Predicting collective behaviour at the Hajj: place, space and the process of cooperation

Hani Alnabulsi[1,2], John Drury[1] and Anne Templeton[1,3]

[1]School of Psychology, University of Sussex, Falmer, Brighton BN1 9QH, UK
[2]Department of Urban Design, Custodian of the Two Holy Mosques Institute for Hajj Research, Umm Al-Qura University, Mecca, Kingdom of Saudi Arabia
[3]School of Psychology, Keynes College, University of Kent, Canterbury, Kent CT2 7NP, UK

JD, 0000-0002-7748-5128; AT, 0000-0002-5422-6297

Around 2 million pilgrims attend the annual Hajj to Mecca and the holy places, which are subject to dense crowding. Both architecture and psychology can be part of disaster risk reduction in relation to crowding, since both can affect the nature of collective behaviour—particularly cooperation—among pilgrims. To date, collective behaviour at the Hajj has not been systematically investigated from a psychological perspective. We examined determinants of cooperation in the Grand Mosque and plaza during the pilgrimage. A questionnaire survey of 1194 pilgrims found that the Mosque was perceived by pilgrims as one of the most crowded ritual locations. Being in the plaza (compared with the Mosque) predicted the extent of cooperation, though crowd density did not. Shared social identity with the crowd explained more of the variance than both location and density. We examined some of the process underlying cooperation. The link between shared social identity and giving support to others was stronger in the plaza than in the Mosque, and suggests the role of place and space in modulating processes of cooperation in crowds. These findings have implications for disaster risk reduction and for applications such as computer simulations of crowds in pilgrimage locations.

This article is part of the theme issue 'Interdisciplinary approaches for uncovering the impacts of architecture on collective behaviour'.

1. Introduction

The Hajj has been called the world's 'global gathering' because people from all over the world attend this annual Muslim pilgrimage to the holy places in and around Mecca [1]. Taking part in the Hajj is expected of all able-bodied and financially capable Muslims at least once in their lifetime. It involves participating in rituals at specified spiritual locations during a certain 5-day period.[1] These requirements, combined with the ease of modern air travel, mean that millions of people attend the Hajj—1 862 909 was the official figure (not counting unofficial pilgrims) in 2016, for example [2]. Therefore, the holy places are very crowded during Hajj. Overcrowding has been linked to fatalities at the Hajj in the past. In 2006 for example, 346 pilgrims died in a crowd crush at the entrance to Jamaraat Bridge [3], and at least 717 died in a crush at Mina in 2015 [4].

Architecture has been seen as part of the solution to this source of risk. The Jamaraat structure was redesigned following the 2006 disaster to allow pilgrims to 'stone the devil' on three different floors, increasing capacity [5]. Research in psychology suggests that collective behaviour is also important in disaster risk reduction [6,7]. Indeed, architecture and psychological processes can interact to produce forms of collective behaviour that reduce, or contribute to, risk. For example, in emergency evacuations a combination of a narrow exit and unfamiliarity with layout are among the predictors of dangerous pushing and trampling [8].

Figure 1. Crowd close to the black stone, at the Ka'aba (picture courtesy of Wessam Hassanin).
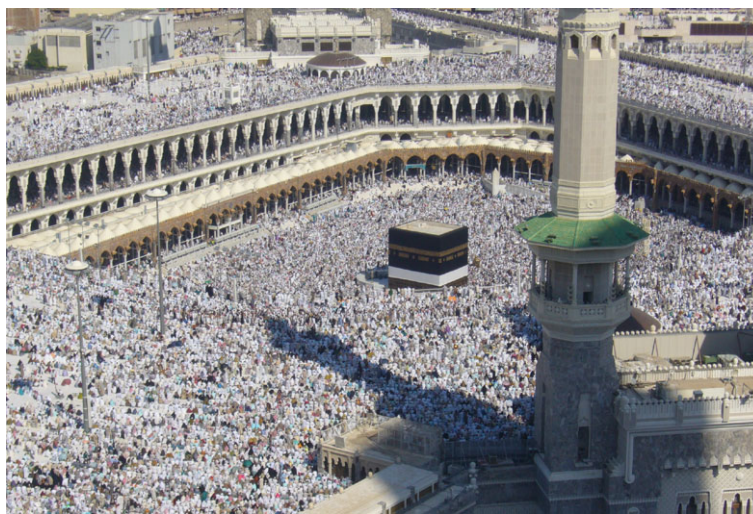

Figure 2. Al-Masjid Al-Haram, or Grand Mosque, Mecca, with the Ka'aba at centre and pillars round edge.

