Changes in Transport Behavior by the Fragmentation of Activities

Submission date: 1st April, 2004

Number of words: (6,647) words, 3 tables, 1 figure

Authors: Claudia Nobis *
Barbara Lenz
German Aerospace Center – Institute of Transportation Research
Rutherfordstrasse 2
D-12489 Berlin
Germany
tel.: 0049 30 67055-233
fax: 0049 30 67055-202
e-mail: claudia.nobis@dlr.de
barbara.lenz@dlr.de

* Corresponding Author

ABSTRACT

The present article was based on an empirical study aiming to reveal the relationship and interaction between use of information and communication technology (ICT) and travel behavior. To this end, a concept is developed built around the basic idea that technological developments, both in the travel and especially in the communication sector, increase flexibility, thus enabling a fundamental reorganization of activities. A major feature of the interplay between ICT and travel is the spatial-temporal fragmentation of activities, which can cause both quantitative and qualitative changes in traffic volume. Questions of this type can only be answered by a long-term study. For this reason, the study presented here is set up as a representative panel, allowing further studies in the future. Using the results of the first set of data, the article describes the relationship between communication and mobility patterns and individual characteristics of people with varying affinities to ICT and which activity-specific ICT use is typical for groups of varying affinity. The article's initial evaluation of an extensive set of data allows a clear description of the relationship between ICT use, communication behavior, and mobility behavior, while providing evidence that the question is a legitimate one.

1. INTRODUCTION

The topic of "the mutual relationship of telecommunications and passenger traffic" has received a considerable amount of attention from traffic researchers for a long time. These discussions have focused on the question as to whether the rapid development and diffusion of new information and communications technologies (ICT) will provide a substitution for or generate new traffic. Some initial publications were characterized by an euphoria that use of ICT will reduce traffic, thus solving the existing traffic problems. This euphoria was accompanied by new terminology, such as "global village", "death of distance" (....) [e.g.: Negroponte, Virilio, Cairncross]. The actual changes have remained well behind expectations. In nearly all areas, e.g. telecommuting, e-commerce, and business (travel) traffic, the reductions in private passenger traffic that had been hoped for did not materialize (*1, 2, 3*).

The scientific confrontation with the effects of ICT use on traffic has essentially encompassed observing individual activities with a high affinity for ICT. The primary goal was to determine the net effect within these individual areas with respect to traffic substitution. Newer approaches, which have thus far existed only on the theoretical level, attempt to approach the problem by directly measuring the change in activity patterns. The basic idea is that the technological developments, both in traffic and especially in communications, have produced a reorganization of activities in that they have become fragmented. This fragmentation enables a concentration of activities, as well as a reduction in their duration, which may in turn produce quantitative and qualitative changes in traffic volume.

The object of this text is to provide a more detailed explanation of this idea and to derive possible effects on travel behavior. The associated hypotheses are checked by evaluating the results of a representative survey structured as a panel investigation, the first of which are presented here. By means of an iterative process, i.e. from the interplay of theoretical assumptions and empirical review of those assumptions, which in turn contributes to the further development of the theoretical framework, the object is to create a well-founded, empirically secure impact model in the long term.

2. THEORETICAL CONSIDERATIONS

The idea of looking at activities as the basis for explaining travel behavior is not new, neither on a theoretical nor on an empirical level. The activity-based approach is gaining importance, especially for the development of traffic simulation models. The reason for this trend is the realization that it is not enough to measure traffic flow and to keep records of trips sorted according to purpose. This data is merely the external result of a complex interplay of various individual and external factors. If travel behavior is to be explained or projected, or if the intent is to estimate the effect of various measures or, as in the present case, the effect of ICT on travel behavior, a deeper understanding is needed of the cause-effect relation which affects travel behavior. To this end, a research branch which is concerned with the context in which travel behavior is formed has sprung up next to conventional research methods. Within this branch, various areas of focus can be differentiated: e.g. the focus may be on people's planning behavior, the development of traffic routines, or systems of values and attitudes and their effect on people's styles of mobility. The fact that the activity-based approach takes into account the reasons for the formation of certain activity patterns is due to this research branch. This branch will be introduced in greater detail below, since it is the basis for the theoretical model for the impact assessment of ICT which will subsequently be developed.

2.1 The activity-based approach as a new concept in traffic research

A person's daily routine is characterized by activities. Activities are the expression of the human need (or necessity) to take part and participate in society. Since activities are performed at certain times at various places, each individual needs a spatial-temporal organization of his activities, a certain percentage of which are associated with travel (*4, 5*).

