Transitional Journey Maps: Capturing the dynamics of operational policing

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Abstract

Operational police work can be characterized by the continuous switching between surveillance, responding to incidents, and office activities. Transitions between these activities are initiated by radio contact, messages on a mobile data terminal, or personal observations. The "information environment" emerging from these channels may cause cognitive overload during demanding activities. Although the notion of fragmented work is acknowledged in police literature, detailed descriptions are lacking. The goal of this study is to better understand cognitive load in police officers by capturing the dynamics of operational policing. Ten officers of the Dutch police force were accompanied while on patrol with their car. The method of contextual inquiry was used to collect 28 hours of data. Activities were mapped on a pre-defined set of categories. Attention was paid to how officers experienced their information environment while performing these activities. All was captured in the Transitional Journey Map, a new method to visualize workflow. The Transitional Journey Map augments a sequence of activities with experiential and contextual information. This method was used to identify cognitive overload situations and differences between solo and dual patrol work. These insights are relevant for improving the information system that assists officers in their patrol vehicle.

Introduction

"After a short break at the police station, C. and S. return to their surveillance duty. The dispatcher calls: 'A missing young girl possibly showed up at relatives and should be picked up.' While S. tries to write down the address in his notebook, they realize they missed the girl's full name and the house number. S. feels stupid for having to ask again. Directly afterwards an alarm goes off. S. glances at the mobile data terminal: 'It's a white vehicle with an unpaid fine.' C. looks around, locates the car, and immediately makes a turn. Just as S. tries to request information on the driver, the dispatcher interrupts him: 'We are detaching you from the previous call. Someone has been spotted in a building that burned down last week.' C. recognizes the address, turns the car again, and accelerates. On their way, S. declines another alarm with a lower priority. They arrive at the scene only minutes later, to find a man in ragged clothes carrying a bag full of copper." (field notes from the present study)

This example illustrates how police officers are faced with a perpetual switching between activities, often resulting from the technology that surrounds them. The

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Dutch police force is currently looking for ways to improve the information system of their police vehicles, including pushing information (e.g., neighbourhood updates, on-board training) to the vehicle. A central question is how much information officers can process in various work situations. Streefkerk et al. (2006) argued that a mobile police information system should be context-aware (i.e., involving time, location, environmental, and social factors) to prevent cognitive overload. This implies that the dynamics of police work should be taken into account for the development of such a system. For example, indications on average time spent on an activity and the corresponding cognitive load may assist in determining the length and appropriateness of an information event (i.e., a moment during which information is presented). As will turn out, a detailed description of work dynamics is lacking in police literature. Therefore, the goal of this study is to better understand cognitive load in police officers by capturing the dynamics of operational policing. First, a background on operational policing, equipment, and activities is discussed. Next, a new approach to visualize workflow is applied to the data of a field study.

Operational policing in The Netherlands

The Dutch police organisation consists of one national unit, and ten regional units. The national unit deals with, e.g., highway patrol, organized crime, and terrorism. In addition, two types of police work can be found in a regional unit (Stol et al, 2004): community policing (Dutch: 'gebiedswerk') and operational policing (Dutch: 'noodhulp'). Community policing is pro-active and preventive, and involves considerable time on networking with civilians (Stol et al., 2004; Smith et al., 2001). Operational policing on the other hand is mostly reactive: it is time and safety critical work based upon officers attending incident sites by car (Sørensen & Pica, 2005). The scope of this paper is operational policing. For this type of work, each police station employs a number of concurrently operating police vehicles. Two officers usually occupy one vehicle, although some regions are experimenting with additional solo patrol vehicles. When an operational police team in The Netherlands is not assigned to a current call, officers typically spend their time on criminal investigation (i.e., based on assignments handed out during briefing), or law enforcement (e.g., surveillance, traffic control).