Cooperation is a crucial form of collective behaviour at the Hajj, in two ways. First, harmonious relations with others are a spiritual value which is both salient and expected at the Hajj, alongside related values such as unity and peacefulness [9]. Second, cooperation is also a practical necessity. This is particularly the case in the Grand Mosque and other very crowded locations, where failure to coordinate with others—for example pushing, not allowing others space—could lead to a crowd collapse and fatalities.

At the time of the 2012 Hajj (the focus of the present study), the Al-Masjid Al-Haram (or Grand Mosque) covered an area of 356 800 m^2 (88.2 acres) [10]. The Mosque contains the *Ka'aba*, a small black cube-shaped building that is the holiest site on Earth to Muslims, since it is said to have been built by Abraham [11]. When Muslims pray, wherever they are in the world, they turn in the direction of the Ka'aba (this is known as *qibla*). On visits to Mecca, pilgrims circumambulate the Ka'aba seven times (*tawaf*). During Hajj, they also attend the Mosque for daily prayer, facing the Ka'aba.

The experience of seeing the Ka'aba is emotionally intense for pilgrims [12]. The communal nature of the experience is emphasized by the fact that all the pilgrims wear a simple white robe for the majority of the rituals; this serves to convey unity, equality and universality in the shared submission to God. But as well as joy and harmonious behaviour, there is also competitive behaviour within the Mosque, as people strive to get close to the Ka'aba, particularly near the black stone, and some use physical force to do so (figure 1). Some enter the Mosque only to find their view of the Ka'aba obscured by pillars (figure 2). Instead, many pilgrims carry out their prayers on the plaza immediately outside (figure 3), where the emotional experience may be less intense, but also less variable, since expectations and competition are both lower.

Despite the importance of understanding collective behaviour at the Hajj, there has been almost no research on this topic. Understandably, most studies of the Hajj examine the public health issue of disease (e.g. [13]). Where collective behaviour is referred to, it tends to be only as a 'panic' or 'stampede' [14], despite the vast majority of Hajj rituals passing without incident.

The emphasis on negative collective behaviour in previous research on the Hajj reflects the history of crowd psychology, which has been overly preoccupied with crowd violence [15,16]. Classical crowd psychology claimed that becoming 'submerged' in a crowd leads to a diminution of self; in this reduced psychological state, primitive aggressive drives, grounded in a 'racial unconscious' [17] or individual biology [18], would predominate, leading to uncontrolled violence. One problem for this approach is that most crowd

Figure 3. Plaza outside the Grand Mosque.

events are peaceful. The approach notably fails to explain behaviour at ritual and ceremonial crowd events, where the act of coming together *reinforces* values and norms, rather than leading people to abandon them [19,20].

The Hajj is an example of such a ritual crowd, and the present study is part of a wider project to examine the psychological and contextual basis of positive experiences and behaviour in crowds, based on the social identity approach [21]. The social identity approach suggests that self or identity is composed of categorizations of self and other that vary in inclusivity in different social contexts [22,23]. The approach has been applied to standard topics in social, organizational and health psychology [24,25]. It has also been used to understand the psychology of place and space across a range of crowd events. Thus a multi-method study of an overcrowded music festival found that the lack of space was uncomfortable only for those who did not share social identity with the rest of the crowd [7]. An interview study of an Orange Order parade in Northern Ireland indicated that domination of the soundscape was a way of imposing identity on the streets [26]. Research on urban riots has repeatedly shown that many of the actions of rioters against police and property reflect a common identity defined in terms of home location and a desire to eject police from that shared territory [27,28].

