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Research article

Coppers context, and conjoints: A reassessment of TAM

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Abstract

This study examines the role and explanatory value of context-, task- and information-related characteristics vis-a-vis individual characteristics in relation with respect to the adoption of mobile technologies and applications. We combine insights from adoption and acceptance literature with media choice and task-technology fit theories. These insights are applied to a case in which police officers use mobile communication tools and information technologies. Officers were asked which mobile applications they preferred to use in specific situations (contexts) and for specific tasks. In a structural equation model focusing exclusively on individual TAM-related characteristics, such as perceived usefulness and perceived ease of use, as well as on a generic media fit concept, the explanatory value of these concepts turns out to be high. We extend our study, based on Ajzen and Madden (1986) by arguing that, in addition to personal characteristics, contextual characteristics, in combination with task-related characteristics, play an important role in people's preferences for specific technologies. Conjoint analysis focusing on contextual and task-related characteristics yields relevant insights. When context-related and individual characteristics are combined into a single hierarchical linear model, the significance of the concepts used in TAM turns out to be low, while context-related issues stand out. On the basis of our research, we conclude that TAM models are too generic to fully explain people's intention to use mobile technologies. Future research should aim at developing models that take contextual and task-related factors into account when studying mobile applications.

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Introduction

Police organizations are information-intensive and 'intelligence led' organizations. Information is crucial to police officers carrying out their daily duties, not only in terms of obtaining the right information on time and in an adequate way, but also with regard to sharing information with colleagues and providing information to relevant information systems. Mobile access to information can improve the efficiency, effectiveness, and quality of police work. New advanced mobile devices and services promise police officers access the information they need, whenever and wherever they need it, to carry out their tasks more easily. However, in the Dutch police force, the decision to adopt specific technologies is not made by officers on the beat, but by managers and politicians and various stakeholders within the police organization. Once the decision to adopt a specific technology has been made and the associated systems are implemented, it is up to individual police officers to decide whether they will actually use the technology in question. It is only then that the anticipated effects can be realized (Bouwman *et al*., 2005).

Both for the police organization and individual officers, it is hard to assess the potential usefulness of an innovative technology. Most of the time the technologies involved are new and not yet available on the market, which means that the potential users have not yet seen or used them. Unfamiliarity with specific technologies and their potential benefits can act as a barrier in terms of user adoption (Rogers, 2003). As a result, the technologies are not used, initial usage levels by early adopters increase slowly, and

may even drop after some time, or users reinvent or adapt the technologies in ways the designers had not anticipated (Tyre and Orlikowski, 1994). It is, therefore, important to gain insight into the concepts that explain the (future) use of mobile applications. The objective is to make information available to police officers, using mobile devices, and ensuring that the information matches their specific preferences, behavior, and context. Consequently, the aim of this study is to obtain an answer to the following research question: what are the relevant context-related, individual, and technological characteristics that play a role in the use of mobile technologies by police officers?

To answer this question, we start with two different conceptualizations of the use of new technologies. As far as the future use of technology is concerned, there are two major approaches, the first of which includes adoption and acceptance theories, for instance diffusion of innovation (DoI) and the technology acceptance model (TAM) and its extensions (TAM/UTAUT), both of which focus on individual perceptions and preferences. The second approach, which includes media choice and task-technology fit theories, focuses on the use of technology to carry out specific tasks within certain (organizational) contexts.

In this paper, we present the adoption and acceptance models as opposed to media choice and task-technology fit models. We begin by providing an overview of existing literature, after which we address everyday police practice to specify our hypothesis in greater detail and present our research approach and methodology. We conclude by presenting and discussing the results and limitations of this study and by offering suggestions for future research.

Theory

Generic acceptance models

Most studies investigating the adoption of new technologies use either the DoI theory (Rogers, 1995) or the TAM (Davis, 1989), and modifications of TAM in what is known as the unified theory of acceptance and use of technology (UTAUT) (Venkatesh *et al*., 2003). A great number of studies have thus far used TAM to investigate the mobile domain (for a recent overview, see López-Nicolas *et al*., 2008).

The five core concepts used in DoI literature are relative advantage, complexity, compatibility, triability, and observability (Rogers, 1995; Ilie *et al*., 2005). Similar concepts that play a central role in TAM are perceived ease of use (related to Roger's complexity concept; Taylor and Todd, 1995), perceived usefulness (related to Roger's relative advantage concept; Taylor and Todd, 1995), behavioral intention to use (based on the theory of reasoned action; Fishbein and Ajzen, 1975, and theory of planned behavior; Ajzen, 1991). On the basis of these concepts, the first hypotheses with regard to the adoption of advanced mobile systems to be tested in this paper are:

H1a: Perceived ease of use will have a positive effect on people's intention to use advanced mobile systems, and

H1b: Perceived usefulness will have a positive effect on people's intention to use advanced mobile systems.

When potential users believe that systems are easier to use, they are also likely to perceive these systems as being more useful. This kind of effect is expected to be even stronger when advanced mobile systems are involved, because these are systems with which people are likely to be less familiar. Accordingly, we propose that:

H2: Perceived ease of use has a positive effect on the perceived usefulness of advanced mobile systems.

There has also been criticism of TAM research. Firstly, in most studies, actual use is not measured. Like the study presented in this paper most studies focus on behavioral intention. In most cases where actual use is measured, it is not measured on the basis of log-data, but on the basis of self-reports, which means that what is measured is not the actual use, but rather self-reported use. Secondly, in many cases the research population consists of students, which may affect the outcome. Student-based studies offer stronger support for a TAM-based approach than studies involving other kinds of populations (Schepers and Wetzels, 2007). A third and more fundamental criticism is that it is unclear to what extent TAM actually provides insight into (intended) user behavior. Other concepts may explain the correlations between the core concepts. In recent TAM-based studies, the focus is on concepts such as self-efficacy (Mao *et al*., 2005), computer experience (Kleijnen *et al*., 2004), subjective norms (Venkatesh and Davis, 2000; Legris *et al*., 2003), hedonistic values (Van der Heijden, 2003), perceived enjoyment (Cyr *et al*., 2006), and personal innovativeness (Lu *et al*., 2005). However, the problem with TAM is that, arguably, the intention to use a (mobile) information technology is (too) closely related to its perceived usefulness. In the original TRA approach (Fishbein and Ajzen, 1975), beliefs and behavioral intention are interrelated. In TAM research, the focus in on one of these beliefs, for example perceived usefulness, which is related to intention to use. Although many studies indicate discriminant validity, these two concepts are very closely related. Items that belong to one of the scales could easily be included in the other and vice versa (see also appendix A 'using mobile systems would make it easier to do my job', which relates to perceived usefulness, and 'I expect mobile systems to make my work more convenient', which belongs to the intention to use scale). This may suggest that these are two concurrent measurements of the same construct. To put it more formally, although in statistical terms there is discriminant validity, we observe a strong of convergence between the two constructs. We believe that the comparable formulations of the items that belong to the different scales, the high correlations between the scales, and the high levels of explained variance in many TAM research papers can be attributed to the strong relationship between the two concepts.

Moreover, TAM treats technology as a black box, rather than taking specific characteristics of technology that may influence people's (intention to) use (of) a technology into account (Legris *et al*., 2003; Lu *et al*., 2003; Amberg *et al*., 2004; Benbasat and Barki, 2007). The question that needs to be answered is: which kinds of user needs, preferences, and behavior are related to which types of (mobile) technologies. An alternative approach to understanding

the adoption and use of mobile devices is based on the adaptive structuration theory (AST) (Poole and DeSanctis, 1990; DeSanctis and Poole, 1994). The core element of AST is the social interaction that takes place between participants in a communication process and their interaction with the technology involved. The interaction is determined by the structures embedded in technology, tasks, and the organizational environment, as well as by a number of characteristics of the participants themselves. AST is based on the notion that task-related characteristics need to match technological characteristics (and vice versa), if effective communication is to take place. The concept of fit was introduced by Daft and Lengel (1984, 1986) and later extended by Goodhue and Thompson (1995) and Dishawa and Strong (1999). Their approaches are known as the media choice, media richness theory, and the task-technology-fit approach. The media choice, media richness theory suggests that not all information and communication technologies are equally suited to meet the information requirements associated with specific tasks. Here, the concept of technology is interchangeable with (mobile) application or media. The media choice, media richness theory has also been the subject of considerable criticism, especially with regard to some of the underlying assumptions (Fulk *et al*., 1990): communication technologies and tasks are assumed to have fixed characteristics; all users are supposed to be aware of the inherent differences between the various available technologies and tasks; the social environment is assumed to have no influence on the choice process; and media choice is viewed as a rational and cognitive process motivated solely by efficiency. More subjective approaches, such as the social influence model (Schmitz and Fulk, 1991), the channel expansion theory (Carlson and Zmud, 1999), and social information processing theory (Walther, 1992), are based on the assumption that the characteristics of task and medium cannot be determined objectively. The same applies to matching information and communication technology and task: different users will make different choices based on their individual characteristics. There is a clear trade-off between (1) perceived usefulness, (2) perceived ease of use of specific technologies, (3) the extent to which a specific medium (application or technology) matches a specific task – in this paper, we use the concept media fit –, and (4) the intention to use the specific medium (see Figure 1). On the basis of the TAM theory and the media choice, media richness concepts, we hypothesize, that, in addition to the direct effects of perceived ease of use and perceived usefulness on intention to use:

> **H3:** Media fit mediates between the original TAM concepts perceived ease of use and perceived usefulness and intention to use advanced mobile systems.