A police officer's information environment

The information environment of a patrolling officer consists of numerous concurrent visual and auditory channels. The patrol car is equipped with a specialized in-vehicle information and communication system. The Mobile Data Terminal (MDT) is a touch screen device positioned on the vehicle console in-between the driver and co-driver, providing the officer with a number of functionalities (see Figure 1). First, the vehicle is equipped with an Automatic Number Plate Recognition (ANPR) system. This system compares license plates scanned by on-board cameras with a database of delicts linked to specific number plates. In case of a 'hit', an alarm can be heard through the car's speakers, and information on the vehicle is displayed on the MDT. Additionally, officers use the MDT to acquire information on a person, to control the lights on top of the car, and for navigation.

Figure 1. View on the cockpit of a police vehicle. The Mobile Data Terminal is located between the driver and co-driver.

There are two main modes of communication between the control room and patrolling officers: direct contact using a mobile phone, and two-way broadcasting. Regarding the latter, officers are equipped with a portophone for radio contact, which consists of an earpiece, a microphone, and a channel selector. Additionally, the vehicle's interior loudspeakers may be used. Broadcast radio messages typically start with a numerical code consisting of the region and the team it is intended for. Consequentially, officers continuously monitor incoming codes to detect if a call is meant for them. Pen and paper are used to memorize details of a call, as well as observations made when dealing with a call.

Monitoring this complex environment may have consequences on performance. Multiple Resource Theory (MRT) predicts that time-sharing between two tasks is best when they require the use of different processing stages (e.g., cognitive vs. response), processing codes (e.g., spatial vs. verbal), and modalities (e.g., visual vs. auditory) (Wickens, 2008). However, the independence of modalities claimed by MRT has been criticized. For example, Spence and Read (2003) showed that dual-task performance decreases when the spatial location of an auditory speech shadowing task does not coincide with the spatial location of a visual driving simulator task. Since police officers typically monitor incoming messages through their earpieces (i.e., from one side), one can expect lower dual-task performance than would be predicted by MRT. These decrements may be enlarged when the traffic conditions become more demanding (Patten et al., 2006), for example during pursuits and high priority calls. Additionally, Anderson et al. (2005) found that police officers frequently perform more than two tasks at a given time, which may also result in performance decrements (e.g., Recarte & Nunes, 2003). Therefore, designing the cockpit of a police vehicle requires an understanding of the situations in which in-vehicle technologies are used.

Fragmentation in police work

Lundin and Nuldén (2007) identified five ways in which Swedish officers used their patrol car: *'on their way to an incident'*, *'on their way from an incident'*, *'at the site of an incident'*, *'general surveillance when driving around or parked at a specific location'*, and *'parked at the station handling detained people or paperwork'*. A comparable categorization was found in a study on British police officers interacting with mobile technology (Sørensen & Pica, 2005). Here, the researchers distinguish five primary activity types: *'waiting in the car before an incident'*, *'driving to an incident'*, *'taking action at the incident'*, *'driving from the incident'*, and *'waiting in the car after an incident'*. Furthermore, they emphasize that this so-called *'generic cycle of operational policing'* can be interrupted and rearranged due to intermediate events (e.g., incoming calls with a higher priority). Borglund and Nuldén (2012) share this statement, identifying work rhythm as problem area in the Swedish police force: *"Much of police work is characterized by interruptions. Planned and ongoing activity can be discontinued at any time. Current routines and access to computer-based systems create a somewhat fragmented work situation for the officers."* Similar accounts have been reported for the U.S. (Straus et al., 2010) and Dutch (Bouwman et al., 2008) police forces. Thus, the notion of fragmented work seems acknowledged in literature on operational policing.

Given the continuous switching between activities, it is important to not only focus on stationary cognitive load during an activity, but also to consider the effects of transitions between activities on cognitive load. Yet, detailed investigations into police routines are typically represented through activity statistics using a full work shift as time window (e.g., Anderson et al., 2005; Frank et al., 1997; Smith et al., 2001). These statistics do not provide information on whether an activity is executed without interruptions, or about patterns of fragmentation. Moreover, these investigations do not reflect police officers' subjective experiences related to these activities. While attempts to characterize police work fragmentation using scenarios (Borglund & Nuldén, 2012) or narratives (Sørensen & Pica, 2005) do include subjective experiences, they too fail to quantify fragmentation. Therefore, the present study aims to unite a quantitative description of work dynamics with subjective experiences related to cognitive load.