The social identity approach agrees with early classical crowd psychology that emotion is a central feature of the phenomenology of many crowd events [21]. However, rather than seeing emotion as primitive and irrational, it suggests that emotional experiences are grounded in our knowledge of our group memberships and in the relationships we have with others in our group [19]. In short, collective behaviour and emotional experience is a function not of a loss of self but of a *shared* self.

The aim of the present study was to explore some of the determinants of cooperation in the Grand Mosque and plaza during Hajj, in order to contribute to an understanding of how collective behaviour operates in these locations. By sampling a relatively matched sample of pilgrims inside and outside the Mosque, we were able to analyse the possible roles of location and crowd density in cooperative behaviour in these locations. We also sought to examine the role of shared social identity in such cooperative behaviour. Shared

social identity [21] is the subjective perception that others are in the same social group as oneself, and indeed share selfhood with one. Shared social identity has been shown reliably to increase bystander helping [29], practical and emotional social support in emergencies [30,31], and mundane solidarity behaviours at a (Hindu) pilgrimage [32]. In the present study, we measured shared social identity in two ways: participants' perception that others in the crowd are good Muslims (i.e. good ingroup members), and participants' identification with the crowd.

We surveyed 1194 pilgrims during the Hajj in 2012. In this paper, first we explore descriptively pilgrims' experience of crowdedness, showing that the Mosque was experienced as the most crowded ritual location. Using researchers' estimates, we then examine any differences in crowd density between the plaza and the Mosque at the time of sampling. To investigate determinants of cooperation, we examine the extent to which location (inside the Mosque or in the plaza) and crowd density each affect pilgrims' perceptions of support provided by others. To further investigate cooperation, we examine predictors of self-reported social support given. Since inside the Mosque there are enhanced expectations but also (for many people) obstructive architecture and competition for the best view of the Ka'aba, we expect that self-reported social support will be slightly lower in the Mosque than in the plaza. We also expect that shared social identity will be significantly and positively associated with giving social support. Finally, we unpack the process of cooperation using structural equation modelling. Based on the notion that others' (normative) behaviour can tell us something about their category membership [33], and that their category membership can affect our behaviour towards them [29,30], we investigated the extent to which perceiving social support in the crowd predicts shared social identity (perceiving others as good Muslims and then identification with the crowd) and shared social identity predicts giving social support. We suggest that if space and place do shape cooperation then this process will also be affected. Specifically, the reduction in social support given in the Mosque compared with the plaza will be accounted for by a reduction in the power of the main predictor, shared social identity.

With respect to the problem of disaster risk reduction at the annual Hajj, our approach suggests a view of collective

behaviour different to the assumption that the crowd is simply a problem that planners have to work around. In this account, shared social identity in the crowd facilitates the cooperative behaviour needed in valued locations where dense crowds gather: it motivates people to be supportive, and it enables them to anticipate each other's behaviour. These processes of self-organization occur 'naturally' in many crowds, though organizers can play a role in supporting them (for example by providing information, communicating regularly, and so on). If our analysis is correct, it means there is a role for social psychology in planning for mass gatherings and crowd safety management training [7,34], when grounded in a broader understanding of place and space in relation to the built environment.

2. Methods

(a) Recruitment procedure

We surveyed 1194 pilgrims, sampling in a way stratified by the main languages of pilgrims at the Hajj: 420 (35%) were Arabic speakers, 150 (13%) were speakers of Malay, 150 (13%) of Urdu, 120 (10%) of French, 120 (10%) of Persian, 120 (10%) of Turkish and 114 (9%) of English. Twelve research assistants, native speakers of the seven languages, were trained to recruit pilgrims with verbally administered questionnaires. The research assistants were all male, but three of them were accompanied by their wives in order to facilitate recruitment of female participants. We recruited 421 (35.7%) participants inside the Grand Mosque and 753 (64.0%) on the plaza immediately outside. Recruitment took place in three phases: 383 (32.5%) participants were surveyed in the 9-day period when people arrive in Mecca; 533 (45.2%) during Hajj rituals; and 260 (22.0%) at the farewell *tawaf* period.[2] (Information on the recruitment time and location of four participants was missing.) Each questionnaire took around 38 min to complete.

