ONLINE APPENDIX - NOT FOR PUBLICATION

Appendix A: Face-to-Face Communication as 'Help' from Handler to Operator

We have interviewed twelve currently serving radio operators, as well as eight currently serving handlers. These interviews occurred in September 2018, a period in which handlers and operators were based in separate buildings. Some of the staff that we spoke with had however been working during our main sample period of 2009-2011.

The overwhelming majority of our interviewees agreed that the ability to communicate face-to-face could help the operator to deal with the incident faster and better. In this Appendix we outline the main reasons given, together with other interesting details that we learnt along the way.

Too Much Information The main reason mentioned is that extracting from the log the information necessary to allocate an officer takes time. This is partly because the log includes many details that are not essential and that the operator must sift through before identifying the details that are. For instance, one operator stated that *'there is a lot of irrelevant information sometimes in the log'.*

The issue of too much information is compounded by the fact that the structure of this information is not necessarily optimal from the operator's perspective. For instance, one operator stated that *'information by handlers is sometimes very convoluted'.* Along the same lines, another argued that *'the operator has a kind of check list in mind and sometimes the handler doesn't, so maybe the information is in the log, but very convoluted'.*

In this context, being able to ask the handler in person provides the operator with a fast and efficient way of extracting the necessary details. For instance, an operator argued that *'the handler can tell you some important info that otherwise you need to read the whole log'.* Similarly, a supervisor of the operators stated that, *'the handler can give some insights that otherwise will take time for the operator to read'.*

Importantly, the fact that the amount of detail and structure are sometimes not optimal from the allocation perspective does *not* necessarily mean that handlers are not doing their job properly. The log is likely to be consulted in the future by police officers, detectives and other staff, and these may benefit from learning details that are not immediately useful to the operator. Secondly, structuring the information better might increase its value to the operator, but would itself take valuable time. That being said, a couple of the operators that we interviewed argued that handlers could potentially make their jobs easier. For instance, one stated that *'when the handlers ask questions, sometimes they don't ask the most important questions or in the right order. Sometimes you need that key info before sending the response team'.* In the same line, another stated that *'if the handler writes well, they should put the relevant information in the first page, but some people just write too much and it takes time to read all of it'.*

Unsurprisingly, many of the handlers that we spoke with argued that their job is difficult enough already, and that it is often impossible to provide the information quickly and in a highly structured way. For instance, one argued that *'sometimes the caller is stressed, and he doesn't know where he is, unable to tell what's going on. Then the operator don't get the information that clear in the right order, but because you are trying to calm down the caller,* *get the information, etc... everything at the same time'.* Another said that *'sometimes they don't see immediately the body of the log where there is some important information. For a burglary, sometimes is very important to put the description of the car in the first line so the operator sees it immediately. However, you don't always get this info at the beginning so it goes to the second page'.* Yet another *'sometimes you get some information while talking, or information becomes more important later. But you can't erase the log and start again, so it goes to the second page although it is very important'.*

Key Information is Unclear The second reason why face-to-face communication helps is that information necessary before allocating an officer is sometimes unclear (and occasionally even missing) in the log. For instance, one operator stated that *'there was a case where I could not understand from the log if the person was still carrying a knife or not, and that can make a big difference in terms of type of response'.* Another operator provided us with a very similar example *'we need to clarify something in the logs sometimes. Sometimes, you get domestic abuse cases where it is not clear if there was sexual assault, rape, etc... This is a very important distinction as in those cases you need to send officers with specific training'.*

The information may be unclear simply due to human error. For instance, an operator told us that, *'recently I had a case with a person with a knife and a child was involved. The description said that the child was NJURED, which could be injured or uninjured, and this is not a small difference as it requires a very different response type'.*

Another possibility is that important information is not clear because the log is not the most appropriate format to convey certain details. One reason for this is that the log is an official document and handlers must be careful about what they write there. A second reason is that written communication may not be the most efficient channel for fuzzy concepts. For instance, a handler stated that, *'we can hear the caller, we know sometimes "this doesn't sound right" but is difficult to convey that by text. Or sometimes the caller is very upset and is difficult to explain in the log how serious you think it is'.* Along very similar lines, another handler told us that, *'yes, this is like text messages, the other person can get a wrong concept. Have you ever tried to argue by text message? Always the other person misinterprets something. Sometimes the caller contradicts himself, so you rely on your own perception, like there is something wrong here but it is sometimes difficult to express it in the log'.*

Again, the ability to speak directly with the handler speeds things up. A supervisor of the operators referring to the present situation (in which handlers and operators are never co-located) stated that, *'you want to understand how serious the incident is before sending people. It would be much easier/faster to have the handler around to clarify this'.* Referring instead to the pre-2012 period, a currently serving operator told us that, *'we usually asked them to come over and explain/clarify the logs'.* This same operator continued later in our discussion: *'when we have a break-in into a house, the description of the suspect is sometimes not clear. Also, there are cases when the handler writes the direction in which the suspect ran or some indication of it. Sometimes it takes time to figure out this in the map and can be faster to ask the handler'.*

Summary and Interpretation We interpret the descriptions above as providing the following view of the operator's production process: (a) after the incident has been created, the operator needs to 'process' the information. This requires reading the log and extracting from there the relevant details that determine the type of response appropriate to the situation. If these details are missing or unclear, they need to be gathered through alternative channels; (b) processing the information takes time, and an officer cannot be allocated until all or at least most of the necessary details have been gathered; and (c) being able to ask short and precise decision-relevant questions to the author of the log can sometimes speed this processing time.