Method

A series of ride-alongs with Dutch police officers were arranged. Based on the method of contextual inquiry (Beyer & Holtzblatt, 1997), officers were interviewed and observed in their natural work environment, where they provided explanations as their work unfolded.

Participants

Ten officers (8 males, 2 females) volunteered to be accompanied in their patrol cars. Each officer had at least two years of experience with operational policing. Four ride-alongs were arranged, including three full eight-hour shifts and two shift changes in total. Hence, the vehicle was chosen as central focus during ride-alongs, while personnel configurations changed from shift to shift. The ride-alongs included

solo (2 cases) and dual patrol (4 cases). With durations varying between 4,5 and 11 hours, in total 28 hours of data were collected. Colleagues of the officers often asked the researcher about his presence during stops at the police station. Their comments on work dynamics and organization are treated as part of the study results.

Apparatus

Data were collected with pen and paper, featuring timestamps, descriptions of the current activity, events in the officer's information environment that caused a transition to another activity (e.g., incoming calls, comments following an officer's observation), and utterances that expressed influences on cognitive load. All data were logged on a template with six rows of pre-defined activity categories. These categories were based on the framework by Lundin & Nuldén (2007), consisting of 'driving to the incident', 'engaging at the incident', 'driving to the station', 'driving surveillance', 'parked surveillance', and 'parked at the station'. As opposed to the original framework, surveillance activities were logged separately for the driving and non-driving category, as the corresponding cognitive load is likely to be different.

Procedure

Before the ride-along began, the researcher explicitly stated that the study was not intended to judge the officers' performance. Agreements were made on safety and privacy. During the ride-alongs, the researcher tried to minimize hindrance by discretely observing what was going on. This non-participatory research approach was at times violated, for example, when an officer asked for details about a recent call. Existing studies recommend that the relationship with the officer should not be sacrificed for the sake of minimizing reactivity (Stol et al., 2004; Spano & Reisig, 2006). Interestingly, such a question can be regarded as a verbalization related to high cognitive load. Officers were occasionally asked to explain what happened during transitions, but only if the work demands allowed for such concurrent reports. Otherwise, they were asked to give a retrospective report shortly after the event.

Results

A new method to visualize workflow will be introduced. The method is used to report findings on cognitive overload, and differences between solo and dual patrol.

Transitional Journey Maps

Connecting consecutive activities and experiences logged in the data template gives a sense of order and time. The graphical representation of these objective and subjective data is referred to as *Transitional Journey Map*. Four Transitional Journey Maps were constructed, one for each ride-along. An example can be found in the lower part of Figure 2. The excerpt shown on top corresponds with the anecdote introducing this paper. The vertical axis displays six activity categories, whereas time is found on the horizontal axis. The main actors are represented through three thick lines: the police vehicle (red violet), the driver (dark blue), and in case of dual patrol, the co-driver (light blue). A journey through activity