Police tasks

Thus far, we have not addressed the domain under investigation, that is the Dutch police force. Sørensen and Pica (2005) provide a detailed ethnographic description of police work in the United Kingdom. With regard to the Netherlands, Elias (1997), Stol *et al*. (2004), and Hoogenboezem and Hoogenboezem (2006) provide insight into the everyday practice of policing. They make it clear that the physical context of police work changes continuously. Police officers can find themselves in a quiet environment or in a very hectic situation with information coming at them from multiple actors. They can do desk work at the precinct, walk around talking to people, drive a car, or ride a horse, bike, or motor while on surveillance. To

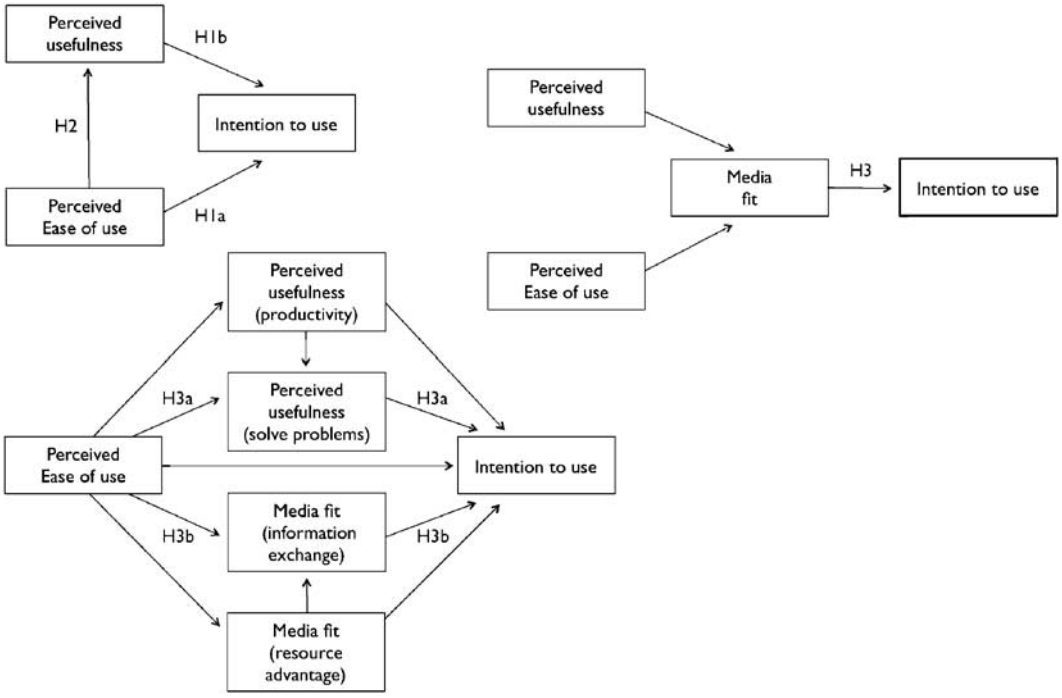

Figure 1 Hypotheses to be tested using structural equation modeling.

a large extent, the question whether and how police officers use mobile devices, systems, and applications depends on the environment in which they have to perform specific tasks. In the Netherlands, a police officer's job can roughly be divided into two types of tasks, the first of which is related to ordinary police officers responding to all kind of emergencies, incidents, and accidents, such as traffic accidents, burglaries, robberies, shop lifting, domestic violence, and so on. The available information and communication technologies have to be instrumental in solving the problems at hand and yield to immediate results. As far as stakeholders within the police organization are concerned, these technologies have to contribute directly to the productivity of the police force. Ordinary police officers are aware that the use of (mobile) applications and technologies can help increase their productivity.

The second type of tasks has to do with neighborhood policing. In most cases, police officers are stationed in and 'responsible' for a specific neighborhood. They walk their beat, talk to people, make it their business to know the shop keepers and other people living in the neighborhood, collect intelligence on the social fabric of the community and on possible suspects, social welfare cases, and so on. They are concerned with the issues that are discussed in the community. Information is crucial in all this, and it is seen as an essential element of crime prevention, in addition to building social capital. The available information and communication technologies have to facilitate the exchange of exchanging information, not only between police officers and citizens but also with fellow police officers and relevant stakeholders, including social welfare workers, doctors, schools, and organizations in the neighborhood. The information has also to be available to the systems that support police work. Mobile applications have to complement existing resources. Police officers assess the perceived usefulness of mobile systems based on the extent to which they complement existing systems (resource advantage).

In addition to the assessment of the perceived usefulness in terms of increased productivity and resource advantage, these tasks also fit more- or less-structured processes. In most cases, information exchange-related tasks are part of highly structured and formalized processes, while problem-solving task are part of unstructured and unpredictable processes (Pica and Sørensen, 2004; Bouwman *et al*., 2005). In the former category, information is processed routinely and dictated by the information systems involved, for instance workflow or process systems. In the latter category, the information being exchanged is unstructured in nature. Tasks are carried out as part of informal processes that require high levels of *ad hoc* response, improvisation, and coordination, with a direct focus on results.

Police officers commonly combine the tasks outlined above: they respond to emergencies (problem solving) while acting as neighborhood officers (information exchange). Although searching, retrieving, and exchanging information may not be a police officer's core activity, it is a very critical aspect of what they do and relates to many tasks they have to carry out (Tapia and Sawyer, 2005). On the basis of this insight, we want to nuance the hypotheses regarding the mediating effect of media fit.

H3a: Media fit related to problem-solving activities mediates between the perceived ease of use and perceived usefulness, as defined in terms of increased productivity, and intention to use advanced mobile systems.

H3b: Media fit related to information exchange activities mediates between the perceived ease of use and perceived usefulness, as defined in terms of resource advantage, and intention to use advanced mobile systems.

Figure 1 summarizes the hypotheses, we developed development for testing using structural equation modeling.

Despite the fact that the TAM model offers more detailed specification, it remains too generic to achieve our research objective. Ajzen and Madden (1986) state that there are many factors that affect people's intention to use a specific technology, some of which are externally oriented, such as context. The concept of context is a rather ambiguous one. Schilit *et al*. (1994) divide context into three categories: computing context, user context, and physical context. Chen and Kotz (2000) add time as a fourth category. In their discussion of the various roles and identities that users assume in different contexts, like for instance police officers responding to urgent situations, or being off-duty, Pedersen and Ling (2002) distinguish between the modalities of mobility, work and leisure, specific demographical groups as proxies for distinctions between end-users contexts, and between public and private contexts, and dynamic context. In this study, we limit ourselves to the physical time–space context and the specific situations in which specific tasks have to be executed. In contrast to the TAM-hypothesis, we relate tasks to contextual characteristics in a more detailed way, based on transcripts of participatory observation, focus group discussions, and lengthy talks with researchers who work for the police force (Steen, 2008). The fieldwork took place over a period of 3 years (2004–2007), a number of involved researchers participated in police work on a regular basis or worked within the police force, more than 15 in depth interviews and more than eight focus group interviews were conducted. To our knowledge, no formal conceptualization of context and tasks has been offered in any existing study.

Context of police tasks

We define a police officer's context as a multidimensional space. Context refers to the immediate physical time–space context, the situations in which police officers have to respond to certain events, to the communicating partners involved, including colleagues, managers, control room, and relevant other parties, as well the public at large, and to the organizational setting, that is, culture and structure of the broader, public police organization. In this paper, we focus on the context of a task as defined by the police officer's physical and immediate environment (at the precinct/office or on the beat/mobile) on the one hand, and by the nature of the tasks, that is, structured (predictable, routine, and non-urgent) *vs* non-structured (unpredictable, *ad hoc*, and urgent) tasks on the other. The shift between types of tasks is frequent and unpredictable. The unpredictable nature of a police officer's work is to a large extent defined by the fact that their tasks can also be

initiated by others. In many cases, police officers respond to incidents in their immediate environment at the request of the control room. This means that, while processing observations in a process system or updating administrative work, police officers may be expected to abandon his task to respond to emergencies.

Police tasks

The tasks police officers carry out while they are on the beat are largely defined by briefings. Although briefings (task initiation) usually take place at the precinct, daily updates (alerts) or consultation of the earlier briefings while on the beat may help police officers carry out their tasks. 'There is a digital briefing in the morning and in the afternoon. That is way too much information to remember. In the course of the day you will want to check things that were discussed during the briefing'. Alerts can lead to changes in tasks, for instance, instead of a planned house visit, a police officer may be requested to survey a railway station where pickpockets have been spotted. Another example of alerts is the distribution of surveillance camera footage of a shoplifter. We observed that police officers inform fellow officers via GSM, using pre-programmed dialing. The direction of the information flow, which is correlated with the execution of the task, is also relevant: police officers can actively retrieve information, receive general alerts, request information, for instance on the identity of a person or ownership of a car, and store the information in process systems, for instance in the case of burglary or drug possession. The choice between retrieving information by police officers themselves or via the control room is critical. 'Now you sometimes follow a car for quite some time because the relevant information has to be retreived (by the control room), and then it turns out that nothing is amiss, and you have wasted your time'. Information registration is highly relevant: 'you go back to what has been recorded, because you cannot possibly communicate with 160 colleagues'.