(b) Measures

Density: the research assistants estimated the number of people per square metre (ppm^2) around each participant they recruited.

Most subjectively crowded ritual locations. Participants were asked to rank the crowdedness of five ritual locations: sa'ee (moving between the hills of Safa and Marwa in the Grand Mosque, symbolizing Hagar's search for water for her son), tawaf, Jamaraat, standing in Muzdalifah, and Nafrah (leaving Arafat).

Cooperation was measured in two ways: first, participants' *perceptions that others give social support* (three items, e.g. 'In my view, most pilgrims are supportive of others'; $\alpha = 0.78$); and second, participants' reports of *giving social support* to others on the Hajj (two items, e.g. 'I have been helpful to others'; $\alpha = 0.66$). Responses on these items and those below (other than demographics) were assessed on a seven-point Likert scale, ranging from 'agree strongly' to 'disagree strongly'. (See electronic supplementary material for full details of these and other items.)

Perceptions that others in the crowd are good Muslims were measured with three items (e.g. 'In my view, other people in this crowd are good Muslims'; $\alpha = 0.79$). *Identification with the crowd* was measured with three items (e.g. 'I feel a sense of togetherness with other people on the Hajj'; $\alpha = 0.80$).

Demographic measures taken included age, gender, level of education, previous experience of the Hajj, nationality and language.

Acquiescence: to control for the possibility that some participants would agree with questionnaire items whatever the content, we created a measure of acquiescence by averaging scores of those items that pointed in two different directions. Full details are provided in the electronic supplementary material.

3. Results

The results are divided into four sections. First, we present sample characteristics. Second, we provide analysis of participants' perceptions of the most crowded locations and researchers' estimates of crowd density. Third, we examine predictors of cooperation. Finally, we present structural equation modelling of the process of cooperation across the Mosque and plaza locations.

(a) Sample characteristics

Generally, it was difficult to persuade pilgrims to take part in the study, especially close to the Ka'aba, since they were there to worship rather than to fill in a questionnaire. Response rates were around 60% inside the Mosque and around 70% on the plaza. There were also some demographic factors noted. Thus response rates were found to decline with increasing age. Some pilgrims declined to participate on the grounds that they were illiterate (and sometimes passed us to a relative instead). Finally, women were more likely to refuse than were men.[3]

The data for 18 participants were entered incorrectly by one research assistant. As there was no way subsequently of correcting these, the data from these participants were removed from the analysis. Inspection of the density data revealed that seven participants were scored at $0\ ppm^2$ and three were scored at implausibly high density ($12\ ppm^2$ and $15\ ppm^2$). The data from these participants were also removed, leaving 1166 participants in the final dataset.

Seven hundred and fifty-two (64.5%) of the participants were male and 414 (35.5%) were female. This matches the proportion of males to females in the population attending Hajj in 2012 [35]. Seventeen participants (1.5%) were aged between 18 and 19 years old; 97 (8.3%) were aged 20 to 29; 223 (19.1%) were aged 30 to 39; 452 (38.8%) were aged 40 to 49, and 377 (32.3%) were aged 50 years and over. Sixty-six participants (5.7%) were illiterate, 193 (16.6%) were educated to 'read and write' level, 193 (16.6%) to primary school level, 236 (20.2%) to secondary school level, 393 (33.7%) to undergraduate degree level, 77 (6.6%) had Master's degrees, and 8 (0.7%) had doctorates. Three hundred and sixty-seven (31.2%) participants had been on Hajj before, whereas for 799 (68.5%) this was their first time.

The study included participants from 72 countries. The majority of pilgrims attend through arrangement with the six Hajj travel establishments, or travel agencies, which are (mostly) structured by geographical region. In most cases, the proportion in our sample from each establishment roughly corresponded with official estimates [35] for the event as a whole: Arab and Arabian Gulf countries 36.1%; America, Australia and Europe (including Turkey) 18.8%; South Asia 13.8%; South East Asia 11.7%; Iran and Tajikistan 10.4%; and non-Arab African Countries 9.2%.