Most people have an entire repertoire of activities which they could pursue. Over time, new activities are added and others are (possibly) eliminated. Some are performed very frequently and others only with large temporal intervals. There are activities which are dependent on the season or which are tied to a specific place. There is a series of factors, both individual and external, which determine which activities a person can theoretically perform. Only a small percentage of these potential activities are performed each day. If they require travel, these activities are the cause of passenger traffic.

On a definitional level, a distinction is made between the "activity repertoire", the set of potential activities, and the "activity program", the activities which are actually performed. A very simplified activity program can be, for example, dwelling (household activities), working, shopping, dwelling, leisure time, dwelling. Since activities are performed at different times at different places, the program results in a spatial-temporal activity pattern (*5*). People's (out-of-house) activity programs show great similarities. Zumkeller was able to show empirically that a majority of trips undertaken by people in performing their out-of-house activities can be described by a few basic patterns (*6*). However, due to spatial and temporal differences, activity patterns show clear differences.

Activity repertoires and programs, as well as the resulting spatial-temporal models, are subject to various factors. On the individual level, socio-demographic features such as age, sex, income etc. play a role, as well as personal preferences, and systems of values and attitudes. In addition to this individual level, Beckmann cites the "supra-individual regime", which includes temporal order, social conditions, and physical configuration. He divides temporal order into natural temporal order (day and night, the seasons) and social temporal order (e.g. work hours, business hours). Both place limits on potential activities, in addition to "social conditions", by which he means all economic, legal, and political regulations. "Physical configuration" refers to the spatial distribution of infrastructure, including locations, the type and quality of opportunity systems, traffic networks, and traffic options, as well as communications networks (*5*).

Thus, Beckmann has adopted the concept of temporal geography which was developed in the 1960's by Hägerstrand (*7*) and which represents an essential basis of action space research. With respect to the limits placed on human activities, Hägerstrand differentiates between three forms of constraints: capability constraints (physical and physiological limitations), coupling constraints (the need to coordinate with others) und authority constraints (legal or institutional regulations).

All of these factors affecting human behavior have been subjected over time to a large number of changes, requiring adaptation of the activities, as well as the associated spatial-temporal model and travel behavior (*8*).

Analyzing activities and the factors affecting them is much more difficult than recording trips and the purposes of those trips. However, it provides much more information on how certain travel behavior came about and appears to be a useful tool for analyzing the effects of ICT. As is travel, communication is often a precondition for the performance of activities. Most activity locations can only be reached by participation in traffic. However, travel can also be a purpose unto itself (driving for fun without a particular reason, taking walks). Communication can replace travel and shift activities to another location. Even though a great deal of attention has been devoted to this area, there are narrow limits to traffic substitution: in general, it can only occur where personal encounters or the transport of goods is not required or desirable for subjective reasons. Concentrating on the effects of substitution carries with it the danger of drawing attention from more subtle changes caused by ICT. The role of communication is not to be underestimated, not only for the performance of activities, but for their preparation as well: e.g. only after the time and place are agreed upon a meeting can occur. Moreover, communication can be an end unto itself, i.e. the activity as such consists of communication, whereby the boundaries between communication as a means to an end and as an end to itself are not firm. Thus, both travel and communication can be described as the backbone, or necessary precondition, for the performance of activities.

2.2 Considerations on the effects of ICT on activities: fragmentation and restructuring

In contrast to the activity-based approach currently standard in traffic research, which is based on analyzing the spatial and temporal sequence of individual activities, the initial theoretical considerations presented here focus on the impact of technology on the performance of activities. This includes the technology which has brought about changes both in transportation and telecommunications technology.

Each technology has a social dynamic which contributes to the changing of routine structures and routine behavior. A large number of technological developments, both in the transport and communication areas, initially have the effect of increasing accessibility. "Accessibility" refers to the potential of individuals to participate in activities. This potential depends on whether a person can reach a specific location to perform activities with reasonable expense of time and resources. In the past, accessibility was primarily a question of transport: the better the transport options, the higher the accessibility. With the spread of ICT, a clear alternative has emerged to physical travel. With the aid of digital information technology, people can participate in economic, social, and cultural activities, at least in principle, from almost anywhere in the world. Thus, the concept of accessibility has received a new dimension with various implications concerning the manner in which activities are performed and travel behavior.