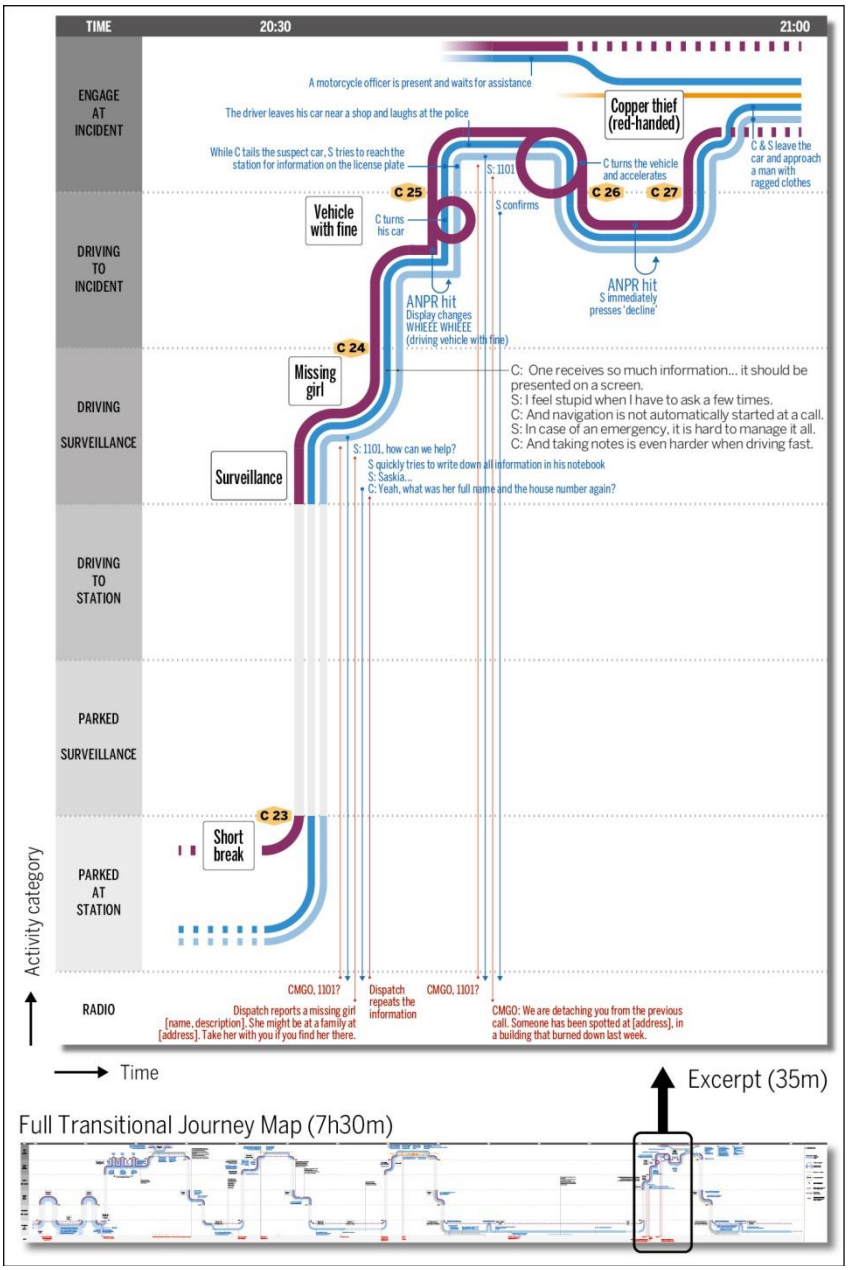

Figure 2. Excerpt of a Transitional Journey Map. The horizontal and vertical axes display time and six activity categories, respectively. Coloured lines refer to the vehicle (red violet), driver (dark blue), and co-driver (light blue). Additional details are described in the text.

categories is created as the actors cross the underlying framework. Additional lines may be used in case other actors come into play (e.g., the case of the copper thief, here represented in orange). Stationary vehicles are depicted with a dashed line.

Similarly, dashed lines are used when officers are having a break. Upon entering their car, officers' corresponding lines are joined with the vehicle's line. Segments of activities are demarcated by the time between adjacent transitions.

A transition is defined as a change from one activity category to another one. In Figure 2, transitions are labelled with yellow boxes, a character for the corresponding ride-along, and a number for the order of occurrence. For example, 'C23' refers to a segment of previous activity at the police station, and marks the transition from 'parked at station' to 'driving surveillance'. Descriptions for ongoing activities are depicted in white boxes for quick reference. Because of its dominant role in police work, instances of radio communication can be found in a separate row. The thin alternating red and blue lines in Figure 2 show how messages are going back and forth between the officers and the dispatcher (e.g., the call of the missing girl).