We believe that this production process is broadly consistent with the assumptions of the theoretical model in Section 3. Note further that some characteristics of face-to-face communication are implicitly important in the descriptions above. For instance, the fact that communicating in person allows for fast and bi-directional interaction appears to be important to resolve or clarify doubts. Of course, it is possible that other technologies such as phone conversations may be also effective in complementing electronic communication.

Appendix B: Assumptions of the Model and Relation with Theoretical Literature

We are aware of no other model that microfounds the effect that communication has on the delay at different stages of the production process. Other ingredients of our model are however standard in the literature. The notion that organisations are structured to process a flow of incoming problems is for instance common (see again Garicano and Prat, 2013). Bolton and Dewatripont (1995) highlight here two motives for internal communication: concern for minimising delay (like in our model) and concern for maximising throughput.[1] Communication in this literature is typically a non-strategic activity, often explicitly interpreted as the 'help' that workers first encountering a problem provide the colleagues that they send the problem to (Garicano, 2000). As in our model, the time spent providing or receiving help is taken away from producing new problems. Also as in our model (but in contrast for instance to Crémer et al., 2007) the communication technology is typically exogenous.

An essential element of our framework is that workers at different levels perform inherently different activities and therefore cannot substitute each others' inputs (although communication performs an 'information subsidy' role, as in Hall and Deardorff (2006)). In this respect, we differ from Radner (1993) or Garicano (2000). A closer parallel is Bolton and Dewatripont (1994), where different tiers specialise in different activities. An important point of departure with respect to this paper and most of the literature is however that we take the organisational structure (i.e. number of levels, workers in each level, etc) as exogenous, and focus instead on the communication effort conditional on this structure.

Lastly, the notion that a sender has to undertake effort to get her message across is also present in Dewatripont and Tirole (2005). Our model is however different, not least because of the emphasis on delay rather than decision-making.

[1] For examples of the first strand see Radner (1993), Van Zandt (1999), Beggs (2001), Arenas et al. (2010) and Golub and McAfee (2011). The last three papers use standard results from queueing theory, as do we. For the second strand, notable examples include Bolton and Dewatripont (1994) and Garicano (2000). A third strand has as an objective optimising the quality of decisions (Sah and Stiglitz, 1986). In our empirical application minimising delay is obviously essential but there is also scope for taking the right or wrong decision. For tractability, we abstract from this motive in the model, although we present evidence on other outcome variables in the empirical section.

Appendix C: Proofs

Lemma 1 The Lemma comes directly form taking the first order condition and rearranging. The second order condition for a minimum is $\frac{1}{(s_1-x)^3}+\frac{w\pi^2}{(s_2+\pi x)^3}>0$. It is easy to see that this condition is satisfied.

Proposition 2 To see Part 1, note that ΔP_1 depends on π only positively through x^* and that the derivative of x^* with respect to π has no unambiguous sign (see equation (3)). Secondly,

$$\frac{d\Delta D_2}{d\pi}=\frac{-\left[x^*+\pi\frac{\partial x^*}{\partial\pi}\right]}{(s_2+\pi x^*)^2}=\frac{-\frac{\sqrt{\omega\pi}}{2}(x^*+s_1)}{(s_2+\pi x^*)^2(\pi+\sqrt{\omega\pi})}<0$$

To see Part 3, note that ΔP_1 depends on s_1, only (positively) through x^*. From (2) we have that x^* is decreasing in s_1. However, θ_1 is a component of s_1, so we have to compute the derivative with respect to that.

$$\frac{dx^*}{d\theta_1}=\frac{\frac{\partial x^*}{\theta_1}(\theta_1(\theta_1-x))-x^*(2\theta_1-x^*)}{(\theta_1(\theta_1-x^*))^2}<0$$

for which we use the fact that $\frac{\partial x^*}{\theta_1}<0$. Secondly, ΔP_1 depends on s_2 only (positively) through x^*. It is immediate to see from (2) that x^* is decreasing in s_2. Thirdly, ΔD_2 depends on s_1 only (negatively) through x^*. It is immediate to see from (2) that x^* is increasing in s_1. Lastly, differentiating with respect to s_2, we have

$$\frac{d\Delta D_2}{ds_2}=-\frac{1}{(s_2+\pi x)^2}+\frac{1}{s_2^2}-\frac{\pi}{(s_2+\pi x)^2}\frac{\partial x^*}{\partial s_2}>0$$