(i) Sample characteristics: Mosque versus plaza

The sample from the plaza ($n = 753$) was larger than that from inside the Mosque ($n = 418$). For age and level of education the numbers sampled in each location were proportionate to these numbers, but there were significant differences for the other variables. For gender, men made up 64% of the overall sample but the proportion of men compared with women sampled within the Mosque was 59%. Pilgrims for whom

Table 1. Perceived crowdedness of ritual locations (means (*M*) and standard deviations). *M* = 5, most crowded; *M* = 1, least crowded.

location	*M*	s.d.
tawaf	3.98	1.38
sa'ee	2.45	1.12
Nafrah	3.04	1.29
Jamaraat	2.91	1.40
Muzdalifah	2.62	1.28

this was their first Hajj made up 69% of the overall sample, but the proportion of these new people who were sampled within the Mosque was 74%. In the sample as a whole, the proportion of non-Arab African country pilgrims was 9%, but this group made up 18% of those sampled in the Mosque. In the sample as a whole, the percentage of French speakers was 9%, but the percentage of French speakers sampled inside the Mosque was 22%. (Statistics for these tests can be found in the electronic supplementary material.)

(b) Crowdedness and density by Hajj location

For participants' ranking of the crowdedness of the five ritual locations, a repeated measures ANOVA with pairwise comparisons showed that participants evaluated tawaf as significantly more crowded than each of sa'ee ($p < 0.001$), Nafrah (Arafat, $p < 0.001$), Jamaraat (i.e. stoning the devil, $p < 0.001$), and standing in Muzdalifah ($p < 0.001$)—see table 1 for means and s.d. When we compared researchers' density estimates for participants surveyed inside the Grand Mosque (mean (M) = 5.63 ppm^2, s.d. = 1.47) with those surveyed in the plaza (M = 4.96 ppm^2, s.d. = 1.85) using regression, as expected location significantly predicted estimated density, $b = -0.185$, $p < 0.001$. These results are in line with the expectation that the Mosque itself would be especially crowded.

(c) Predictors of cooperation

Descriptives and correlations for all measures are presented in table 2. The first examination of predictors of cooperation used *perceived social support* in the crowd as the dependent measure. As table 3 shows, in the first block of the regression equation, four of the control variables were significant predictors. Participants in the 40–49 age bracket reported most, and those under 20 reported least, perceived social support. French speakers, those from Turkey, America, Australia and Europe, and those from non-Arab African countries were less likely than others to perceive social support whereas those high in acquiescence were more likely to report perceiving social support. (See electronic supplementary material for additional statistics.) The second block comprised the two 'place and space' variables: density and location, neither of which was a significant predictor. The R^2 change from block 1 to block 2 was not significant, $p = 0.14$.

The second examination of predictors of cooperation used the measure of the participant *giving social support* to others. Table 4 shows that four of the control variables were predictive. Older participants were more likely to report giving social support than were younger participants. Male

participants were more likely to report giving social support than were female participants. Higher level of education predicted more support given. French speakers gave less support than the other language groups. Those who had been to Hajj before gave more support than those for whom it was the first time. (See electronic supplementary material for additional statistics.) When the 'place and space' variables were added in block 2, density was not predictive, but location was: more social support was given in the plaza than in the Mosque (though levels of social support given were high in both locations): M_{Mosque} = 5.89, s.d. = 0.85; M_{plaza} = 6.19, s.d. = 0.84). The R^2 change from block 1 to block 2 was significant, $p = 0.044$. When the shared social identity variables were then added in a third block, perception that others were good Muslims and identification with the crowd each positively predicted giving support (table 4). Importantly, the final block explained considerably more of the variance than the other two, and the R^2 change from block 2 to block 3 was significant, $p < 0.001$.