Applying Transitional Journey Maps to operational policing

Visual inspection of a full Transitional Journey Map confirms the notion that police work is fragmented. The lower part of Figure 2 shows periods of many short activity segments followed by relatively long stretches of paperwork at the police station. This is reflected in the boxplots of Figure 3, which show the durations of activity segments per activity category, including all ride-alongs.

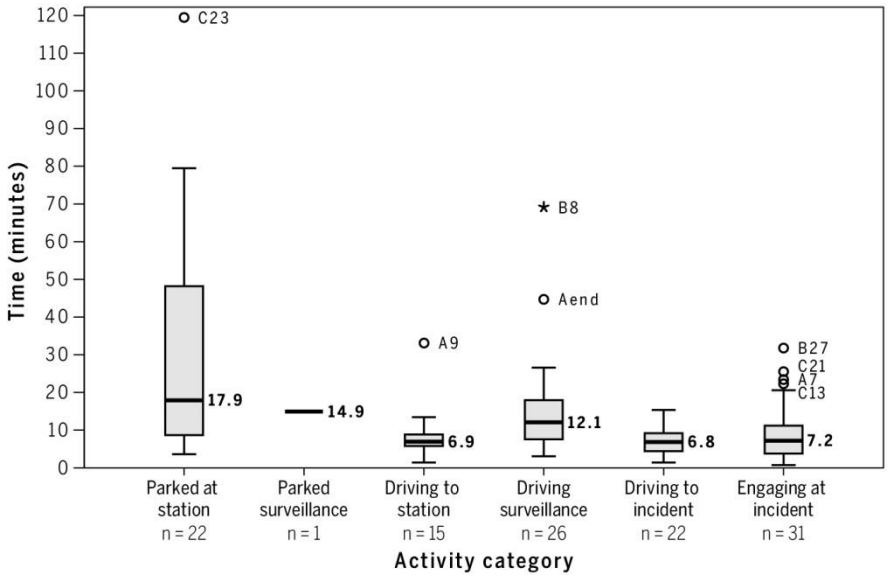

Figure 3. Boxplots of time spent in each activity category, summarized over all ride-alongs. Median values are shown next to each box. Whiskers depict the lowest and highest datum within a 1.5 interquartile range of the lower and upper quartile, respectively. Outliers labelled with an asterisk or a circle concern solo and dual patrol, respectively.

Outliers in the 'engaging at incident' category were cases where victims and/or suspects were questioned, namely theft (A7, C21) and domestic violence (B27,

C13). All of these cases required more than half an hour of paperwork, with an outlier at two hours (C23). However, officers were often interrupted by incoming calls before finishing their office work, as reflected by the median duration of 17.9 minutes. Other outliers refer to picking up remote colleagues (A9), surveillance while bringing the researcher to the train station (Aend), and surveillance across a deserted national park (B8).

The categories 'parked at station' and 'driving surveillance' seem to take longer than 'driving to station', 'driving to incident', and 'engaging at incident', who seem to have similar segment durations (see Figure 2). Given the skewed distributions, non-parametric tests (SPSS v20) were used to compare between activity categories. As only one instance of 'parked surveillance' occurred, this category was excluded from further analysis. Segment duration is significantly affected by activity category ($H(4) = 23.71$, $p < .001$). Seven Mann-Whitney tests were used to follow up this finding. Therefore, a Bonferroni correction was applied, and all effects are reported at a .007 level of significance. The duration of activities in the 'parked at station' category was generally significantly longer than 'driving to station' ($U = 70$, $r = -.48$), 'driving to incident' ($U = 90$, $r = -.54$), and 'engaging at incident' ($U = 148$, $r = -.48$), but not longer than 'driving surveillance' ($U = 208$, $r = -.23$). Furthermore, activities performed in the 'driving surveillance' category took significantly longer than 'driving to incident' ($U = 139$, $r = -.44$) and 'engaging at incident' ($U = 235$, $r = -.36$), but not longer than 'driving to station' ($U = 108$, $r = -.37$). It can be concluded that most time for an informing event can be found when officers are working at the police station, or during surveillance while driving. Based on this dataset, an informing event should take less than 6.8 minutes if at least half of these events are to be fully processed in any activity category before a next transition takes place. However, these statistics do not address whether officers have spare capacity to successfully process the information.