The consequence of this new dimension of accessibility is that activities are no longer tied to specific times and places. This, in turn, has consequences for travel behavior. For example, travel can now be replaced entirely by use of ICT. Work involving the handling and processing of information can be performed at various locations without changing the working medium. Activities which were previously restricted to certain times of day, e.g. shopping, can now be performed at any time. Thus, the new technologies reduce dependence on space and time, at least potentially.

In this manner, each individual now has the option of conducting a deep-seated reorganization of his activities. Couclelis (*9*) speaks in this regard of the "fragmentation" of activities, which she calls one of the major phenomena of the information age. "Fragmentation" refers to the dissolution of activities occurring on several levels.

Spatial fragmentation: Previously, there was a close connection between activities and the place where they were performed, since the number of places where e.g. work or shopping was possible was subject to clear limitations. Consequently, knowledge of a person's location allowed for conclusions as to the activity performed at that location ("Tell me where you are and I tell you what you are doing“, *9*: 346). In addition, there was a spatial proximity between activities ("Tell me where you work and I may tell you where you are likely to live“, *9*: 346). In the information age, however, it is possible to perform activities at many different locations, at least in the case of activities which have a lot to do with the exchange of information in its largest sense (e.g. writing a chapter of a scientific publication is also a kind of exchange of information). For example, cell phones allow people to communicate with friends or business partners at nearly any location. "Thus the *contact set* of individuals, the number of places they interact with, explodes from one location per activity to a potentially indefinite number of locations”, *9*: 342).

Temporal fragmentation: With respect to the temporal fragmentation of activities, two developments can be distinguished, both of which are directly linked to spatial fragmentation. The fact that activities are no longer tied to a single or a small number of locations, but can instead be performed at a large number of locations, results in greater temporal flexibility. While previously people could only call their friends if they were near a land line, they can now do so while traveling. The time window in which certain activities can be pursued has thus been expanded. The second development concerns the option of not only shifting the time and place of an activity, but to divide the activity itself into different fragments. In this manner, activities previously performed at once can be divided into different sequences. One consequence of this is that the "nine-to-five weekday job gradually gets fragmented into chunks spread out over arbitrary hours of the day (and many of the night), interspersed with tasks from other activities occurring at equally odd – by traditionally standard – times as well as places” (*9*: 346). In the information age, activities can experience a completely new spatial-temporal distribution.

Fragmentation of the manner in which activities are performed: The third level of fragmentation concerns the manner in which activities can be performed. The standard linkage, i.e. the combination of a specific activity with a specific physical trip or with an [electronic] communication process, is increasingly becoming less firm. Instead, activities can now be performed in one way once and then in another. The combination of both options plays a major role: "It is this interweaving and mutual dependence of physical mobility and electronic communication, not merely the spread of ICTs, that defines the major information-age challenge” (*9*: 346).

It appears that the higher accessibility, as well as the option of pursuing activities at any time at any place in any way, will result in a higher total number of contacts. For example, while performing an activity today, it is possible to prepare another activity. It is assumed that this will reduce the overall duration of activities and ultimately result in a consolidation and parallelization of activities, while it is at least possible that the space used for these activities will further expand due to the acceleration in the traffic sector.

A large part of the increasing demand for contacts is satisfied by use of ICT. The often-cited substitution of ICT use for travel is ongoing and will continue in all probability. However, this is only part of the development. A higher percentage of the increasing contacts will remain linked by physical travel due to objective or subjective necessities. It is therefore assumed that despite, or, in certain areas, precisely because of, the increasing use of ICT, demand for physical travel will increase, at least under the present conditions, particularly the relatively low cost of travel. Couclelis therefore formulates the following hypothesis: "The fragmentation of activity enabled by the spatial technologies of the information age is one of the reasons for the widely observed increases in travel demand in the industrialized world“(*9*: 348).

In describing these developments, one must not lose sight of the fact that the resulting from the adaptation of technologies which is described here is generally a slow process. It takes time until the possibilities offered by new technologies are exploited by a *large* number of people. Human behavior is determined by routines and habits which change only very slowly, unless there is a clear necessity or an apparently useful new option. In addition, the social relation to places and e.g. the character of activities as experiences must not be forgotten: in addition to the actual activity serving a specific purpose (e.g. shopping), there are often side effects (e.g. meeting people in the shopping centre) which serve to counteract the acceptance and use of time and money-saving technologies. For this reason, no sudden changes are to be expected with regard to ICT as well. On the other hand, there are groups for which a change in activity patterns with the aforementioned elements, "fragmentation, consolidation, and acceleration", has already occurred. This is to be expected primarily for wage-earners whose function focuses on the preparation, processing, and presentation of information and knowledge. Members of this group derive particular benefit from ubiquitous ICTs. Therefore, it is presumed that this group shows a high use of ICT and that changes can be observed in their activities. This raises the question as to whether this group travels often because it can use ICT or whether it always traveled frequently and therefore bears particular affinity for ICT.