Technologies available to police officers

D'Ambra *et al*. (1998) suggest that both tasks and technologies are perceived along multidimensional lines. Technologies vary with regard to the networks that are used, authentication procedures, graphical interfaces (text-based, black-and-white, or color interfaces), modality (communication functionality, information exchange, exchange of color videos), portability, and battery usage. To carry out their tasks, police officers use PCs, laptops, mobile data terminals and telephones, over fixed as well as radio lines, wireless and mobile communication. Mobile data terminals, including automatic car location systems, and PDAs are common. Sometimes, police officers use their own private PDA-system: 'I record everything: red BMW's in the neighborhood, boys with ponytails, and so on. Although that is not allowed due to privacy legislation, it comes in handy. I have become better and better at how I store information, for instance Renault [space] white: that is easy to relocate'. In addition to communication devices, Dutch police officers have access to a broad array of process systems and databases, the core of which is made up of the GBA (the general database of all Dutch inhabitants) and geographical information systems.

Because the various police regions operate independently, two PDA-based systems have been developed, that is Mobiel Blauw (Mobile Blue) and P-INFO. In some of the regions, although not all of them, one of these two systems was in use when we conducted this study. Although both systems have been extensively tested and evaluated (Jonge, 2003; Kool *et al*., 2003; Stijnman *et al*., 2004), usage levels remain low. 'When it becomes too complicated, such a device is soon abandoned on the back seat'. High security requirements act as a barrier: substantial security procedures are in place to make sure the information does not fall into the wrong hands. Several studies describe new mobile technologies that police officers may use in their work. Tapia and Sawyer (2005) discuss the implementation and use of PDA and the use of 3G networks in a field trial, while Sørensen and Pica (2005) provide an overview of the use of mobile data terminals, personal radio, and mobile phones by vehicle response teams. With regard to new mobile devices, they conclude that voice communication is crucially important and that the use of displays can be highly risky: having to look at a screen instead of observing and communicating with suspects may put police officers in personal danger in urgent and stressful situations. This was mentioned a number of times by police officers. Network limitations, cumbersome authentication, capacity, and coverage also act as a threshold.

The extent to which specific tasks within a given context, as discussed, match the technological characteristics of devices and applications, follows some simple logic. Traditionally, non-urgent (structured) tasks are carried out at the precinct, where it is most likely that PCs or laptops will be used. In the case of non-urgent (structured) tasks that have to be carried out while on the beat, mobile technologies with a graphical interface will be used. Basically, mobile devices then replace traditional devices. The information that is registered can be synchronized with process systems at the precinct. This is one of the uses stakeholders expect will make police work more efficient and effective. We hypothesize that:

H4a: police officers, when faced with an urgent task and starting from their office or on surveillance, will prefer a voice interface over a graphical interface, and mobile devices over non-mobile systems.

H4b: when faced with non-urgent tasks, police officers will use traditional systems with a graphical interface when they are at the precinct, and mobile devices with a graphical interface when they are on surveillance.

Task initiation

Another aspect of task execution has to do with who initiates a specific activity. If a task is initiated by police officers, we observed that they prefer traditional communication and information systems such as a PC or laptop computer. We also observed that they tend to observe, register, if necessary reporting via radio communication to the control room, and respond to what happens in their environment. At the precinct there is more time to store and share information via process systems and to initiate follow-up actions. If a task is initiated by the control room,

this will be done via personal radio. Control rooms deal with many activities at the same time and using personal radio offers dispatchers the most convenient way to communicate with several officers at the same time. In cases where police officers are dealing with briefing information that will serve as a starting point for the execution of a task, we observed that police officers retrieve the information via mobile devices to refresh details and to read possible updates. We hypothesize that

H5: when tasks are initiated by the control room, they will be followed up by communication and information exchange via radio communication, while in cases where police officers initiate tasks or when tasks are started based on briefing information, either traditional systems will be used when at the precinct or mobile devices when on surveillance.

Finally, the type and flow of information are also relevant. Police officers retrieve information themselves from process systems and databases (pull information). If the information cannot be obtained from a process system or a database, police officers can ask the control room to retrieve the information they need. Although the information can be requested verbally, it is delivered via advanced systems. Information can also be pushed to police officers, for instance via alerts. Finally, police officers store relevant information in process systems or databases.

The use of mobile device with a GUI and local information enables police officers to look at the information at a convenient moment. We observed that police officers prefer to receive alert information or information from the control room via traditional radio communication or GSM. When it comes to providing information, they prefer to use advanced technologies. On the basis of our observations, we hypothesize that

H6a: When at a police station (context) and in non-urgent situations (context), police officers request and administrate information via traditional laptop or PCs. When they are on the road (context) and the situation is non-urgent (context), they will use mobile devices to retrieve and store information.

H6b: In urgent situations, police officers will use mobile connections. When retrieving information, they use the control room, either via a voice channel or using an advanced handset on which graphical information can be displayed.

An outline of the relationships between context, task-related, and technological characteristics is presented in Table 1.

Earlier, we stated that some of the weak points of TAM are related to the fact that technology is treated as a black box. This is why we look at alternative technologies that are available to officers in relation to different contexts in which (information-related) tasks have to be executed. Moreover, we argue that the intention to use a technology can be explained more precisely by tasks as executed within a given context rather than by perceived usefulness. On the basis of Ajzen and Madden (1986), we expect that context-related characteristics, together with task-related and information-related characteristics, have a higher predictive value than TAM-concepts such as perceived ease of use and perceived usefulness as well as media fit concepts. We hypothesize that:

H7: the explanatory power of context- and task-related concepts will be higher than the explanatory power of TAM-related and media fit concepts.

For a summary of the hypotheses tested in this study (see Figure 2), which shows how TAM and generic media fit as

Table 1 A specification of the relationships between task-related and technological characteristics

Context, task-, and information-related characteristics	*Technological preference/characteristics*
Physical context/urgency	
Office/non-urgent	Fixed, non-voice, graphical, for example PC/laptop (alternative 1)
Office/urgent	All kind of mobile communication, mainly voice (alternatives 1–7)
Surveillance/non-urgent	Mobile PDA, graphical, color photo, and video (alternatives 6 and 7)
Surveillance/urgent	All kinds of mobile communication, mainly voice (alternatives 1–7)
Task initiation	
Control room	Personal radio (alternative 2)
Briefing	Advanced mobile PDA's color photo and video (alternatives 6 and 7)
Police officer	PC/laptop (alternative 1)
Information use	
Information request police officer	Advances handset with GUI, GSM (alternatives 3, 4, and 5)
Alert information	Traditional radio or GSM (alternative 2)
Information via control room	Advances technologies (alternatives 6 and 7)
Information administration	PC, laptop (office) (alternative 1), mobile PDA (non-office) (alternatives 4–7)

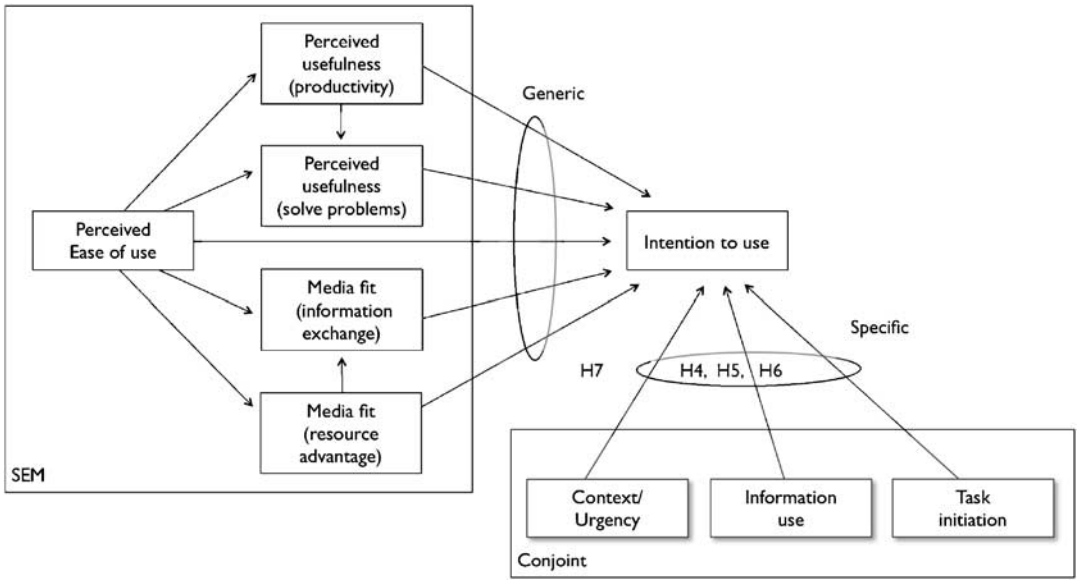

Figure 2 Conceptual model to be tested with HLM, as well as sub-models for SEM and conjoint analysis.

well as context-related task factors can be used to explain people's intention to use advanced mobile services.

Methodology

To compare the sub-models presented in Figure 2, we use the research approach commonly used to test the TAM and media fit model, for example web-questionnaire in combination with structural equation modeling, and to analyze context-related tasks variables in relation to the characteristics of the technologies, we use conjoint analysis. To test the final hypothesis, we use an alternative data-analysis approach, that is, hierarchical linear modeling (HLM).