Reports of cognitive overload

Comments by police officers regularly contained descriptions of situations witnessed during other ride-alongs, which were indicators for cognitive overload. For example, compare the following anecdote with Figure 2:

"An incoming call instructs the officers to advance to a car that was broken into. L. takes a notebook from her pocket to record the address: 'This way you don't have to ask again.' A. responds: 'On the group radio one often hears colleagues asking for a repetition of the suspect description. At the time they receive a call and they have to move as fast as possible, their mind set is already preoccupied.'" (field notes ride-along A)

Because of the activity descriptions and their characteristic visual pattern, the layout of a Transitional Journey Map facilitates remembering and retrieving events with related comments. Furthermore, the content of a comment dictates in which activity category it should be placed (e.g., a colleague at the station talking about an arrest belongs to 'engaging at the incident'). Thus, an overview of information processing issues within an activity category can be obtained by scanning along the

corresponding row in the Transitional Journey Maps. This approach resulted in the identification of an information processing paradox.

On the one hand, police officers not only monitor the radio for messages addressed to themselves, but they also want to stay informed on the whereabouts and tasks of their colleagues. One reason is safety: *"If there is a call with violence, it's good to know if colleagues are nearby... then you know if and how long you should wait before stepping in."* Vice versa, officers may offer assistance. Second, there are functional implications: *"Those officers are busy over there, so I'll compensate by patrolling more centrally in this area."* Finally, it is part of a social system: when returning at the station after an emotionally demanding call, officers find support from colleagues that listened in. One officer commented that he was missing too much information, even though three channels were concurrently monitored (i.e., car radio and two earpieces).

On the other hand, police officers have trouble in processing all information. As described above, incoming calls regularly contain too much information to remember. This is further inhibited by situational and state related factors: *"If a situation is dangerous, you feel the adrenaline, stress, fatigue and tension, and this affects your ability to concentrate. In those situations it is hard to hear something amidst other voices."* Messages are often hard to comprehend due to auditory masking by the police vehicle (e.g., when driving at high speed, often accompanied by a siren) and signal degradation in the communication system. In the meanwhile, the continuous monitoring and filtering of radio messages takes its toll. Up to 26 messages were counted in a time span of five minutes. Officers complained about high volumes, occasional feedback beeps, and fatigue: *"My left ear is deaf for other sounds because of the earpiece. After a busy shift I still hear the voices at home."*

Comments on the necessity of monitoring radio communication were found in all activity categories, except for 'parked surveillance'. However, the representativeness of this exception is doubtful, since action in this category was observed only once. Comments on auditory masking were found in all activity categories that involved driving. Comments on overload were found in all activity categories, except for 'driving to station.' Overall, the observations and comments suggest that police officers want more information than they can handle with the current system.

Comparison solo and dual patrol

All outliers in Figure 3 were cases of dual patrol, except for B8. This suggests a considerable difference in time spendings between solo and dual patrol, and as a result, more time for information events during dual patrol. Non-parametric tests were performed per category. Using a Bonferroni correction, the effects were compared with an alpha level of .008. None of the tests on time spending reached statistical significance. Nevertheless, police officers did mention differences between solo and dual patrol modes. The biggest impact is the opportunity to distribute tasks among officers in case of dual patrol. Generally, the driver only concentrates on driving, whereas the co-driver is responsible for communication and surveillance tasks. Many officers commented that it is hard to operate the mobile