3. EMPIRICAL SECTION

3.1 Basic hypothesis and derived hypotheses

These general considerations allow derivation of a series of hypotheses representing the crux of the empirical study and which relate particularly to medium to long-term changes in the communication and travel behavior of individuals. These hypotheses are derived from the basic hypothesis that the spatial-temporal organization of activities, and, consequently, individual travel behavior, is affected by ICT use. Hence, we can expect

- the sequence of activities to become shorter,
- the number of potential activity locations to rise,
- the potential time window in which activities are performed to expand,
- that certain activities will become linked both with physical travel and with electronic information and communication.

At the same time, however, it is assumed that the fragmentation and restructuring of activities only affects a small section of the population. This group is distinguished by a high number of network contacts, activity locations, and physical trips. In addition, they display a higher temporal flexibility with regard to the times when activities are performed.

The method used for arriving at hypotheses, checking those hypotheses, and developing a concept on the basis of those hypotheses to describe the effects of ICT on spatial-temporal [travel] behavior is that of abduction, as it is often used in the social sciences. Starting point is a set of basic hypotheses that is tested while the empirical results are used at the same time for the generation of additional hypotheses to refine and broaden the original set. The purpose of that method is to bring new concepts, explanations, or valid and well-founded presumptions into the scientific discussion. The goal of abductive problem-solving is to systematically review possible explanations of observed phenomena, assuming that the explanation is not a "law", defined as a constant relationship based on logical principles, but a "regularity“, which describes probable relationships in the empirical world. Koenig (*10*) writes in this regard: "Abduction, which does not follow the principles of strict natural-sciences logic, is a process which allows unordered perception of the empirical world in order to avoid attempts to make presumptions about the relationships between things [...]. Abduction means that conclusions are drawn from observation which can then be further tested and discussed“. The result is a conceptualization of scientific questions which is subject to a dynamic iterative process.

3.2 Research design

A large number of questions regarding changes in routine behavior through ICT use can only be answered by a long-term study. This is true e.g. for questions such as whether the purchase of cell phones and increasing use of those products are associated with changes in activities. For this reason, the empirical study presented here was set up as a panel, allowing for the possibility of repeating the study and analyzing the resulting changes in routine behavior on an intra-personal level. The panel used in this case is formed from an existing panel of the market and opinion research institute TNS Emnid. The members of the panel, which has existed since 1998, were chosen using a standardized random method.

With the aim of generating a statistically measurable relation between activities, travel behavior, and ICT use which can be differentiated on a group-specific basis, the survey included the following:

- description of activity patterns
- description of activity-specific ICT use
- description of activity-specific travel behavior, including spatial aspects.

The corresponding questions are supplemented by questions regarding attitudes and motivations using item batteries and by the content of extensive basic questionnaires from TNS Emnid, which, in addition to extensive socio-demographic data, generate a psychographic description of the person using the "semiometry" method. The semiometric approach provides an instrument to describe in more detail general attitudes and values of individuals that are influencing their decisions and their behavior. The approach itself is based on an estimation of 210 words that represent a wide range of social and human dimensions. Although the semiometric approach is not an explanation for human behavior it supports explanation of human behavior (*11, 12*). As an initial approach to the question of behavioral changes caused by ICT to specific activities, the survey also includes a self-assessment by the respondents on such possible changes. In view of the general problems associated with self-perception and self-assessment, the questions were posed carefully and placed in the questionnaire so that the distortions typically induced by polls were minimized.

The study was performed as a written survey during the period between 12 May and 3 June 2003. The results are representative of German-speaking residents of the Federal Republic of Germany aged 14 and up. Thus, the results can be projected up to a total of 64.1 million people. The sample size is 3,500 people.

Since the present study is the first of a series of studies planned with the same panel sample, the intra-personal and inter-temporal comparison described above cannot be conducted yet. This will be possible as soon as the next wave of the panel is carried out what is planned within a distance of three years from the first survey. At present, it can be analyzed, using the data of the survey, whether high or low (resp. no) ICT use causes differences in the performance of activities and mobility patterns. Thus, the study is purely descriptive as it stands now. Future panel surveys and supplementary qualitative interviews will allow a description of possible causal relationships.