Web-questionnaire

To test our hypotheses we used a web-questionnaire, the first part of which consisted of the widely used TAM-related items perceived ease of use, perceived usefulness (productivity and resource advantage) and intention to use, which we rated on a seven-point Likert scale (Pavlou, 2003; Suh and Han, 2003; Venkatesh *et al*., 2003), and media fit-related items (Van den Hooff, 1994). Van den Hooff's scale is a very elegant measurement tool that is more concise than the Goodhue task-technology fit scales. For an overview of all the items we used, see appendix. The second part of the questionnaire presented the respondents with the kind of cases that are commonly used in conjoint analysis. In the later sections, we elaborate on this method. The final part of the questionnaire contained a number of questions dealing with background characteristics, including position, gender, and age.

Conjoint analysis as included in the web-questionnaire

We used conjoint measurement to analyze the context variables in relation to a preference for specific technologies. Conjoint measurement (Vriens, 1995; Molin, 1999) is a technique that is traditionally used to identify preferences in a multi-attribute decision-making space. Studies using conjoint measurement can provide insight into the relationship between context, tasks, and technologies. Conjoint analysis (Gustafsson *et al*., 2003), also known as factorial survey and vignette studies (Rossi and Anderson, 1982), offers a valuable alternative, because it integrates the strict factorial design and the concept of attribute orthogonality (Louviere, 1988), and because it can be applied in studies into the future use of information technology (Van de Wijngaert, 1999; Bouwman and Van de Wijngaert, 2002, 2003). Respondents are presented with fictitious cases, which are also known as conjoints. The cases vary by systematically changing contextual (4), task-related (3), and information-related (4) characteristics (see Table 1). The differences between cases, in relation to the respondents' preferences for specific technologies, provide insight into the contextual and task-related characteristics that influence the use of, for instance, mobile technologies. To select the cases, we used an orthogonal design in such a way that data could be used in a conjoint analysis, and the effects of all the relevant aspects could be assessed. The conjoint cases contain descriptions of specific situations with which police officers are familiar. This was validated before presenting the cases to the police officers. We decided to use the list of concepts presented in Table 1, which would result in $4 \times 3 \times 4$, that is 48 combinations. Using the orthogonal design tool provided by SPSS, we managed to reduce the number of cases to 16, which were all presented to the respondents. Two examples are as follows:

> Case description 6: During your rounds in the neighbourhood, the control room informs you that some people parked their cars in the wrong place near a conference center not far from where you are, and the control room sends you additional information about the situation. There is no rush.

Case description 11: You are at the precinct when you receive a report about a row between neighbours. In addition, the information system informs you that there have been previous incidents involving the same people and that some of the people involved may respond aggressively to police presence.

After being presented with a case description, the police officers were asked to rate how suitable the following seven (mobile) technologies would be in that specific case, on a scale from 1 (totally unsuitable) to 10 (most suitable). The following seven alternatives were offered (see also Table 1):

1. Textual information via desktop (PC or laptop, currently used by police officers)
2. Textual (voice) information via personal radio (tetra, currently used by police officers)
3. Spoken information via mobile handset (GSM, currently used by police officers)
4. A device that enables both spoken information and textual and on-screen graphical information, for instance an i-Mode enabled telephone with graphical interface or a PDA (for instance existing systems like P-Info or Mobile blue)
5. A device, for instance a GPRS-phone that allows for both spoken and textual information and the display of graphical information (black and white pictures, low resolution)
6. A device, for instance a high-end UMTS-phone or advanced PDA that allows for both spoken information and textual and graphical information on screen (color screen, pictures, high resolution)
7. A device, for instance a high-end UMTS-phone or advanced handheld computer that enable both spoken information and textual, graphical and video information (color screen, pictures, high resolution)

The respondents were also asked which device they would ultimately use.

Sample

The web-questionnaire was presented to Dutch police officers who are involved in operational police tasks on a daily basis. The respondents were approached via the police organization's Intranet and were invited to fill out the questionnaire by clicking on a link. About three quarters of the 106 police officers who accepted our invitation were male (77%), which is close to the actual percentage of male operational police officers (82%). As a result, female police officers are slightly overrepresented in our sample (23%, *vs* 18% in the entire police force). On average, the respondents were 39 years old, with an average of 16 years experience on the force, which is representative for the population as a whole.

Data analysis

Before testing the TAM-related hypotheses, we discuss the scale depuration and reliability of all the measures included in this study. We conducted a confirmatory factor analysis (CFA), using LISREL 8.7 for the model ($c^2 = 158.64$, d.f. = 137, CFI = 0.98, IFI = 0.98, NFI = 0.94, NNFI = 0.98, GFI = 0.86, and RMSEA = 0.03). All loadings for the items on their respective constructs were large and significant (smallest t-value = 6.91), which provides evidence of convergent validity for each construct (Bagozzi and Yi, 1988). All factor loadings for the individual indicators on their respective constructs are statistically significant ($P < 0.001$). The reliability of the multi-item scales was assured by calculating Bagozzi and Yi (1988) composite reliability index and with Fornell and Larcker (1981) average variance extracted index. Both indexes fall within the range recommended in literature, providing evidence of a good adjustment of each construct (Table 2). We further assessed the discriminant validity of the latent constructs in two ways. Firstly, as suggested by Anderson and Gerbing (1988), we calculated the 99% confidence intervals around the correlation parameter estimates between all possible pairs of scales, and were able to establish that none of the intervals included 1.

Secondly, the comparison of the square root of the AVE (diagonal in Table 2) with the correlations among the constructs (i.e., off-diagonal elements) reveals that the square root of the AVE for each component is greater than the correlation between the components (Fornell and Larcker, 1981). Although these findings provide evidence of discriminant validity among the components and constructs (see Table 3), we also see moderate correlations between perceived usefulness constructs and behavioral intention to use. Overall, these results suggest an adequate level of reliability and validity.

HLM analysis

Because each officer was presented with all 16 cases, a multi-level analysis was necessary to test Hypothesis 7 (regarding the explanatory value of context factors in

Table 2 Correlations between constructs and average variance extracted for individual constructs

Correlations and average variance extracted (AVE)	*1*	*2*	*3*	*4*	*5*	*6*
1. Intention to use	0.88					
2. Fit information exchange	0.50***	0.87				
3. Fit solve problems	0.36***	0.50***	0.71			
4. Perceived usefulness productivity	0.34***	0.41***	0.53***	0.81		
5. Perceived usefulness resource advantage	0.51***	0.63***	0.47***	0.62***	0.87	
6. Ease of use	0.38***	0.42***	0.30***	0.34***	0.40***	0.87

Significance levels: ***$P < 0.01$ and **$P < 0.05$.
The numbers on the diagonal are the square root of the AVE. Off-diagonal elements are correlations among constructs.

Table 3 Descriptive statistics and reliability of TAM constructs

	Mean	*SD*	*#Items remain*	*Cronbachs alpha*	*Eigenvalue*	*Lowest t-value*	*SCR*	*AVE*
Intention to use	6.36	0.89	4	0.93	3.34	10.17	0.94	0.78
Fit information exchange	6.22	0.76	2	0.86	1.75	9.46	0.86	0.75
Fit solve problems	5.33	0.97	4	0.80	2.51	6.91	0.80	0.50
Perceived usefulness productivity	5.63	0.93	3	0.83	2.30	8.73	0.83	0.66
Perceived usefulness resource advantage	6.10	0.73	3	0.90	2.50	9.51	0.90	0.75
Ease of use	5.62	0.91	3	0.90	2.56	10.33	0.90	0.76

$c^2(137) = 158.64$, CFI = 0.98, IFI = 0.98, NFI = 0.94, NNFI = 0.98, GFI = 0.86, and RMSEA = 0.03.

relation to that of factors related to the perceptions of individual officers) for three devices the police officers actually use, that is laptop or desktop computer (alternative 1), radio communication (alternative 2), and GSM phone (alternative 3), and the device they are most likely to use according to the conjoint analysis, that is high-end PDA's (no video) (alternative 6). We used HLM-software (version 6) to analyze the models. At an individual level (level-2 model) ($N = 104$) there are six predictors, whereas at case level there are three predictors (context with three values, task initiation with three values, and information use with four levels, leading to seven dummy predictors). We employed a two-level linear regression model (Hox, 2002) using the following model:

Level 1 Model

$$\begin{aligned}\text{Preference for a device}_{ij} &= \beta_{0j} + \beta_{1j}\,\text{Context}\,1_{ij} \\ &+ \beta_{2j}\,\text{Context}\,2_{ij} + \beta_{3j}\,\text{Initiator}\,1_{ij} + \beta_{4j}\,\text{Initiator}\,2_{ij} \\ &+ \beta_{5j}\,\text{Issue}\,1_{ij} + \beta_{6j}\,\text{Issue}\,2_{ij} + \beta_{7j}\,\text{Issue}\,3_{ij} + e_{ij}\end{aligned}$$

Level 2 Model

$$\begin{aligned}\beta_{0j} &= \gamma_{00} + \gamma_{01}\text{F1}_j + \gamma_{02}\text{F2A}_j + \gamma_{03}\text{F2B}_j \\ &\quad + \gamma_{04}\text{F3A}_j + \gamma_{05}\text{F3B}_j + \gamma_{06}\text{F4}_j + u_{0j} \\ \beta_{1j} &= \gamma_{10} + u_{1j}, \quad \beta_{2j} = \gamma_{20} + u_{2j} \\ \beta_{3j} &= \gamma_{30} + u_{3j}, \quad \beta_{4j} = \gamma_{40} + u_{4j} \\ \beta_{5j} &= \gamma_{40} + u_{5j}, \quad \beta_{6j} = \gamma_{40} + u_{6j} \\ \beta_{7j} &= \gamma_{40} + u_{7j}\end{aligned}$$