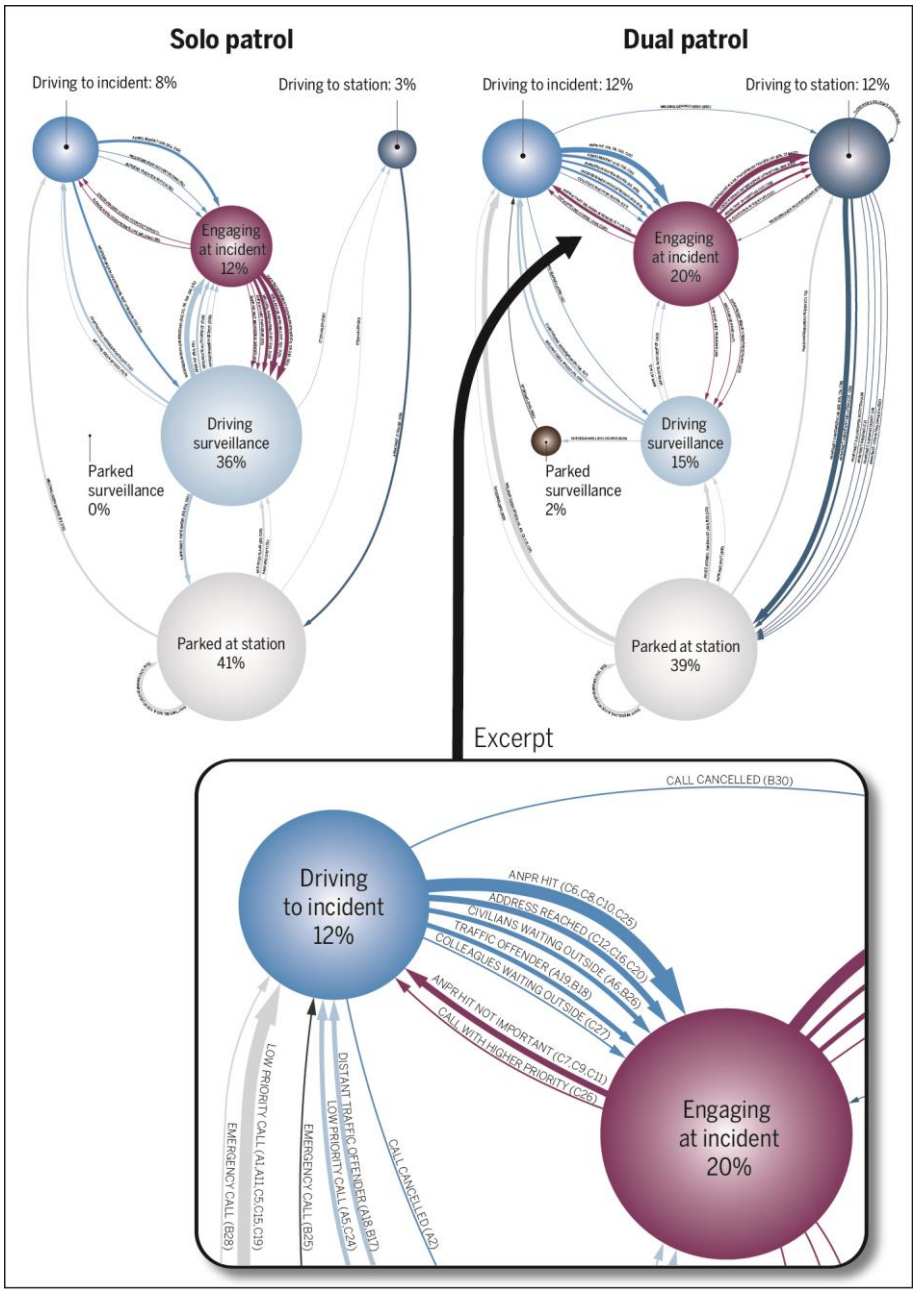

Figure 4. State diagrams of transitions during solo patrol (top left, 12.6 hours observed) and dual patrol (top right, 15.1 hours observed). The excerpt shows observed causes for transitions between activity categories. Codes in parentheses refer to transitions in the Transitional Journey Maps.

data terminal while driving solo. Additionally, there are organizational differences between the patrol modes: *"If you're patrolling solo, you only get a call when the others cannot handle it. In cases of violence we always operate with couples."* This suggests that differences may be found between the distributions of transitions.