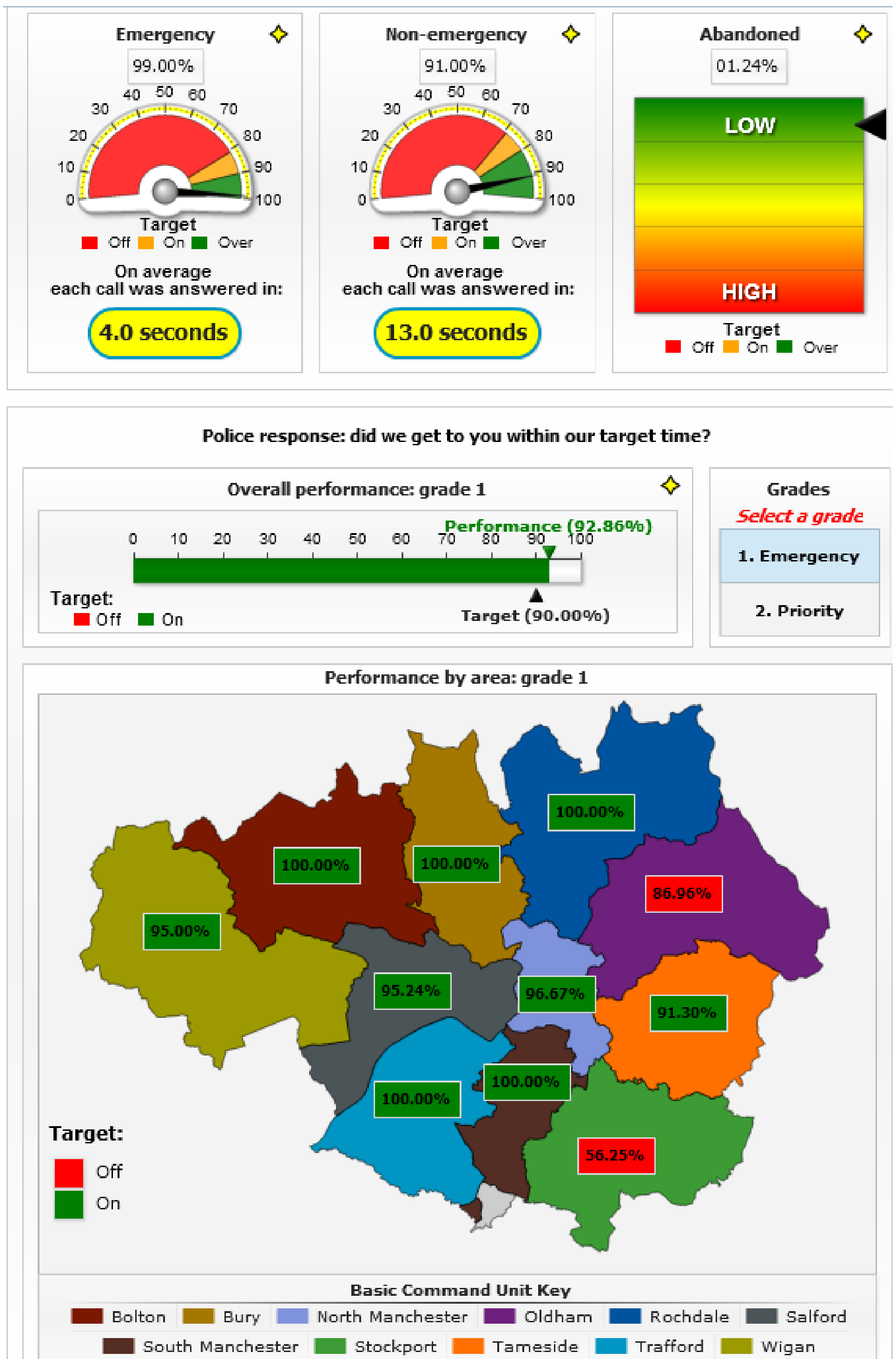
To see Part 2, note that x^* is increasing in ω, and that ΔP_1 depends on ω only (positively) through x^*. Similarly, ΔD_2 depends on ω only (negatively) through x^*.

Appendix D: Appendix Tables and Figures

FIGURE A1: Greater Manchester Police Annual Report 2016-17

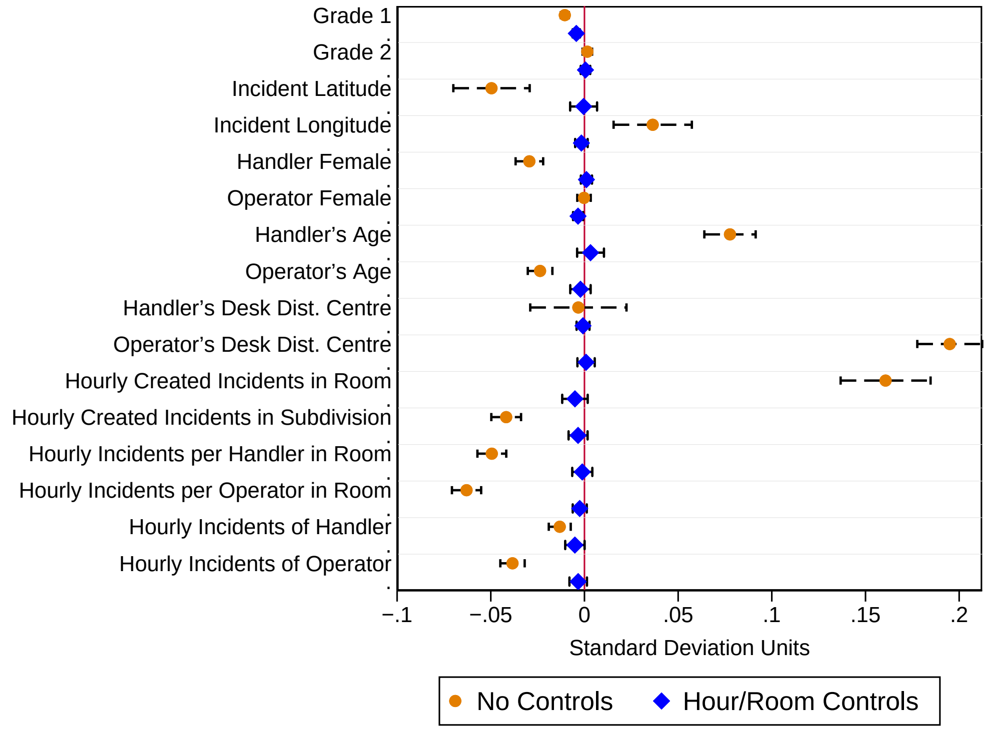
. Source: GMP (2017)

