Orgères: in non-accompanied trips (top: alone or with other children) and in trips with parents (bottom), during two school level periods (T1 and T2)



All maps show nuances in terms of the extent and type (function) of places. Despite the reduced coverage of the map (1:6000 scale for Orgères; 1:12000 scale for Rennes), that limits the representation of all places, we can observe changes in the visited places for each selected school sector. We observe that the PAPs during the elementary school period remain basic and are mainly centered on the school, some leisure places, and stores. However, when children reach the 6th grade, the range of places they visit increases, mainly because of the school catchment area.

For the two study sites, we observe the same trend changes concerning the average number of places visited by children: the average number of places where children are accompanied by adults decreases between the period of 5th grade and the transition to 6th. Conversely, the average number of places where children go alone increases during the transition to 6th grade. This result is noteworthy because it could explain an effect of the transition between school levels. Finally, the low diversity of visited places in the center of urban sites is only slightly compensated by visits to friends' homes, which remain very moderate or even decrease.

5. Discussion-Conclusion

In the context of a large metropolitan area comprising a mix of different, more or less urbanized spaces, this study examines children's spatial autonomy beyond the classic approaches. The current challenges of the energy transition show a growing need for the use of "soft modes of travel" (cycling, walking) which implies a better

understanding of the springs of children's autonomy including their ability to cope with various spaces and social situations.

Thus, this exploratory study aimed to describe how children's spatial autonomy evolved during the "normative transition" from primary to middle school, a key event in individual and familial biography (Scheiner, 2007) that transforms the territory and the daily life rhythms. In this perspective, from our multidimensional definition of autonomy, and while results focused here on three dimensions, we assumed that children in middle school are more likely to travel and visit places independently. One finding overlaps with other important comparative studies showing "*the transition from primary to secondary school as a major change in children's autonomy*" (Carver & al., 2013, p. 272). The MK results tend to confirm those of the HTS concerning the differences in elementary school children's travel modes in the Rennes suburbs, particularly in the use of cars (48%). In contrast, the site differences of walking are less marked in the MK than in the HTS data. It could be due to the collection mode (GPS data loggers and interviews). This afforded to capture the pedestrian modes in a more granular manner than in HTS. While the primary school children seem to be more escorted by their parents in both territories, they are less so in Rennes city than in the suburbs when transitioning to middle school. This could be explained by the Rennes larger size of the school catchment area for middle school (an exosystem factor) and other factors related to parents' urban living and family structures (meso-system factors). It may force children to use more public transport and to vary the number of accompanying persons supporting their independence.

The MK results tend also to show that children are more independent (less accompanied) on weekdays when they attend middle school. However, parental accompaniment seems to increase at weekends. This begs the question what children's independence competences mean in some cases. Would the absence of parental accompaniment also be linked to issues of family's activity sequencing? Indeed, parental accompaniment may not only be a functional, security-protection activity, but also a time spent together in shared activities as Fotel and Thomsen have stated (2004). These are moments that can help to strengthen family relations and compensate for limited exchange time during the week.

These initial findings on travel independence are reinforced by the number of places visited while children travel alone after the transition to middle school. However, given the variety of places visited, which seems to be reduced during this transition, the data on the children's level of independence are not sufficiently complete for us to qualify this as a form of autonomy as defined earlier. The indicator of distance or time spent traveling alone - planned in future analyses to define autonomy - would allow for a more confident interpretation of these time differences. However, the results seem to show reinforced routines with respect to some visited places (related to extracurricular activities) but also a functional impoverishment of places visited during the transition to middle school, whatever the living context. This result, which could be explained by more constrained schedules or "space-time of action" (Demoraes et al., 2020), could also raise questions for some other children's place uses showing more frequent use of formal but also informal socializing places, especially visits to stores alone, often characteristic of girls (Carver et al., 2014).