Figure 4 depicts state diagrams for solo and dual patrol. An arrow line represents each cause for a transition between two activity categories. Thicker lines are used if the same cause was observed more than once. The total time spent observing solo and dual patrol were 12.6 hours and 15.1 hours, respectively. The relative time spent in each activity category is represented by the size of the corresponding circles. The two figures reveal that solo patrol involves relatively more 'driving surveillance' activity than dual patrol (36% vs. 15%). Solo patrol involved more transitions from 'driving surveillance' to 'engaging at incident' (10 vs. 2), but less transitions from 'driving to incident' to 'engaging at incident' (5 vs. 12). Interestingly, in both patrol modes 15 transitions were counted towards 'engaging at incident'. However, relatively more time on 'engaging at incident' was spent in dual patrol (20% vs. 12%). This was caused by the longer times spent on investigating incidents with violence (see outliers in Figure 2). Additionally, dual patrol involved more time spent on 'driving to station' (12% vs. 3%), which may be due to the large amount of paperwork after serious incidents, and a higher likelihood of transporting victims or suspects afterwards. In sum, the state diagrams on solo and dual patrol reflect the organizational differences uttered by the police officers.

Discussion

The Transitional Journey Map is a model to describe workflow, by connecting objective and subjective data along a timeline. Similar models have been developed, but there are a number of structural differences. Although the customer journey map used in service design (e.g., Zomerdijk & Voss, 2010) served as inspiration, it is based on a fixed sequence of consumption activities. In contrast, the Transitional Journey Map is aimed at capturing unpredictability, which is one of the essential characteristics of operational police work. The Cognitive Pathway visualization, which was developed to map the workflow of nurses (Wolf et al., 2006), does consider unpredictability. However, it does not include the subjective experiences of participants, or the interaction with other professionals in the work domain. Therefore, the Transitional Journey Map, with its emphasis on time and transitions, may be a valuable addition to the existing palette of work models (e.g., Beyer & Holtzblatt, 1997). In case the time dimension is less relevant for analysis, the derivative state diagrams could offer insights from a different perspective. Finally, Transitional Journey Maps may also be employed as scenarios to compare alternative solutions in a design context.

It has been argued that knowledge on work dynamics and related cognitive load is beneficial for the development of an information and communication system. Regarding work dynamics, the current data suggest that in most cases an information event that takes place while driving may not take longer than 6.8 minutes if it is to be fully processed before a next transition takes place. However, this finding does not address cognitive load. The comments made by officers suggest that the demands of concurrent driving, surveillance, and monitoring force them into a

permanent state of task-related effort (De Waard, 1996). Therefore, although no complete performance breakdowns were observed, the continuously experienced high workload was exhausting in the long run. 'Driving to station' is the only activity category that may be used for additional information events, given the absence of comments on cognitive overload. However, the applicability would be limited during solo patrol. Overall, the data suggest that the means with which police officers currently obtain information from the system should be improved, before pushing of additional information can be considered.

The present study was an initial exploration into the dynamics of operational policing. Therefore, more data on segment durations are required before a final statement can be made on opportunities for information events. More specifically, exposure to activities in the 'parked surveillance' category is needed, as well as observations during early mornings. Police officers may have been tempted to show parts of their work that they considered most interesting to show. An automated logging system may help in gathering a more detailed work pattern. However, this would be at the cost of subjective experiences.

Conclusion

The Transitional Journey Map, a new visualization method, describes workflow by connecting observed events with subjective experiences on a timeline with a set of activity categories. This method was applied to the data of a field study on operational policing. Embedded in an unpredictable workflow, the information environment of a police officer includes numerous visual and auditory information channels. Analysis of workflow fragmentation and officers' comments on cognitive overload suggests that the police vehicle's cockpit should be improved, before pushing additional information can be considered. Particularly, alleviation of the auditory channel is needed. The current results warrant further application of the Transitional Journey Map method in other contexts, such as information processing by other emergency services, and tracking group dynamics for crowd management.

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