Results

TAM results

First of all, we discuss the results with regard to Hypotheses 1 and 2 on perceived ease of use and perceived usefulness in relation to intention to use, as well as Hypothesis 3 related to the intermediary effects of media fit. The proposed structural equation model (SEM) is specified based on the hypothesized relationships using LISREL 8.7. We used conventional maximum likelihood estimation techniques to test the model (Jöreskog and Sörbom, 1996). The model provides a satisfactory fit ($c^2(142) = 207.54$, CFI = 0.96, IFI = 0.96, NFI = 0.92, NNFI = 0.96, GFI = 0.83, and RMSEA = 0.06). The model was tested against alternative models. The explained variance for intention to use is 31%. However, as far as the media fit assumptions are concerned, the explained variance was 44% for exchanging information, and only 30% for solving problems, which suggests that police officers consider mobile services more appropriate for exchanging information than for solving problems. Ease of use is positively related to perceived usefulness, which we defined as perceived increase in productivity. Ease of use only has an indirect effect on intention to use, while perceived usefulness only has a direct effect when it comes to the advantage of mobile systems as an additional resource. Productivity-related usefulness does not affect intention to use. Hypothesis 1a (perceived ease of use explains intention to use advanced mobile systems) is not accepted. The same applies to Hypothesis 1b, which relates perceived usefulness to intention to use. The straightforward formulation of the TAM hypotheses is too generic. The picture as formulated in Hypotheses 3a and 3b is more nuanced. Hypothesis 2, relating perceived ease of use to perceived usefulness, is supported. Hypothesis 3 is only partly supported: although media fit is an intermediating variable, this is only the case with regard to exchanging information and not with regard to solving problems (Figure 3).

Intention to use advanced mobile systems can be explained by the ability of mobile systems to improve the exchange of information, as well as the perceived usefulness of mobile services as an addition on existing systems. The explained variance in the media fit with regard to exchanging information (44%) is higher than intention to use (31%). Hypothesis 3b is supported. There is no relationship with perceived usefulness in terms of productivity gains and intention to use. Hypothesis 3a is rejected. It may be concluded that police officers view mobile systems as additional resources that are more suitable for sharing information than for solving problems in urgent situations. To summarize, media fits plays a role in the trade-off between ease of use and usefulness, and intention to use.

Conjoint results

The effect of the various context parameters on the intention to use one of the seven alternatives is assessed by means of a conjoint analysis. Table 4 contains the results of the analysis of the part worth utilities (effects) of the

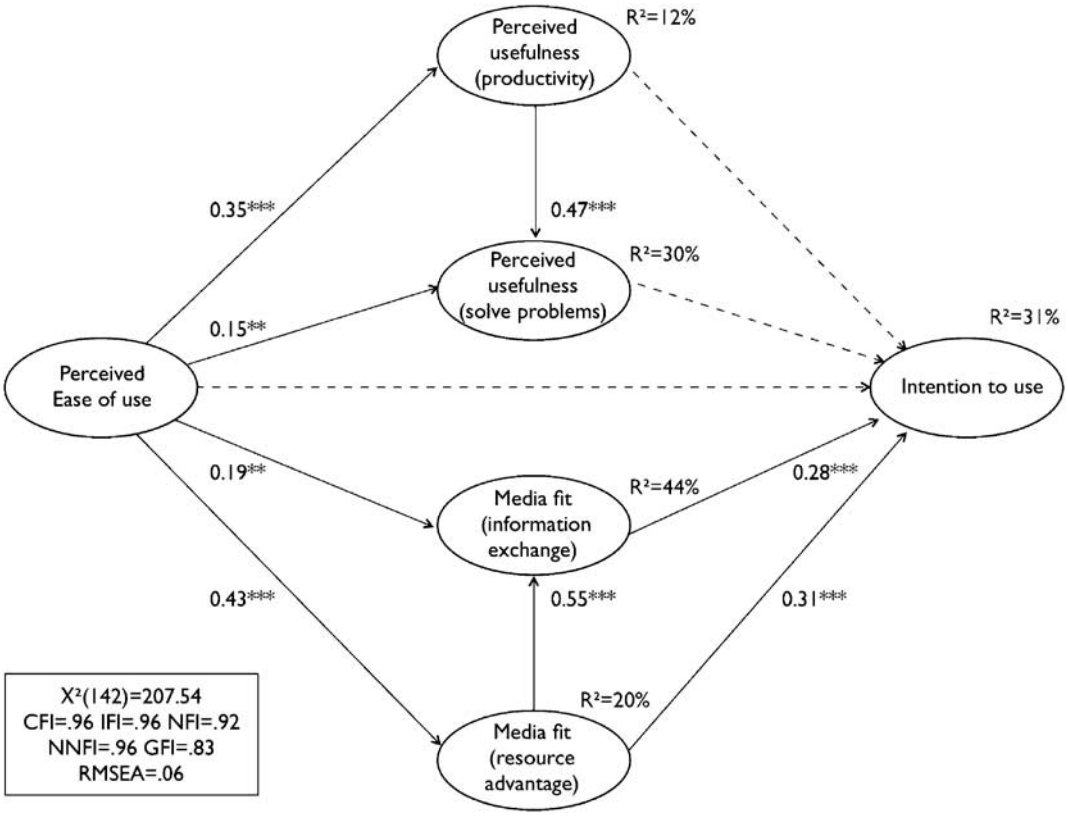

Figure 3 SEM explaining intention to use advanced mobile systems by police officers (dotted lines indicate non-significant relationships).

various attributes and levels at an aggregated level. The model fit proved acceptable for all the nine models: Pearson's *R* varies between 0.75 and 0.95, and Kendall's Tau between 0.55 and 0.88, which indicates a reasonable fit between the estimated utilities and the subject or group rating. The explained variance is lowest for the most advanced mobile technology and highest for personal radio, that is the mobile technology with which police officers are most familiar and least advanced. The high standard deviation for the utilities is striking, and it indicates there is a high level of variability between the respondents in terms of their intention to use. However, this is common in most conjoint studies.

Some findings are highly relevant. First of all, the effect of the physical context, either at the precinct or on the beat, is striking. In an office environment, utilities are highest for PC or laptop (0.60), while in urgent situations the traditional mobile phone GSM (0.20), personal radio (0.19), and simple PDAs such as P-info (speech and text) (0.18) show the best scores. Personal radio has the highest utility in mobile contexts. The more advanced technologies have negative utilities in a non-urgent office environment, while their utilities are positive in all emergency situations. The utilities for the more advanced PDAs are low. In a mobile context, personal radio (0.28) and traditional mobile phones (0.27) have the highest utilities in non-urgent situations, while PDAs and more advanced mobile systems have a negative utility. In urgent situations, personal radio stands out (0.47). Utilities for high-end advanced mobile systems (0.30 and 0.31) are slightly higher than they are for traditional GSM phones (0.29). In emergency situations, there is a clear preference for PDA's with speech functionality. Hypotheses 4a and 4b are accepted. Urgency is positively related to the use of mobile technologies.

When tasks are initiated by the control room, there is no clear preference and the utilities are generally low (ranging from −0.09 to 0.11). With regard to briefings, the utilities are the highest for advanced mobile devices (0.39 and 0.38). When tasks are initiated by police officers, utility is highest for the traditional PC or laptop (0.37), while advanced technologies show a highly negative score (−0.48 and −0.49). Hypothesis 5 is partly supported. Initiation of tasks by the control room does not adhere to a clear pattern, whereas the role of advanced mobile systems was not expected according to the hypothesis. The use of traditional systems by police officers when initiating tasks is supported.

Utilities are positive in the case of advanced mobile systems used to retrieve information (0.21 and 0.15), which illustrates the willingness of police officers to use advanced mobile devices to retrieve information from process systems and databases. Speech radio and handheld GSM show negative utilities. As far as information alerts are concerned, the devices that are currently being used show the highest utilities: personal radio (0.62) and GSM (0.48). Advanced mobile systems have positive but weaker utilities; from 0.11 to 0.25. PC and laptop have negative utilities. The same pattern occurs in the case of information provided by the control room: personal radio (0.63) and GSM (0.43). However, advanced technologies have negative utilities (−0.22 and −0.23).