(d) The process of cooperation

We used R to conduct structural equation modelling (SEM) with robust maximum likelihood on the direct and indirect pathways from perceived social support to giving social support via the perception that others are good Muslims and then identification with the crowd—see figure 4. We included the following variables as covariates: education, language, prior experience of the Hajj, and acquiescence.[4]

We first performed confirmatory factor analysis to explore the measurement models for all participants, and then separately for participants inside the Grand Mosque and on the plaza. The fit indices of the measurement model for participants in both locations were Akaike information criterion (AIC) = 49 147.588, root mean square error of approximation (RMSEA) = 0.072, Standardized Root Mean Square Residual (SRMR) = 0.049, confirmatory fit index (CFI) = 0.891, χ^2_{99} = 680.691, $p < 0.001$; inside the Grand Mosque, AIC = 16 759.791, RMSEA = 0.060, SRMR = 0.046, CFI = 0.908, χ^2_{99} = 242.939, $p < 0.001$; in the plaza, AIC = 32 050.306, RMSEA = 0.090, SRMR = 0.059, CFI = 0.851, χ^2_{99} = 685.153, $p < 0.001$. Overall, the fit indices suggest that the order of the serial mediation is a good model, and conducting separate models for the two locations provides the best measurement.

When exploring the model for participants in both locations, the fit statistics were AIC = 51 372.174, RMSEA = 0.071, SRMR = 0.047, CFI = 0.889, χ^2_{99} = 680.054, $p < 0.001$. There was a significant direct effect, $b = 0.391$, $p < 0.001$, $z = 7.615$, but the indirect effect was non-significant, $b = 0.181$, $p = 0.063$, $z = 1.859$. There were significant direct effects of perceived social support on the perception of others as good Muslims, $b = 0.354$, $p < 0.001$, $z = 0.160$, on social identification with the crowd, $b = 321$, $p < 0.001$, $z = 6.220$, and on giving social support, $b = 0.391$, $p < 0.001$, $z = 5.327$, and a significant direct effect of the perception of others as good Muslims on social identification with the crowd, $b = 0.534$, $p < 0.001$, $z = 4.741$. However, the direct effect of perceiving others as good Muslims on giving social support was non-significant, $b = 0.140$, $p = 0.098$, $z = 1.657$, as was the effect of social identification with the crowd on giving social support, $b = 0.111$, $p = 0.199$, $z = 1.283$. All indirect effects were non-significant: perceived social support on giving social support via social identification with the crowd, $b = 0.035$,

Table 2. Means, standard deviations and correlations. *p<0.05; **p<0.01.

	mean	s.d.	2	3	4	5	6
acquiescence	4.77	0.63	0.09**	0.08**	0.07*	0.02	0.15**
perceived social support	5.83	0.96		0.39**	0.30**	0.43**	0.03
giving social support	6.08	0.86			0.27**	0.33**	−0.03
others are good Muslims	6.16	0.71				0.52**	−0.06
social identification with crowd	6.05	0.78					−0.10**
estimated density	5.20	1.75					

perception of others as good Muslims — $b = 0.534, p < 0.001$ → social identification with the crowd

$b = 0.354, p < 0.001$

$b = 0.321, p < 0.001$

$b = 0.140, p = 0.098$

$b = 0.111, p = 0.199$

perceived social support

$b = 0.391, p < 0.001$

giving social support

indirect effect: $b = 0.181, p = 0.063$
total effect: $b = 0.497, p < 0.001$
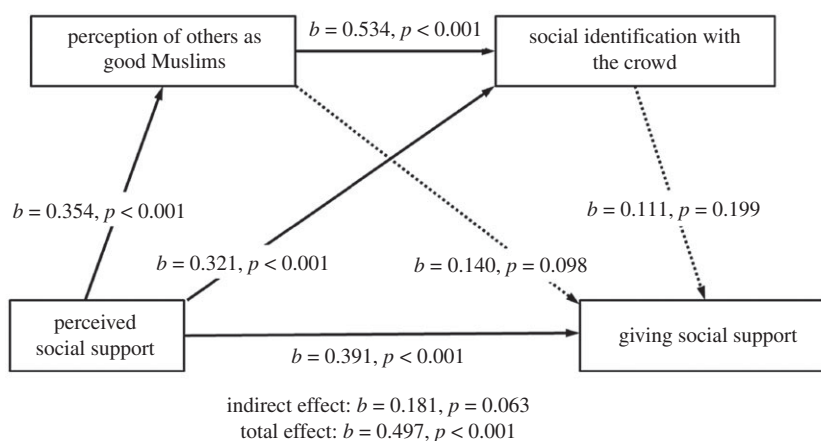
Figure 4. Structural equation model for both locations.