3.3 Preliminary results

The presentation of the first results is meant to enable an initial review of the basic hypotheses. First, a rough overview will be provided of some essential data in order enable classification and comparison of the study with other empirical studies on [tele]communication and mobility behavior. The focus will be on questions of the availability, respective purpose, and frequency of use of various ICT devices and network connections in the households of the respondents.

The true analysis of the basic theses of the concept is accomplished by a more detailed representation of groups with different affinities for ICT with respect to their communication and mobility behavior. The object is to find out if high or low affinity for ICT has an effect on [tele]communications and mobility behavior. While the data will only be evaluated here using simple statistical methods, much more detailed evaluations and more complex methods will be used during the course of a comprehensive data analysis that will follow in the next months. It is the authors' intention, of course, to publish future results in international journals.

3.3.1 The diffusion of ICT in households

A major indicator of ICT penetration in households is the equipment of households with such technologies. Regardless of the type or frequency of use, the presence of such a device or network access is an important precondition for its use in the private environment. In addition, an attitude manifests itself in the acquisition of devices and access which implies the expectation of subjective benefit. Various studies have shown that the usefulness of a technology plays a major role in the acceptance and actual use of ICT, while the prestige associated with ownership is of only secondary importance (*13*). This observation is confirmed in the present study.

In analyzing the data collected in light of the rate of diffusion, this study confirms once more that ICTs have become quite common in German households. 83% of households responding owned a cell phone, of which somewhat more than half had two or more cell phones. Thus, the equipment of households with mobile telephones is on the way to achieving a similar penetration rate as land lines, which are present in 98% of households responding. The device availability in the private households studied is therefore somewhat higher than on the national level. In any case, when comparing the figures, it must be kept in mind that a temporal gap exists between the two surveys: the official data and the present study (see table 1).

The availability of the internet in private households has remained much lower than cell phones and land lines, although the increase in recent years has been considerable in this case as well. The results of the present survey show that 45% of households have an internet connection, and another 10% have multiple internet connections. In other words, more than half of households have a computer with internet access. This figure as well is much higher than the national figures for 2002.

Devices with low penetration rates [so far] include laptops and PDAs (Personal Digital Assistant). The diffusion rates for these devices are only 12% and 3% respectively, with a correspondingly low percentage of households with several such devices available. Therefore, the following conclusions can be drawn: the distribution of mobile telephones and the internet in Germany has reached high levels, thus laying the groundwork, at least in principle, for changes in activities as a result of ICTs. With the exception of cell phones, the diffusion of mobile ICTs, especially laptops and PDAs, is still low. However, mobile terminals are expected to have a particularly strong impact on the fragmentation and restructuring of activities.

Thus, it can be said that overall ICT availability is approaching car availability, which is 89% in the households responding. 73% of respondents have a vehicle available at all times. This high availability is hardly unexpected if one keeps in mind that 35% of households responding own two or more vehicles.

3.3.2 Regarding ICT use

Studies have repeatedly shown that the increase in internet use among the German population continues unabated. Private internet use now amounts to 50% on the national average, albeit with clear regional differences (*14*: 8). With a 13% increase since 2001, the percentage of internet users in Germany has increased rapidly in recent years. The essential precondition, as was referred to above, is access to ICT.

The close relation between availability and use is shown by the survey on which this article is based. The majority of people whose households have at least one cell phone or a computer with internet access actually use these devices. The number of those who do not take advantage of this option remains low. In the case of cell phones, for example, this number is only 3%; in the case of computers with internet access, it is 6%. (As compared with use of land lines: only 0.1% of respondents indicate that they do not use their telephone even though one is present in their home.)

In cases where the devices are used, there is a high correlation with high frequency of use. Among households with a computer with internet access, this computer is used by three fourths of respondents at least several times per week, in most cases daily (see table 2). This intensive use of ICT is generally applicable. Thus, if one compares these figures with those for use of a device which shows a low diffusion rate at the moment, such as PDAs, 62% of respondents use that device several times a week, or even daily. This shows that not only is the purchase of ICT linked to a subjective expected benefit, but that expectation is converted into the realisation of personal benefit.