Table 4 Utilities based on conjoint analysis for the seven alternatives

Alternatives	*(1) Text with PC or Laptop*		*(2) Personal radio (porto)*		*(3) Speech mobile phone*		*(4) Speech and text*		*(5) Speech, text, and black and white images*		*(6) Speech, text, and color images*		*(7) Speech, text, and video*	
	Utility	*SD*	*Utility*	*SD*	*Utility*	*SD*	*Utility*	*SD*	*Utility*	*SD*	*Utility*	*SD*	*Utility*	*SD*
Constant	6.028	1.70	5.38	1.82	5.24	1.74	6.04	1.59	5.80	1.93	7.06	1.74	6.28	2.11
Physical context/urgency														
Office non-urgent	0.60	0.95	−0.95	0.90	−0.76	0.90	−0.33	0.85	−0.12	0.65	−0.04	0.83	−0.02	0.874
Office urgent	0.00	0.80	0.19	0.81	0.20	0.76	0.18	0.71	0.05	0.54	0.10	0.74	0.05	0.70
Surveillance, non-urgent	−0.22	0.88	0.28	0.88	0.27	0.90	−0.02	0.95	−0.17	0.77	−0.36	0.90	−0.35	0.89
Surveillance, urgent	−0.39	0.99	0.47	0.85	0.29	0.88	0.18	0.68	0.24	0.73	0.30	0.86	0.31	0.85
Task initiation														
Control room	−0.10	0.47	−0.01	0.50	0.05	0.47	0.03	0.48	0.08	0.39	0.09	0.50	0.11	0.47
Briefing	−0.27	0.66	0.02	0.60	0.14	0.64	0.07	0.54	0.24	0.53	0.39	0.66	0.38	0.66
Police officer	0.37	0.60	−0.01	0.61	−0.20	0.54	−0.10	0.61	−0.32	0.65	−0.48	0.85	−0.49	0.68
Information use														
Information request by officer	0.03	0.73	−0.15	0.73	−0.03	0.73	0.12	0.65	0.04	0.62	0.21	0.85	0.15	0.75
Alert information	−0.27	0.69	0.62	0.95	0.48	0.79	0.16	0.74	0.24	0.71	0.25	0.80	0.11	0.78
Information via control room	−0.63	0.96	0.63	0.94	0.43	0.79	0.13	0.67	0.00	0.65	−0.22	0.88	−0.23	0.89
Information administration	0.87	1.20	−1.10	1.27	−0.88	1.16	−0.40	0.93	−0.28	0.80	−0.23	0.93	−0.03	0.96
N	103		103		103		104		104		101		101	
Model fit statistics														
Pearson's *R*	0.84	0.00	0.95	0.00	0.92	0.00	0.85	0.00	0.90	0.00	0.79	0.00	0.75	0.00
Kendall's Tau	0.55	0.00	0.88	0.00	0.75	0.00	0.54	0.00	0.71	0.00	0.54	0.00	0.58	0.00

Pearson's *R* and Kendall's Tau indicate how well the model fits the data. Generally speaking, Pearson's *R* and Kendall's Tau should be very high.
The average utilities indicate the degree in which the approx. 100 respondents prefer a specific alternative with regard to a specific condition. For instance, the positive utility for text with PC or laptop is dependent (1) on non-urgent work in the office, (2) on a task initiated by the police officer, and (3) on a police officer who is storing information.

With regard to registering information, traditional PCs and/or laptop computers (0.87) are preferred. Clearly, police officers are not convinced of the benefits of using advanced mobile systems to administer information, contrary to commonly held beliefs that using advanced devices would lighten their administrative burdens. Hypothesis 6a is supported, while Hypothesis 6b is partly supported. Instead of using advanced PDAs, police officers prefer to use a traditional GSM phone.

To conclude, it is clear that text input using PC and laptop computer is especially suitable in non-urgent office situations. In urgent situations while police officers are at the precinct, preferences shift toward traditional and familiar technologies. Generally speaking, all technologies are relevant in urgent situations, both in an office environment and on the beat. In the latter case, more advanced technologies are expected to be beneficial. There is a preference for receiving task-related briefings on advanced equipment. On the other hand, police officers prefer using PCs or laptop computers in cases where they initiate a task themselves. As far as retrieving information is concerned, police officers have a slight preference for advanced mobile technologies. PCs or laptop computers are preferred when it comes to administering information (see Figure 4).

On the basis of conjoint analysis, we were able to relate many (although not all) of the contextual and task-related characteristics to technological characteristics. Context-related variables play an important role in people's preference for specific devices and functionalities. These preferences vary from situation to situation. There are subtle differences, implying that a careful examination of the various conditions regarding the use of specific mobile devices for executing specific tasks is highly relevant.

HLM results

To reduce possible bias that may be attributed to the specific tools with which we analyzed the data using SEM and conjoints analysis, we use HLM that enable the combined analysis of the specific contributions of the individual TAM characteristics and the context, and specific task-related characteristics. The results of the HLM analysis are presented in Table 5. This analysis estimates the effects of the individual factors (at respondent level) and the effects of the context-related variables (at case-conjoint- level). The context-related variables were re-coded to dummy variables. The results show that the individual level predictor, that is the TAM and media fit concepts, have no significant explanatory value, except with regard to intention to use in the case of the advanced PDA device (device 6: speech, text, and color images). By contrast, there are many significant effects in the case of the context-related variables. Although these effects are not particularly strong, they are significant, and compared with the individual characteristics they actually help explain respondent preferences.

When we take a closer look at the differences between the context-related effects, we see that 'urgency' has a significant effect for all four alternatives included in HLM.

PCs or laptop computers are preferred in non-urgent situations, while the other three alternatives are preferred in urgent situations. 'Location' has a significant effect for all alternatives, with the exception of the advanced PDA alternative. For situations, the occur when police officers are on the beat, personal radio and mobile telephone (alternatives 2 and 3) are preferred, whereas PCs or laptop computers are preferred in the office (alternative 1), which supports the results of the conjoint analysis.

With regard to who initiates the communication, PCs or laptop computers are preferred when tasks are initiated by the police officer or the control room. In cases where a task is initiated through a briefing, GSM and advanced PDA are preferred. The question that initiates a given task has no significant effect on the suitability of personal radio. With regard to alert information, it would appear that all alternatives are suitable. When it comes to requesting and providing information, PCs or laptop computers are also a preferred medium.

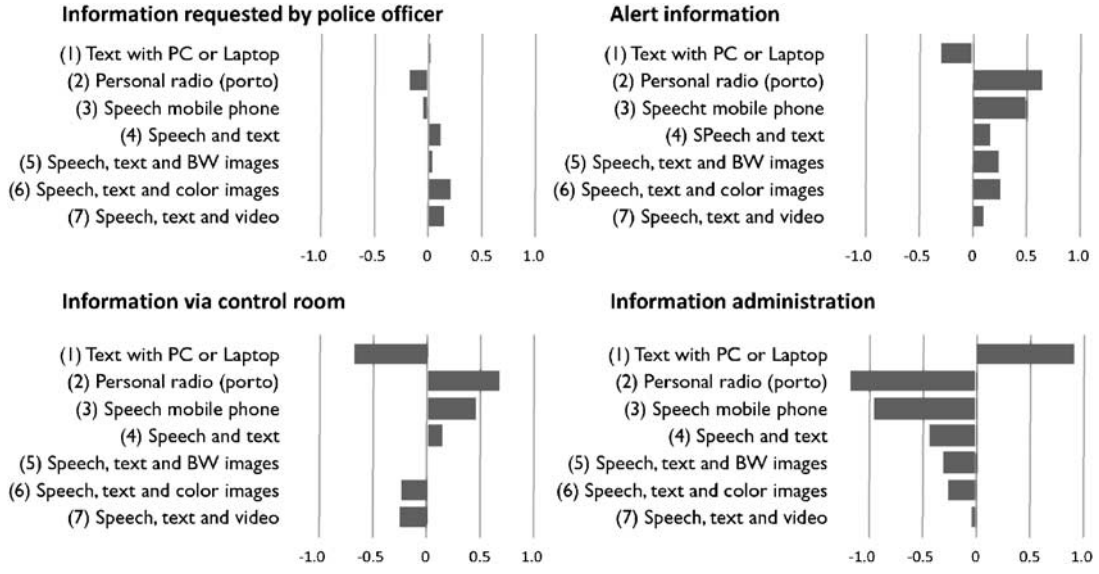

Figure 4 Utilities with regard to the various information flows.

Table 5 Results of the HLM analysis

Intercept	*Coefficient*		*Alternative 1 PC/laptop*	*Alternative 2 Radio communication*	*Alternative 3 Mobile phone*	*Alternative 6 Advanced PDA speech, text, color image*
		γ_{00}	6.11**	5.31**	5.31**	7.47**
B_0 Factor 1	Intention to use	γ_{01}	0.02	0.01	0.18	0.37*
Factor 2	Media fit: info exchange	γ_{02}	0.13	−0.21	−0.23	0.07
Factor 3	Media fit: solve problems	γ_{03}	−0.07	−0.03	0.23	0.27
Factor 4	Perceived ease of use	γ_{04}	0.10	0.25	0.17	−0.10
Factor 5	PU: productivity	γ_{05}	−0.10	−0.09	−0.18	0.26
Factor 6	PU: resource advantage	γ_{06}	0.01	0.09	0.05	0.20
B_1 Context 1	Urgency[a]	γ_{10}	−0.37**	0.66**	0.49**	0.39**
B_2 Context 2	Location[b]	γ_{20}	−0.59**	0.73**	0.54**	−0.06
B_3 Task initiation 1	Police officer *vs* briefing[c]	γ_{30}	0.63**	−0.03	−0.35**	−0.84**
B_4 Task initiation 2	Control room *vs* briefing[c]	γ_{40}	0.18	−0.03	−0.09	−0.28**
B_5 Information use 1	Via control room *vs* Alert info[d]	γ_{50}	−0.37**	−0.01	−0.06	−0.47**
B_6 Information use 2	Info provisioning *vs* alert info[d]	γ_{60}	1.09**	−1.67**	−1.34**	−0.48**
B_7 Information use 3	Information request *vs* alert info[d]	γ_{70}	0.30**	−0.76**	−0.50**	−0.05

* = $P<0.05$ and ** = $P<0.00$; all variables entered uncentered.
[a]Urgency: 0 = non-urgent and 1 = urgent.
[b]Location: 0 = office and 1 = surveillance.
[c]Initiator: briefing = 0.
[d]Issue: alert information = 0.