FIGURE A2: GMP Website Extract Infographic on Call Queuing Times and Response Times



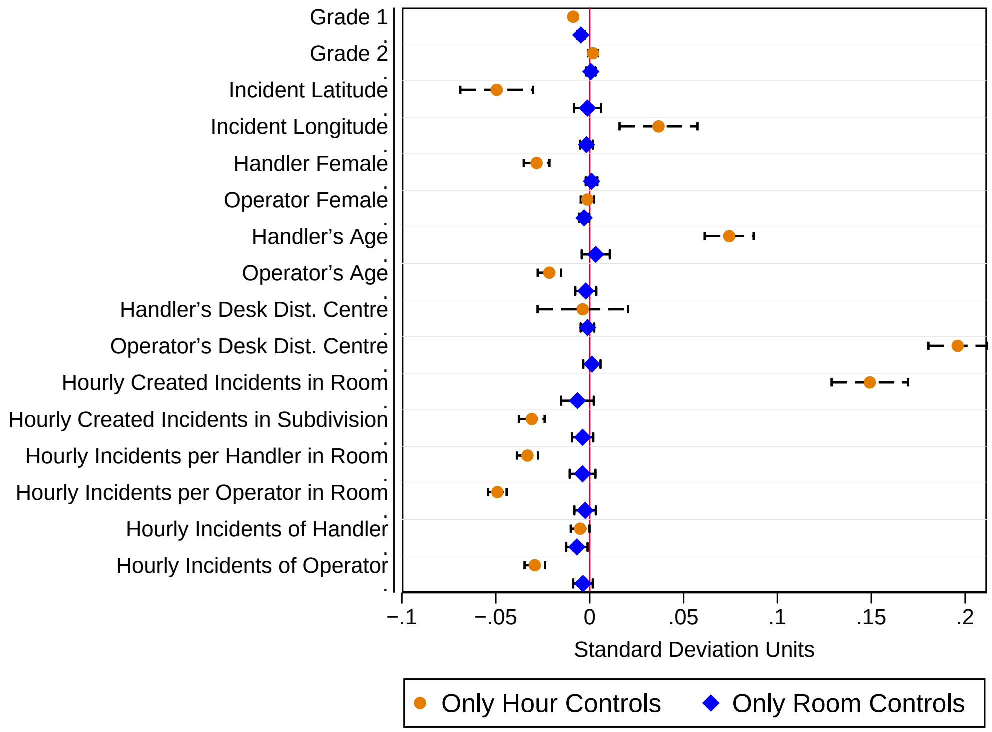
. Source: GMP (2015)

FIGURE A3: Balance of Incident, Worker and Room Characteristics on Same Room



Each row in the figure displays the results of two regressions, where the row variable is the dependent variable and Same Room is the independent variable. The first regression includes no controls and the second regression controls for Year X Month X Day X Hour of Day, Operator Room and Handler Room. The displayed 95% confidence intervals are for the coefficient of the Same Room variable. Non-binary dependent variables are standardised. Standard errors are clustered at the Year X Month X Operator Room level. Grade 1, Grade 2, Handler Female and Operator Female are the only dummy variables. Handler's Desk Dist. Centre is the euclidean distance between the handler's desk and the centre of the room. Hourly Incidents per Handler in Room is the number of incidents created during the hour of the index incident, divided by the number of handlers working during that hour. A similar definition applies to Hourly Incidents per Operator in Room. Hourly Incidents of Handler is the number of incidents created by the handler in charge of the index incident, during the hour of creation. Hourly Incidents of Operator is the number of incidents allocated by the operator in charge of the index incident, during the hour of the creation of the incident.

FIGURE A4: Balance of Incident, Worker and Room Characteristics on Same Room Incidents Including the Core Controls Separately



Each row in the figure displays the results of two regressions, where the row variable is the dependent variable and Same Room is the independent variable. The first regression includes only Year X Month X Day X Hour of Day controls and the second regression includes only controls for Operator Room and Handler Room. The displayed 95% confidence intervals are for the coefficient of the Same Room variable. Non-binary dependent variables are standardised. Standard errors are clustered at the Year X Month X Operator Room level. Grade 1, Grade 2, Handler Female and Operator Female are the only dummy variables. Handler's Desk Dist. Centre is the euclidean distance between the handler's desk and the centre of the room. Hourly Incidents per Handler in Room is the number of incidents created during the hour of the index incident, divided by the number of handlers working during that hour. A similar definition applies to Hourly Incidents per Operator in Room. Hourly Incidents of Handler is the number of incidents created by the handler in charge of the index incident, during the hour of creation. Hourly Incidents of Operator is the number of incidents allocated by the operator in charge of the index incident, during the hour of the creation of the incident.