In view of the high diffusion and relatively high frequency of use of the internet, cell phones, and land lines, we ultimately arrive at the question which is essential for the research interest at issue here: for what purpose are these media used? A particularly striking aspect of the survey results is the fact that only a small percentage of the respondents actually take advantage of a broad range of possible uses. For example, while internet access is primarily associated with searching for information and sending e-mails, the primary function of both cell phones and land lines is to make and maintain contacts and to organize meetings. Although the devices themselves offer multiple functions, the demand for these additional functions remains low. This statement clearly applies for cell phones and land lines, but is somewhat less applicable with respect to the internet, where banking and shopping have a certain significance (see figure 1).

3.3.3 Communication and travel behavior of heavy and non-ICT users in comparison

As an initial attempt to approach the question as to the relation, on a purely descriptive level, between the frequency of ICT use and other personal features, we will now compare two extreme groups and describe them using socio-demographic factors, mobility information, etc. The groups used in this comparison are heavy ICT users on the one hand, i.e. people who use cell phones and computers with internet access present in their homes multiple times per week (n=1,070), and non-ICT users on the other hand. The latter group includes all people whose household owns neither a cell phone nor a computer with internet access and therefore cannot use any such devices in their home (n=516). The group has not been adjusted for the few who have access to such media at work. With n=1,586 in the overall group, 67.4% are heavy ICT users and 32.6% are non-ICT users. These two percentages are used as a basis for comparison for determining the proportionality of the shares of the individual groups depending on various factors.

Clearly distinct character features result for both groups on almost all levels (see table 3). Using these socio-demographic features, the groups can be described as follows:

- Heavy ICT users are much better represented in the younger age groups. Overall, a linear relationship can be observed. Heavy ICT users have a disproportionately high representation among 14 to 19 year-olds, with a share of 99.4% (comparison figure: 67.4%). This number decreases with increasing age, but remains at 81.0% among 40 to 49 year-olds. Only among people 60 years old and up do non-users predominate.
- Men are more likely to be heavy ICT users than women.
- Heavy ICT users have a high degree of education. There is a linear relationship in this regard as well, although that relationship is broken at the end. Among college graduates, the percentage of heavy ICT users is (only) 72.5%, as opposed to a percentage of 92.8% among people whose highest degree is a high school diploma. Apparently, the latter phenomenon is a result of the age factor. A majority of heavy ICT users are very young: too young to have a college degree.
- The percentage of heavy ICT users is particularly high among employed persons, apprentices, and trainees, as well as among children and students. Among the latter group, the percentage of heavy users is actually 100% (n=172). In contrast to this, a high percentage of non-users are non-employed or retired.
- The percentage of heavy ICT users increases with rising household income. Non-users have the majority up to a net monthly income of € 2,000. For households with a monthly income of € 2,000 and up, the percentage of heavy users predominates, with a clearly rising trend.
- Heavy ICT users are more likely to live in households consisting of three or more people. This result is entirely consistent with previous studies, in which children and teenagers have proven to be essential drivers for private computer and internet purchases (*13*). Obviously, their presence in the household results in higher use, possibly also due to the "support" which they provide other household members with their familiarity with the technology and possible applications.

Heavy users and non-users also show clear differences with respect to their mobility and communication:

- ICT non-users travel fewer kilometers per year. In a disproportionately high number of cases, they drive only up 5,000 km per year, or indicate that they do not drive at all. Heavy ICT users, on the other hand, are over-represented in all other driving categories, in this case as well with a clearly linear effect. Among people driving between 5,001 km and 10,000 km per year, the percentage of heavy users is 71.7%. Among those driving more than 30,000 km, the number is 97.4%.

- The car availability of households with heavy ICT use correlates with their higher driving frequency. Heavy ICT users are more likely to live in households with two or more cars. Non-users, on the other hand, live most often in households with no (80.4%) or one car (38.6%). Accordingly, heavy ICT users indicate more frequently that they have access to a car at all times.
- With regard to their attitudes, heavy ICT users have a much greater affinity for cars. Based on a five-step item battery, the following statements can be made: heavy ICT users are more likely to say,
    - that they need their car to be flexible,
    - that they can save a lot of time by using the car,
    - that owning one's own car is simply part of life today,
    - that they cannot imagine life without a car.
- Heavy ICT users have more contacts in general, both private and professional. They use ICT, too, to make and maintain contacts.

In conclusion, it can be said that there are differences between heavy ICT users and ICT non-users on almost all levels examined, differences which are confirmed by significance tests. Heavy users prove both more mobile and more communicative, and not only with respect to the media which were the basis for forming the groups (cell phones, internet), but also with respect to land line telephone as common communications media.