Those results confirm the need to go beyond the sole independence indicators and incorporate more qualitative indicators concerning children's self-confidence and

coping strategies. In this sense, even if moving alone seems more typical of children's mobility in Rennes than in Orgères, children feel more capable of taking an unfamiliar or unexpected trip on their own when attending middle school. This relies also on a strategy of coping with specific transport modes. Their active travel practices may reinforce a sense of familiarity which contributes to their autonomy, based on different strategies (such as to plan their trip to feel able to make it, to ensure social support). The transition to middle school induced independent bus travel, and the ability to travel longer distances. This enhanced bus use (salient in both the MK and HTS results) may show how transitions can translate into mobility and become a descriptor of biographical and institutional dimensions (Barker et al., 2019). The distance to be covered is particularly decisive in undertaking an unknown route and can be overcome by using the bus which affords cognitive support and means of reassuring children. Increased travel independence, notably reflected in more frequent use of public transports (noted in results on travel mode as well as on the maps of visited places), could be related to the group of “transport-dependent children”. Those confirm environmental psychology research highlighting children's need to interact with space and peers (Depeau, 2003; Karsten and van Vliet, 2006; Prezza and Pacilli, 2007) to help them to acquire self-confidence in coping with unexpected situations. The impact of residential anchoring and intra-family spatial routines raises questions about the role of contextual factors in the development and acquisition of autonomy.

Thus, drawing on mixed methods (qualitative and quantitative data including GPS technology), it was possible to simultaneously observe spatio-temporal indicators (to measure independence) and psychological indicators (to define autonomy) such as the coping strategies used by children when they face unfamiliar or unexpected socio-spatial situations. However, the next step is to look at autonomy as a multi-dimensional process. It should make it possible in the future to better explain the reasons for changes in behavior.

While the longitudinal approach was analyzed but still underexploited, this first insight into the MK results data allowed to identify some differences in children's travel behavior, as well as other social and psychological dimensions according to the normative transition to middle school. Mobility makes manifest a large part of the changes occurring during transitions and whatever the period of life (cf. changes in auto-mobility with elders in cities, Lord et al., 2011). Certainly, transportation is also an important vector (place and time) for social relationships during the transition to middle school, especially when the children no longer attend the same school class.

We must also point out some limits and perspectives of this research. As the presented results are only at an aggregate level, an intra-individual analysis applied to a sample of children who underwent both survey periods would be necessary to analyze changes more finely and with greater confidence. The use of GPS technology with children implied a need for anonymity and data protection that necessitated limiting map representations of the group of places that are important in the children's daily lives. Moreover, these results have no inferential value and should be interpreted with caution. They cannot give a general view of children in urban and suburban environments. Indeed, trace analysis remains a complex process that requires considering not only their intrinsic quality but also their volume at an individual level due to the inter-individual variability of the GPS trace collection time. This means that other more developed statistical analyses (such as hierarchical models) would be required for deeper investigation. However, results provided unprecedented insights

into how and where children travel and spend their time. And, by enhancing GPS tracks with qualitative data, we are able to understand what the senses of place are for children, and their role in children's perceived coping strategies.

Lastly, another way to understand the transition to middle school with respect to the acquisition of children's autonomy in urban contexts will be to observe and compare both the mobility of children and parents and activity patterns, and their evolution in order to explore the mobility socialization (Scheiner and Rau, 2020). To address this question, we can use additional MK data concerning a wide range of factors that will be studied under the notion of "urban educative cultures".

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NOTES

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ABSTRACTS

In the context of urban transformation, children's mobility is a field of study in the social sciences that has been growing rapidly over the last twenty years. In this research, we aim to understand how children's autonomy evolves during a "normative transition" from elementary (T1) to middle school (T2). Children's autonomy is studied through daily independent travel, types of places visited as well as by observing children's ability to deal with unexpected and unfamiliar situations.

Based on a longitudinal Mobi'kids survey using mixed methods (GPS travel/stop data; data from prompted recall interviews with children), children's autonomy (based on independent travel, types of places visited and the ability to deal with unexpected situations) was analyzed over two periods (T1, n=86 and T2, n=56). The results show differences in mobility habits between the suburban and city children (in both T1 and T2), but also the same evolution trend in terms of independent travel while attending middle school (T2). The normative transition seems to have a role in some travel patterns and consequently on a few coping strategies to deal mainly with unfamiliar contexts.

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Keywords: Children's autonomy, Independent travel, GPS tracks, Longitudinal study, Routines

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