Figure A5A: Distribution of Handlers’ Maximum Desk Usage

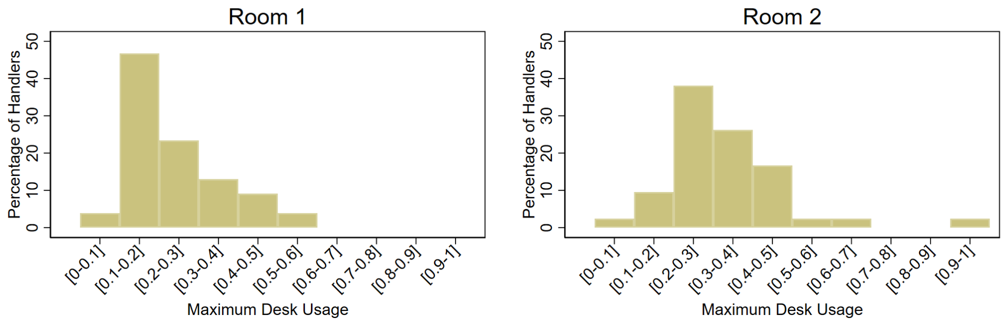


Figure A5B: Distribution of Handlers’ Average of Top 3 Desk Usage

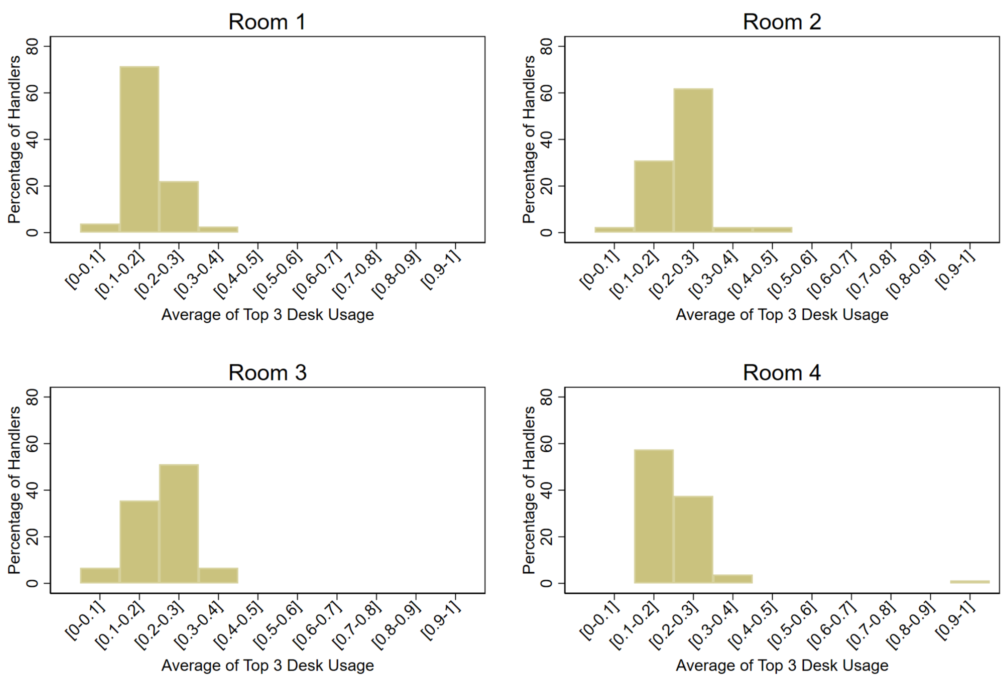


TABLE A1: ROBUSTNESS TO CLUSTERING STRATEGY

Dependent Variable (in logs)	(1) Allocation Time	(2) Response Time	(3) Not Ready Time
Coefficient (Same Room)	-.0201	-.0172	.0252
Year X Month X Subdivision (Baseline)	(.004)	(.003)	(.0093)
	[1408]	[1408]	[832]
Handler/Operator Pair	(.0041)	(.0032)	(.0077)
	[89927]	[89849]	[71737]
Subdivision	(.0039)	(.003)	(.0075)
	[61]	[61]	[57]
Date	(.004)	(.0031)	(.0078)
	[822]	[822]	[461]
Year X Month	(.0038)	(.0034)	(.0071)
	[27]	[27]	[16]
Year X Week	(.0043)	(.0035)	(.0065)
	[117]	[117]	[68]
Handler	(.0042)	(.0035)	(.0095)
	[420]	[420]	[321]
Operator	(.004)	(.003)	(.0077)
	[552]	[554]	[486]
Year X Month X Operator	(.004)	(.0031)	(.008)
	[9691]	[9693]	[5542]
Multiway: Operator/Handler	(.0043)	(.0036)	(.0098)
	[552/420]	[554/420]	[486/321]
Multiway: Operator/Year X Month	(.0039)	(.0034)	(.0069)
	[552/27]	[554/27]	[486/16]
Multiway: Operator/Handler/Year X Month	(.0039)	(.0037)	(.0089)
	[552/420/27]	[554/420/27]	[486/321/16]
Multiway: Operator/Handler/Year X Week	(.0045)	(.0039)	(.0087)
	[552/420/117]	[554/420/117]	[486/321/68]
Multiway: Subdivision/Operator X Week	(.004)	(.0031)	(.0078)
	[61/9691]	[61/9693]	[57/5542]