Presumably, the majority of the differences are attributable merely to the higher age of non-users: a high percentage of non-users are of retirement age. To what extent age is actually a decisive variable must be determined in future analyses, e.g. the analysis of differences within the same age groups. The extremely high percentage of heavy ICT users in the 14-19 and 20-29 age categories demonstrates that future generations of adults will in any case be much more strongly affected by the potential effects of ICT. However, as “age” represents a category that should be looked upon not only from a socio-demographic perspective further in-depth analysis about the importance of “age” concerning communication and mobility will be made (cf. for the discussion of the meaning of “age” *15*, *16*).

In order to further our understanding of the interesting questions raised here regarding the relationship between the manner in which activities are performed and the associated mobility behavior and ICT use, it must be examined e.g. whether the differences observed in this study also exist upon comparison of groups which are less sharply delineated.

4. CONCLUSIONS

The objective of this article, specifically demonstrating the relationship between ICT use and travel behavior, is emphasized in the presentation of the behavioral differences between heavy ICT users and non-users. This presentation has shown that the "classic" socio-demographic and socio-economic variables which are often used to characterize groups of different technology use: age, sex, degree of formal education, and income, show a particularly close relationship with communication and travel behavior. Thus, the results of the present study have proven consistent with the few studies which have been performed in the past with a similar focus, but with other theoretical and methodological concepts (*17*, *18*).

The result of the survey, specifically the fact that people with high ICT use show above-average mobility, serves as a major indication that a mutual relationship exists between ICT and mobility, although the individual effects of that relationship remain entirely open. However, it may be hoped that a more detailed evaluation of the data collected here will produce results which will not only further differentiate the relationships, but reveal causalities as well.

In general, we have come to the conclusion that our basic assumption, that mobility is affected by ICT, can be shown empirically by the study. The expectation that ICT affects human behavior in the medium term, resulting in structural, possibly even quantitative, changes in traffic, is based not only on the relationships presented in the present article, but also based on the self-assessments made by the respondents. In particular, these statements provide multiple evidence of behavioral changes in order to save time and physical trips, or to shift the time of activities, such as the fact that 22.6% of respondents with internet access at home (n=1,865) agree with the statement "I consciously do some things over the internet in order to save myself the trip." It will be the task of future studies to show what consequences arise from these changes.

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TABLE 1 Results of the study in comparison with the national situation

ICT	DLR survey 2003 (percent of households with device; n=3,500)		National survey 2002* (percent of households with device; n=25,848)
Telephone (land line)	98.0		99.5
Mobil telephone, cell phone	82.9		73.2
PC with Internet	52.9	65.2	57.6
PC without Internet	25.7		
Laptop with Internet	8.0	11.8	
Laptop without Internet	4.7		
Handheld/PDA	3.0		
Internet access	54.8		42.3

* Calculations based on data of „Mobilität in Deutschland“ – national survey on mobility behavior 2002

TABLE 2 Frequency of use for land lines, cell phones, and computers

Purpose	Frequency of use (percent)	Telephone (land line) (n=3,388)	Mobile telephone, cell phone (n=2,867)	PC with internet access (n=1,832)	Laptop with internet access (n=272)	Handheld computer/ PDA (n=103)
Private	Multiple times daily	49.1	28.1	17.4	14.1	21.5
	Daily	24.0	18.2	27.5	12.8	20.1
	Multiple times per week	20.8	21.5	30.8	31.0	20.5
	Multiple times per month	4.6	16.3	12.3	15.2	14.1
	About once a month	0.5	3.7	2.6	5.4	3.5
	Less or never	1.1	12.3	9.5	21.4	20.5
Purpose	**Frequency of use (percent)**	**Telephone (land line) (n=1,528)**	**Mobile telephone, cell phone (n=633)**	**PC with internet access (n=846)**	**Laptop with internet access (n=110)**	**Handheld computer/ PDA (n=40)**
Professional	Multiple times daily	67.4	48.1	51.3	38.4	42.5
	Daily	8.7	13.9	12.3	16.5	22.8
	Multiple times per week	7.7	12.8	11.1	10.8	4.5
	Multiple times per month	5.5	9.7	7.1	15.5	6.6
	About once a month	1.7	2.0	1.9	5.3	7.3
	Less or never	9.0	13.5	16.2	13.5	16.4