In general, the HLM analysis shows a variety of positive and negative effects for each of the alternatives. We can conclude that every alternative has unique characteristics, which indicates suitability for different tasks in different situations. PCs or laptop computers and speech radio and GSM are each others' opposites in terms of the effects of context-related variables, which means that they are mutually exclusive in terms of their suitability in specific contexts. Together, they cover the entire spectrum of a police officer's communication and information needs. There appears to be limited room for advanced mobile systems.

At case level, the variance ranges from 50% for the advanced alternatives to 60% for the traditional alternatives. At the individual level, variance ranges from 40% for the traditional alternatives to 50% for the advanced alternatives, which would suggest that contextual variables may be more important than individual factors. Context-related variables explain about 2–9% of the overall variance, which is relatively modest. Tasks-related characteristics are relevant as well. It is only with regard to Alternative 6 that the individual characteristics play a role. This can be explained as follows. When people have to give their opinion about a new alternative, they will be influenced by individual characteristics. In light of the importance of the contextual characteristics as well as the task-related characteristics, we have to conclude that hypothesis 7 (concerning the importance of individual and context-related variables) is partly supported.

Discussion, limitations, and conclusions

In this study, we have investigated the explanatory power of task-related contextual characteristics and individual preferences with regard to specific technologies designed to communicate and exchange information within the Dutch police force. We have compared insights from adoption and acceptance (DoI and TAM), media choice and task-technology fit theories to an approach in which specific tasks and user context play a central role. We have treated the two approaches as rival theories and examined whether it is individual characteristics or contextual and specific task parameters have the greatest explanatory value. We have used several methods of analysis. We started by applying a TAM-based model to the data we collected by means of structural equation modeling, a practice that is commonly used in TAM-related research, to assess the explanatory value of individual factors. In addition, we performed conjoint analyses to assess the effects of contextual and task-related variables on respondent preferences. We presented a number of police officers with a range of alternative cases (conjoints) and communication alternatives and asked them which alternative they would (prefer to) use in specific cases. Finally, we combined the two approaches (TAM and media choice) in a hierarchical linear model.

Both the conjoint analysis and the HLM analysis indicate that the context and specific characteristics of tasks and information usage have a significant impact on which technology people prefer. Controlling for these three elements (context, tasks, and information usage), we concluded that TAM and media fit constructs do not significantly predict which mobile systems police officers prefer. We would argue that the relevant TAM-related concepts are too generic to shed a realistic light on people's behavior with regard to (new) mobile technologies or, for that matter, to be useful in designing devices that have a practical use. It turns out that context, in combination with specific task-related characteristics and the way information is handled (push, pull, retrieved, administrated) play a more prominent role than people's personal attitudes and perceptions in explaining their preferences. The use for

specific technologies is largely dependent on the (interaction of) context, information, and task characteristics. Depending on the specific combinations, communication channels, that is, voice interfaces are far more attractive than text-based information exchange. Specifically in situations, where a large number of cues have to be dealt with both in the physical context as via the communication channel, rapid exchange of information via mobile communication technologies has to be enabled. In situations where exchange of information is routine, specific, and predictable more advanced mobile information technologies with graphical interfaces appear to be more attractive.

When we include contextual and individual characteristics into a single model, the results clearly indicate that the relevance of the TAM-based and media-fit-based concepts is decreasing, while contextual factors become more relevant. It is clear that more conceptual work on task-related contextual characteristics is needed if we are to understand the implications of mobility for mobile applications and systems.

We are aware of the limitations of our research: the explained variances in the hierarchical linear model are relatively low, although we found that variance components at an individual level are lower than those at case level (i.e., context, task, and information). This not only suggests that contextual, task-, and information-related characteristics are more important than individual characteristics, but it also suggests that we need a more elaborate representation of the concept of context. We argued earlier that, although TAM is based on concepts that appear to have an acceptable concurrent validity, we have our doubts. We would argue that the core concepts are related to each other in a somewhat recursive fashion. However, the model we tested showed mixed and contradictory results with regard to the discriminate validity of perceived usefulness and behavioral intention. In our defense we stress that we used two more specific measurement tools for perceived usefulness, that is, resource advantage and productivity, rather than the more generic perceived usefulness concept. Nevertheless, on the one hand we see that perceived usefulness (resource advantage) relates to intention to use, while on the other hand we see no correlation between perceived usefulness (productivity) and behavioral intention.

The conjoint and HLM analyses offer a more detailed insight into the reason why police officers prefer certain technologies. Our experience with conjoint analysis is that it offers a non-obtrusive approach to testing which concepts explain future behavior, while taking context in account, even if the conceptualization of context is fairly generic in nature (Bouwman and Van de Wijngaert, 2002, 2003; Van de Wijngaert and Bouwman, 2009). In particular, the unobtrusive nature is very attractive. If we compare generally expressed opinions, for instance regarding the likelihood that police officers will use PDAs to administer information while on the beat, and embed them in conjoint cases, the strength of conjoint analysis becomes clear. When we talked to police officers face to face, they expressed an interest in using advanced PDAs to store information in the process systems. When we systematically vary related core concepts in cases, we see exactly the opposite, that is, police officers are highly unlikely to use advanced alternatives to administer information. The results make it clear that designing and developing technologies that will fit personal and contextual characteristics is an art in itself and require a subtle knowledge of user behavior.

Thus far, we have emphasized the scientific value of this study. As a concluding remark we would like to mention that the results of the conjoint analysis were actually translated into user requirements for the development of new mock-ups and demonstrators. These were again tested making use of conjoint analyses and field experiments. Our approach to developing new mobile applications helps avoid making investments in new applications that are not used in practice. To that extent, this kind of research helps make the Dutch police organization more effective and productive, which will eventually lead to a safer society.

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References

Ajzen, I. (1991). The Theory of Planned Behavior, *Organizational Behavior and Human Decision Processes* **50**(2): 179–211.

Ajzen, I. and Madden, T.J. (1986). Prediction of Goal-Directed Behavior: Attitudes, intentions, and perceived behavioral control, *Journal of Experimental Social Psychology* **22**(5): 453–474.

Amberg, M., Hirschmeier, M. and Wehrmann, J. (2004). The Compass Acceptance Model for the Analysis and Evaluation of Mobile Services, *International Journal Mobile Communications* **2**(3): 248–259.

Anderson, J.C. and Gerbing, D.W. (1988). Structural Equation Modelling in Practice: A review and recommended two-step approach, *Psychological Bulletin* **103**(3): 411–423.

Bagozzi, R.P. and Yi, Y. (1988). On the Evaluation of Structural Equation Models, *Journal of the Academy of Marketing Science* **16**(1): 74–94.

Benbasat, I. and Barki, H. (2007). Quo Vadis, TAM? *Journal of the Association for Information Systems* **8**(4): 211–218.

Bouwman, H. and Van de Wijngaert, L. (2002). Content and Context: A new research approach to the basic characteristics of information needs, *New Media and Society* **4**(3): 329–354.

Bouwman, H. and Van de Wijngaert, L. (2003). E-commerce in Context: Policy capturing and customer value, 16th Bled Conference on eTransformation. Bled.

Bouwman, H., Van den Hooff, B., Van de Wijngaert, L. and Van Dijk, J.A. (2005). *Information and Communication Technology in Organizations*, London: Sage.

Carlson, J.R. and Zmud, R. (1999). Channel Expansion Theory and the Experiential Nature of Media Richness Perceptions, *Academy of Management Journal* **42**(2): 153–170.

Chen, G. and Kotz, D. (2000). A Survey of Context Aware Mobile Computing Research. Dartmouth, *Computer Science Technical Report TR* 2000–2381.

Cyr, D., Head, M. and Ivanov, A. (2006). Design Aesthetics Leading to m-Loyalty in Mobile Commerce, *Information & Management* **43**: 950–963.

Daft, R. and Lengel, R. (1984). Information Richness: A new approach to managerial behavior and organizational design, in L. Cummings and B. Staw (eds.) *Research in Organizational Behavior*, Vol. 6, Greenwich, CT: JAI Press, pp. 191–233.

Daft, R. and Lengel, R. (1986). Organizational Information Requirements, Media Richness and Structural Design, *Management Science* **32**(5): 554–571.

D'Ambra, J., Rice, R.E. and O'Connor, M. (1998). Computer-Mediated Communication and Media Preference, *Behaviour & Information Technology* **17**(3): 164–174.

Davis, F. (1989). Perceived Usefulness, Perceived Ease of Use and User Acceptance of Information Technology, *MIS Quarterly* **13**: 319–340.

DeSanctis, G. and Poole, M. (1994). Capturing the Complexity in Advanced Technology Use: Adaptive structuration theory, *Organization Science* **5**(2): 121–147.

Dishawa, M.T. and Strong, D.M. (1999). Extending the Technology Acceptance Model with Task–Technology Fit Constructs, *Information & Management* **36**(1): 9–21.