This table displays estimates of OLS regressions of allocation time, response time and not ready time on the Same Room dummy. All regressions also include indicators for Call Source, Year X Month X Day X Hour of Day, Operator Room, Handler Room, Operator and Handler. The first row displays the Same Room coefficient. Subsequent rows display the standard errors when clustered in different ways. For every clustering strategy we display the standard errors in parentheses (.) and the number of clusters in square brackets [.]. The last five rows estimate multiway clustering (Cameron et al., 2011).

TABLE A2: EFFECTS ON OTHER OUTCOME MEASURES EXCLUDING GRADE AND OPENING CODE INDICATORS

Dependent Variable (binary)	**Escalated to Crime**	**Cleared**	**Cleared within 24hrs**
Same Room	-.002***	-.002	.002**
	(.001)	(.003)	(.001)
Baseline Controls	Yes	Yes	Yes
Observations	957,164	186,379	186,379

This table displays estimates of OLS regressions of different outcome variables on whether the handler and operator are located in the same room. The dependent variable in the first column is a dummy taking value one if the incident was classified as a crime. In the second and third columns, the dependent variables are dummies taking value one if the crime was cleared, or cleared within 24 hours of the crime being committed and reported. The samples in the last two columns include only incidents that the police classified as crimes. All regressions include indicators for Call Source, Year X Month X Day X Hour of Day, Operator Room, Handler Room, Operator and Handler. Standard errors are clustered at the Year X Month X Subdivision level.

TABLE A3: INVESTIGATING WHETHER HANDLER AND OPERATOR ARE MORE ALIKE WHEN BASED ON THE SAME ROOM

Dependent Variable	(1) Match Charac.	(2) Match Charac.	(3) Same Room	(4) Same Room
Same Gender	.0044	.00437	.00395	.00405
	(.00586)	(.00595)	(.0054)	(.00548)
Log Difference in Age	.00704	.00691	.00276	.00272
	(.00748)	(.00744)	(.0029)	(.00288)
Log Difference in Experience	.00123	.00106	.00024	.00014
	(.00986)	(.00979)	(.00604)	(.00602)
Log Difference in Hours Worked in Month	.01031	.00988	.0024*	.00291
	(.0064)	(.00636)	(.00143)	(.00184)
Log Difference in # Incidents in Month	.00097	.00093	.02974	.02846
	(.00136)	(.00136)	(.04661)	(.04657)
Log Difference in Average Response Time	-.00048	-.00036	-.00086	-.0009
	(.00704)	(.00686)	(.00217)	(.00214)
Interaction Controls with Year X Month	No	Yes	No	Yes

This table investigates whether handler and operator are more alike when they are based in the same room. The sample is constructed as follows. For every month in the period November 2009-December 2011, we identified the identity of the active handlers and operators. We then construct a subsample for every month comprising of all the combinations of handler and operator. The regression sample aggregates the 27 month subsamples (N=1691560). In columns (1) and (2) each coefficient follows from a separate regression, in which the match characteristic displayed in the row is the dependent variable and Same Room is the independent variable. In columns (3) and (4) each column displays the coefficients from a separate regression, in which the variable Same Room is the dependent variable and the match characteristics displayed in the rows are the independent variables. In columns (3) and (4) we fail to reject the null hypothesis that all the displayed coefficients are jointly significant. Same Room takes value one if handler and operator are working on the same room in that month. Same Gender is a dummy take value one if handler and operator share the same gender. Log Difference in Age is the log of the difference in their ages. Log Difference in Experience is the log of the difference in their years of experience. Log Difference in Hours Worked in Month is the log of the difference in the number of hours that handler and operator worked on that particular month. Log Difference in # Incidents in Month is the log of the difference in the number of incidents being dealt with in a particular month. Log Difference in Average Response Time is the log of the difference in the average response time associated with the incidents of handler and operator. Columns (1) and (3) control for Year X Month, Handler, Operator, Handler Room, and Operator Room indicators. Columns (2) and (4) control for the interaction between Year X Month and the rest of indicators. Standard errors are two-way clustered at the Handler and Operator level.