TABLE 3 Socio-demographic profile of heavy and non-ICT users and their communication and traffic behavior

		Heavy ICT users	Non ICT users
	Total (n=1,586)	**67.4%**	**32.6%**
Socio-demographic and socio-economic variables			
Sex	Male (n=794)	77.7%	22.3%
χ^2=76,3; df=1; p=0.000	Female (n=791)	57.1%	42.9%
Age	14 - 19 years old (n=157)	99.4%	0.6%
χ^2=857,8; df=5; p=0.000	20 - 29 years old (n=234)	98.7%	1.3%
	30 - 39 years old (n=297)	94.9%	5.1%
	40 - 49 years old (n=247)	81.0%	19.0%
	50 - 59 years old (n=175)	69.1%	30.9%
	60 years and up (n=477)	16.8%	83.2%
Education	Primary/secondary sch. without vocational training (n=160)	41.9%	58.1%
χ^2=160,9; df=4; p=0.000	Primary/secondary school with vocational training (n=574)	56.3%	43.7%
	Further education without high school diploma (n=542)	76.0%	24.0%
	High school diploma (n=209)	92.8%	7.2%
	Advanced education (university, college) (n=102)	72.5%	27.5%
Employment status	Employed full-time (n=586)	89.4%	10.6%
χ^2=683,5; df=6; p=0.000	Employed part-time (n=139)	83.5%	16.5%
	Currently unemployed (n=44)	68.2%	31.8%
	Retiree, pensioner (n=437)	22.9%	77.1%
	Trainee/apprentice (n=59)	98.3%	1.7%
	Child/student (n=172)	100.0%	0.0%
	Not employed (n=126)	42.9%	57.1%
Household income	Up to EUR 1,000 (n=159)	34.6%	65.4%
χ^2=229,4; df=6; p=0.000	EUR 1,000-1,500 (n=270)	48.9%	51.1%
	EUR 1,500-2,000 (n=283)	61.1%	38.9%
	EUR 2,000-2,500 (n=311)	75.2%	24.8%
	EUR 2,500-3,000 (n=171)	81.9%	18.1%
	EUR 3,000-3,500 (n=142)	90.1%	9.9%
	EUR 3,500 and up (n=164)	92.1%	7.9%
Household size	One person (n=324)	49.4%	50.6%
χ^2=245,6; df=3; p=0.000	Two persons (n=575)	52.9%	47.1%
	Three persons (n=306)	83.0%	17.0%
	Four persons and up (n=381)	92.4%	7.6%
Information on mobility and communication			
Distance driven per year	Up to 5,000 km (n=203)	49.8%	50.2%
χ^2=314,3; df=6; p=0.000	5,001-10,000 km (n=297)	71.7%	28.3%
	10,001-15,000 km (n=257)	84.8%	15.2%
	15,001-20,000 km (n=143)	95.8%	4.2%
	20,001- 30,000 km (n=106)	96.2%	3.8%
	Over 30,000 km (n=77)	97.4%	2.6%
	I don´t drive (n=499)	44.1%	55.9%
Number of cars in household	No car (n=163)	19.6%	80.4%
χ^2=347,5; df=3; p=0.000	One car (n=748)	61.4%	38.6%
	Two cars (n=484)	90.9%	9.1%
	Three or more cars (n=116)	94.0%	6.0%
Item: I need a car in order	Top Two: correct (n=1112)	78.1%	21.9%
to be flexible	Partially (n=114)	61.4%	38.6%
χ^2=128,5; df=2; p=0.000	Bottom Two: incorrect (n=264)	43.6%	56.4%
Item: By using a car, I can	Top Two: correct (n=1086)	78.4%	21.6%
save a lot of time	Partially (n=204)	66.2%	33.8%
χ^2=149,2; df=2; p=0.000	Bottom Two: incorrect (n=190)	35.3%	64.7%
Item: I cannot imagine live	Top Two: correct (n=830)	77.5%	22.5%
without a car	Partially (n=256)	71.1%	28.9%
χ^2=52,7; df=2; p=0.000	Bottom Two: incorrect (n=377)	57.0%	43.0%
Number of private daily	No contacts (n=31)	90.3%	9.7%
contacts with land line	1 contact (n=320)	61.6%	38.4%
χ^2=35,7; df=4; p=0.000	2-3 contacts (n=694)	66.6%	33.4%
	4-5 contacts (n=324)	77.2%	22.8%

FIGURE 1: Use profile of internet, cell phones, and land lines