Elias, M. (1997). *Onder dienders: onstuimig en beklemmend: de wereld van de politie*, Uitgeverij Balans.

Fishbein, M. and Ajzen, I. (1975). *Beliefs, attitude, intention and behaviour: An introduction to theory and research*, Reading, MA: Addison-Wesley.

Fornell, C. and Larcker, D.F. 1981. Evaluating Structural Equation Models with Unobservable Variables and Measurement Error, *Journal of Marketing Research* **18**(1): 39–50.

Fulk, J., Schmitz, J. and Steinfield, C.W. (1990). A Social Influence Model of Technology Use, in J. Fulk and C.W. Steinfield (eds.) *Organizations and Communication Technology*, Newbury Park, CA: Sage, pp. 117–142.

Goodhue, D.L. and Thompson, R.L. (1995). Task-Technology Fit and Individual Performance, *MIS Quarterly* **19**(2): 213–236.

Gustafsson, J., Hermann, A. and Huber, F. (2003). Conjoint Analysis as an Instrument of Market Research Practice, in J. Gustafsson, A. Hermann and F. Huber (eds.) *Conjoint measurement, methods and applications*, Berlin: Springer, pp. 5–46.

Hoogenboezem, J. and Hoogenboezem, D. (2006). Coping with Targets: Performance measurement in The Netherlands police, *International Journal of Productivity and Performance Management* **54**(7): 568–578.

Hox, J. (2002). *Multilevel Analysis, Techniques and Applications*, London: Erlbaum.

Ilie, V., van Slyke, C., Green, G. and Lou, H. (2005). Gender Differences in Perceptions and Use of Communication Technologies: A diffusion of innovation approach, *Information Processing Mangement Journal* **18**(3): 13–31.

Jonge, E. (2003). Evaluatie Project PWIG, Technisch Rapport. Regiopolitie Groningen Dienst Bedrijfsvoering.

Jöreskog, K.G. and Sörbom, D. (1996). LISREL 8 User's Reference Guide, *Scientific Software International*.

Kleijnen, M., de Ruyter, K. and Wetzels, M. (2004). Consumer Adoption of Wireless Services: Discovering the rules while playing the game, *Journal of Interactive Marketing* **18**(2): 51–61.

Kool, R., Hoogstraten, J., Dunnen den, M. and Koning, W. (2003). Implementatieleidraad 1.0., Technisch Rapport, September 2003.

Legris, P., Ingham, J. and Collerette, P. (2003). Why do People use Information Technology? A Critical Review of the Technology Acceptance Model, *Information & Management* **40**(3): 191–204.

López-Nicolas, C., Molina Castillo, F. and Bouwman, H. (2008). An Assessment of Advanced Mobile Services Acceptance: Contributions from tam and diffusion theory models, *Information & Management* **45**(6), September 2008, 359–364.

Louviere, J.J. (1988). *Analyzing Decision Making. Metric Conjoint Analysis*, Newbury Park: Sage.

Lu, J., Yao, J. and Yu, C. (2005). Personal Innovativeness, Social Influence and Adoption of Wireless Internet Services via Mobile Technology, *Journal of Strategic Information* **14**: 245–268.

Lu, J., Yu, C.-S., Liu, C. and Yao, J. (2003). Technology Acceptance model for Wireless Internet, *Internet Research: Electronic Networking Applications and Policy* **13**(3): 206–222.

Mao, E., Srite, M., Thatcher, J. and Yaprak, O. (2005). A Research Model for Mobile Phone Service Behaviors: Empirical validation in the U.S. and Turkey, *Journal of Global Information Technology Management* **8**(4): 7–28.

Molin, E. (1999). *Conjoint modeling approaches for residential group preferences*, Eindhoven: Eindhoven University of Technology.

Pavlou, P. (2003). Consumer acceptance of E-commerce: Integrating trust and risk with the technology acceptance model, *International Journal of Electronic Commerce* **7**(3): 101–134.

Pedersen, P.E. and Ling, R. (2002). Mobile End-user Service Adoption Studies: A selective review, Paper submitted to Scandinavian Journal of Information Systems.

Pica, D. and Sørensen, C. (2004). On Mobile Technology in Context: Exploring police work, *Journal of Computing and Information Technology* **12**: 287–295.

Poole, M. and DeSanctis, G. (1990). Understanding the Use of Group Decision Support Systems: The theory of adaptive structuration, in J. Fulk and C. Steinfield (eds.) *Organisations and Communication Technology*, Newbury Park: Sage, pp. 173–193.

Rogers, E.M. (1995). *Diffusion of Innovation*, New York: The Free Press.

Rogers, E.M. (2003). *Diffusion of Innovations*, 5th edn., New York: The Free Press.

Rossi, P.H. and Anderson, A.B. (1982). The Factorial Survey Approach: An introduction, in P.H. Rossi and S.L. Nock (eds.) *Measuring Social Judgments*, Beverly Hills: Sage, pp. 15–67.

Schepers, J. and Wetzels, M. (2007). A meta-Analysis of the Technology Acceptance Model: Investigating subjective norm and moderating effects, *Information & Management* **44**: 90–103.

Schilit, A., Adams, N. and Want, R. (1994). Context aware Computing Applications, in Proceedings of IEEE workshop on Mobile Computing Systems and Applications, Santa Cruz: IEEE Computer Society Press, 85–90.

Schmitz, J. and Fulk, J. (1991). Organizational Colleagues, Media Richness, and Electronic Mail: A test of the social influence model of technology use, *Communication Research* **18**(4): 487–523.

Sørensen, C. and Pica, D. (2005). Tales from the Police: Rhythms of interaction with mobile technologies, *Information and Organization* **15**: 125–149.

Steen, M. (2008). *The Fragility of Human-Centred Design*, Amsterdam: IOS Press.

Stijnman, G., Lugard, F., Slotema, M. and Lith, M. (2004). Evaluatie Pilot Mobiel Blauw, Technisch Rapport. Regiopolitie Amsterdam Amstelland.

Stol, W.Ph., van Wijk, A.Ph., Vogel, G., Foederer, B. and van Heel, L. (2004). *Politiestraatwerk in Nederland: Noodhulp en Gebiedswerk*, [Police streetwork in The Netherlands]. Apeldoorn/Zeist: Nederlandse Politie Academie/ Kerkebosch.

Suh, B. and Han, I. (2003). The Impact of Customer Trust and Perception of Security Control on the Acceptance of Electronic Commerce, *International Journal of Electronic Commerce* **7**(3), Spring 2003, 135.

Tapia, A. and Sawyer, S. (2005). Beliefs About Computing: Contrary evidence from a study of mobile computing use among criminal justice personnel, in C. Sørensen, Y. Yoo, K. Lyytinnen and J.I. DeGross (eds.) *Designing ubiquitous information environments: socio-technical issues and challenges*, New York: Springer.

Taylor, S. and Todd, P.A. (1995). Understanding Information Technology Usage – a Test of Competing Models, *Information Systems Research* **6**(2): 144–176.

Tyre, M.J. and Orlikowski, W.J. (1994). Windows of Opportunity: Temporal patterns of technological adaptation in organizations, *Organization Science* **5**(1): 98–118.

Van de Wijngaert, L. (1999). *Information Needs and New Media Choice*, Enschede: Utrecht University/Telematica Instituut.

Van de Wijngaert, L. and Bouwman, H. (2009). Would You share? Predicting the potential use of a new technology, *Telematics & Informatics* **26**(1): 85–102.

Van den Hooff, B. (1994). *Incorporating Electronic Mail*, Amsterdam: Otto Cramwinckel Publisher.

Van der Heijden, H. (2003). User Acceptance of Hedonic Information Systems, *MIS Quarterly* **28**(4): 695–704.

Venkatesh, V. and Davis, F. (2000). A Theoretical Extension of the Technology Acceptance Model: Four longitudinal field studies, *Management Science* **46**(2): 186–204.

Venkatesh, V., Morris, M., Davis, G. and Davis, F. (2003). User Acceptance of Information Technology: Towards a unified view, *MIS Quarterly* **27**(3): 425–477.

Vriens, M. (1995). *Conjoint Analysis in marketing. Developments in stimulus representation and segmentation methods*, Groningen: Groningen University.

Walther, J.B. (1992). Interpersonal Effects in Computer-Mediated Interaction: A relational perspective, *Communication Research* **19**(1): 52–90.

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Appendix A

Ease of use

1. Learning to operate mobile systems will be easy for me
2. I would consider mobile systems to be flexible in terms of interaction
3. It would be easy for me to become skilled in using mobile systems

Perceived usefulness (productivity)

1. Using mobile systems in my job would enable me to accomplish tasks more quickly
2. Using mobile systems in my job would increase my productivity
3. Using mobile systems would make it easier to do my job

Perceived usefulness (resource advantage)

1. I would consider mobile systems useful in my job
2. Mobile communication systems are a nice supplement to existing systems
3. Mobile systems have many advantages over other systems

Media fit (solve problems)
Mobile communication systems are the proper media for:

1. Decision-making
2. Gaining an overview of the situation
3. Asking questions
4. Solving problems

Media fit (information exchange)
Mobile communication systems are the proper media for:

1. Exchanging information
2. Retrieving information

Intention to use

1. I intend to use mobile systems in the future
2. I expect mobile systems to make my work more convenient
3. I will frequently use mobile systems in the future
4. I will strongly recommend others to use mobile systems