TABLE A4: INVESTIGATING EFFECTS ON THE OPERATOR AND HANDLER ALLOCATION OF SCARCE RESOURCES OTHER OUTCOME VARIABLES

	Spillovers by Same Room Incidents during Period:					
	60 min.		30 min.		15 min.	
Dependent Variable (binary)	(1) Escalated to Crime	(2) Cleared within 24hrs	(3) Escalated to Crime	(4) Cleared within 24hrs	(5) Escalated to Crime	(6) Cleared within 24hrs
% Same Room Incidents Received Operator	.001	.001	0	.001	0	.001
	(.001)	(.001)	(.001)	(.001)	(.001)	(.002)
% Same Room Incidents Received Handler	.001	.001	0	.001	0	.001
	(.001)	(.001)	(.001)	(.001)	(.001)	(.002)
Baseline Controls	Yes	Yes	Yes	Yes	Yes	Yes
Opening Code	Yes	No	Yes	No	Yes	No
No Other Calls Indicator	Yes	Yes	Yes	Yes	Yes	Yes
Observations	957164	186382	957164	186382	957164	186382

This table investigates potential spillovers from Same Room incidents into other contemporaneous incidents. The dependent variables in the OLS regressions are dummy variables taking value one if: (a) the incident was classified as a crime, and (b) the crime was cleared within 24 hours of the crime being committed and reported. The independent variables are the percentage of incidents during the index incident time period for which the handler and operator were co-located, excluding the index incident. These percentages are respectively for the operator and for the handler. In Columns (1) and (2) the period comprises of 60 minutes (respectively, 30 minutes for columns (3) and (4) and 15 minutes for columns (5) and (6)). All regressions include indicators for Grade, Call Source, Year X Month X Day X Hour of Day, Operator Room, Handler Room, Operator and Handler. The regressions also include indicators for whether there were no calls received by the Operator and by the Handler during the time period. Columns (1), (3), and (5) also include indicators for the Opening Code. Standard errors are clustered at the Year X Month X Subdivision level.

TABLE A5: HETEROGENEITY OF SAME ROOM EFFECT BY MEASURES OF TEAM HOMOGENEITY COEFFICIENTS OF CONTROL VARIABLES

Dependent Variable (in logs)	(1) Allocation Time	(2) Response Time	(3) Not Ready Time
Same Room	-.021	-.031*	.113**
	(.023)	(.018)	(.05)
Same Gender	-.002	-.003	-.001
	(.004)	(.003)	(.008)
Log Difference in Age	.013***	.01***	-.005
	(.003)	(.002)	(.005)
Log # Past Interactions	-.073***	-.061***	-.003
	(.005)	(.004)	(.008)
Log Handler Experience	.058***	.045***	-.012
	(.009)	(.007)	(.027)
Log Operator Experience	-.057	-.026	.24**
	(.049)	(.036)	(.104)
Same Room X Log Handler Experience	-.004	-.003	-.015
	(.004)	(.003)	(.01)
Same Room X Log Operator Experience	.005	.009*	-.022*
	(.006)	(.005)	(.013)
Same Room X Same Gender	Yes	Yes	Yes
Same Room X Log Difference in Age	Yes	Yes	Yes
Same Room X Log # Past Interactions	Yes	Yes	Yes
Baseline Controls	Yes	Yes	Yes
Observations	923156	918628	437169

This table displays estimates of OLS regressions of allocation time, response time and not ready time on the Same Room dummy, interacted with whether the Operator and Handler are of the same gender, with the log of their difference in age, and with the number of previous incidents in which they have worked together. These coefficients can be found in Table 8. We display the coefficients for the controls: the uninteracted Same Gender, Log Difference in Age and Log Number of Past Interactions. All regressions further control for Handler Experience and Operator Experience and their interactions with Same Room. Baseline Controls include indicators for Grade, Call Source, Year X Month X Day X Hour of Day, Operator Room X Year, Handler Room X Year, Operator and Handler. Standard errors are clustered at the Year X Month X Subdivision level.

TABLE A6: HETEROGENEITY OF SAME ROOM BY DISTANCE INSIDE ROOM CONTROLLING FOR PAIR/SEMESTER

	(1)	(2)
Dependent Variable	**Log Allocation Time**	**Log Response Time**
Same Room X Log Distance	.031***	.019**
	(.011)	(.009)
Baseline Controls	Yes	Yes
Handler/Operator/Semester Indicators	Yes	Yes
Observations	877739	873047

This table displays estimates of OLS regressions of allocation time and response time on whether the handler and operator are co-located, interacted with the distance between their desks when they are in the same room. The sample includes all incidents received by the GMP between 2009 and 2012. The distance between their desks is calculated as the euclidean distance in the floorplans provided by the GMP. Basline Controls include indicators for Grade, Call Source, Year X Month X Day X Hour of Day, Operator Room X Year and Handler Room X Year Identifiers. Standard errors are clustered at the Year X Month X Subdivision level.

TABLE A7: ROBUSTNESS OF DISTANCE INSIDE ROOM REGRESSIONS

Dependent Variable (in logs)	(1) Allocation Time	(2) Response Time	(3) Not Ready Time
Panel A: By Occupation of Room at Handler's Start of Shift			
Same Room	-.05***	-.036***	.003
	(.012)	(.01)	(.022)
Same Room X Log Distance X Room Busy	.025***	.018***	.027*
	(.009)	(.007)	(.016)
Same Room X Log Distance X Room Not Busy	.029***	.018***	.009
	(.009)	(.007)	(.016)
Baseline Controls	Yes	Yes	Yes
Observations	940587	936035	465488
Panel B: By Whether Handler Sits in Preferred Desk			
Same Room	-.047***	-.033***	.032
	(.013)	(.01)	(.023)
Same Room X Log Distance X Preferred Desk	.029***	.018***	-.006
	(.009)	(.007)	(.016)
Same Room X Log Distance X Not Preferred Desk	.023***	.016**	-.004
	(.009)	(.007)	(.016)
Baseline Controls	Yes	Yes	Yes
Observations	944448	939878	466409

This table displays estimates of OLS regressions of allocation time, response time and not ready time on whether the handler and operator are co-located, interacted with the distance between their desks when they are in the same room. The independent variables are further interacted with the discretion that the handler had in choosing their desk. The sample in columns (1) and (2) includes all incidents received by the GMP between November 2009 and December 2012. In column (3) the dependent variable is the log of not ready time that the handler takes following the creation of the incident. This measure is only available starting on the second semester of 2010 and then is (for exogenous reasons) further missing for some months. The distance between desks is calculated as the euclidean distance in the floorplans provided by the GMP. Baseline Controls include indicators for Grade, Call Source, Year X Month X Day X Hour of Day, Operator Room X Year and Handler Room X Year. Standard errors are clustered at the Year X Month X Subdivision level.

TABLE A8: SAME ROOM MATCH HANDLER/OPERATOR PAIR FIXED EFFECT, DIFFERENTIATING THE BASELINE PERIOD FROM THE PLACEBO PERIOD

Dependent Variable (pair fixed effects)	(1) Allocation Time	(2) Response Time	(3) Not Ready Time
Same Room Match	-.051***	-.04***	.05***
	(.008)	(.006)	(.016)
Placebo Period	-.014***	-.013***	.042***
	(.004)	(.004)	(.009)
Same Room Match X Placebo Period	.046***	.041***	-.05***
	(.012)	(.01)	(.019)

This table displays differences-in-differences estimates of the handler/operator pair fixed effects on the Same Room Match dummy, the Placebo Period dummy and its interaction. The sample includes both the baseline period (2009-2011) and the placebo period (2012-2013). The variable Same Room Match takes value one if the call handler and the radio operator were located in the same room in the 2009-2011 period. Initial regressions estimate the handler/operator pair fixed effects, separately for the baseline period and the placebo period (only those pairs appearing in the sample in a minimum of 20 observations are computed). These initial regressions include indicators for Call Source, Year X Month X Day X Hour of Day, Radio Operator Room and Call Handler Room, all interacted with a Placebo Period dummy. The number of estimated pair fixed effects and the number of observations in the second stage displayed regressions is 72623, 72548 and 67845 for the allocation, response and not ready time regressions respectively. The displayed regressions are of the estimated pair fixed effects on Same Room Match, a Placebo Period dummy, and their interaction. Standard errors are bootstrapped with 100 repetitions.

APPENDIX REFERENCES

Arenas, A., Cabrales, A., Danon, L., Diaz-Guilera, A., Guimera, R., and Vega-Redondo, F. (2010), “Optimal Information Transmission in Organizations: Search and Congestion”, *Review of Economic Design*, 14(1-2): 75-93.

Beggs, A. W. (2001), “Queues and Hierarchies”, *Review of Economic Studies*, 68(2): 297-322.

Bolton, P., and Dewatripont, M. (1994), “The Firm as a Communication Network”, *Quarterly Journal of Economics*, 109(4): 809-839.

Bolton, P., and Dewatripont, M. (1995), “The Time and Budget Constraints of the Firm”, *European Economic Review*, 39(3-4): 691-699.

Cameron, A. C., Gelbach, J. B., and Miller, D. L. (2011), “Robust Inference with Multiway Clustering”, *Journal of Business and Economic Statistics*, 29(2): 238-249.

Crémer, J., Garicano, L., and Prat, A. (2007), “Language and the Theory of the Firm”, *Quarterly Journal of Economics*, 122(1): 373-407.

Dewatripont, M., and Tirole, J. (2005), “Modes of Communication”, *Journal of Political Economy*, 113(6): 1217-1238.

Garicano, L. (2000), “Hierarchies and the Organization of Knowledge in Production”, *Journal of Political Economy*, 108(5): 874-904.

Garicano, L., and Prat, A. (2013), “Organizational Economics with Cognitive Costs”, *Advances in Economics and Econometrics*, 1: 342.

GMP (2015), “Greater Manchester Police Website ”, Accessed 30 January, 2015. https://www.gmp.police.uk/

GMP (2017), “Annual Report 2016-2017, Infographics ”, Retrieved 01 March, 2019 from https://www.flickr.com/photos/gmpolice1/35427256585/

Golub, B., and McAfee, R. P. (2011), “Firms, Queues, and Coffee Breaks: a Flow Model of Corporate Activity with Delays”, *Review of Economic Design*, 15(1): 59-89.

Hall, R. L., and Deardorff, A. V. (2006), “Lobbying as Legislative Subsidy”, *American Political Science Review*, 100(1): 69-84.

Sah, R. K., and Stiglitz, J. E. (1986), “The Architecture of Economic Systems: Hierarchies and Polyarchies”, *American Economic Review* 76(4): 716-727.

Radner, R. (1993), “The Organization of Decentralized Information Processing”, *Econometrica*, 61(5): 1109-1146.

Van Zandt, T. (1999), “Decentralized Information Processing in the Theory of Organizations”, in *Contemporary Economic Issues.* Palgrave Macmillan, London.