perception of others as good Muslims — $b = 0.224, p < 0.108$ → social identification with the crowd

$b = 0.560, p < 0.001$

$b = 0.517, p < 0.001$

$b = -0.068, p = 0.726$

$b = -0.134, p = 0.402$

perceived social support

$b = 0.783, p = 0.001$

giving social support

indirect effect: $b = -0.188, p = 0.351$
total effect: $b = 0.659, p < 0.001$
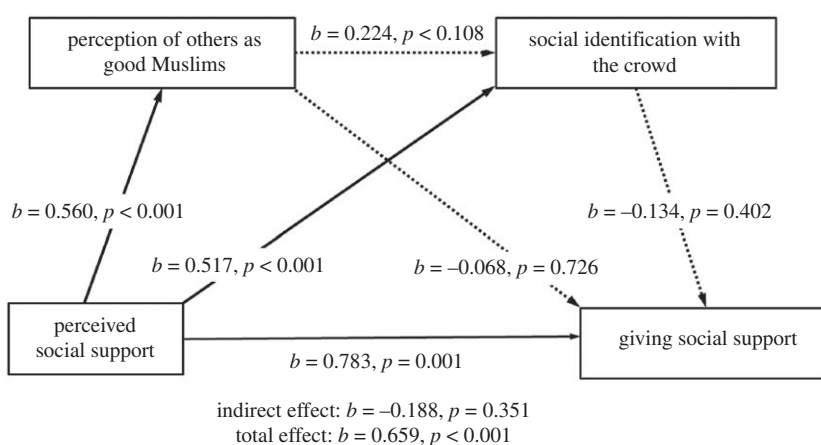
Figure 5. Structural equation model for inside the Grand Mosque.

perception of others as good Muslims — $b = 0.600, p < 0.001$ → social identification with the crowd

$b = 0.277, p < 0.001$

$b = 0.283, p < 0.001$

$b = 0.124, p = 0.224$

$b = 0.237, p = 0.026$

perceived social support

$b = 0.266, p < 0.001$

giving social support

indirect effect: $b = 0.311, p = 0.007$
total effect: $b = 0.407, p < 0.001$
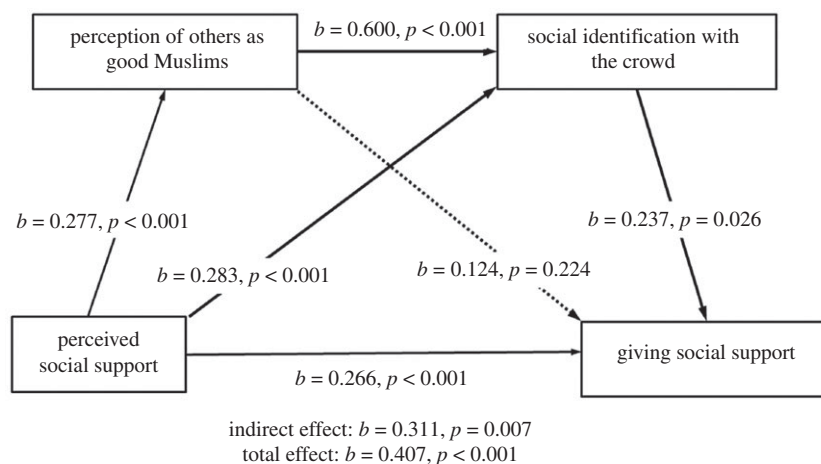
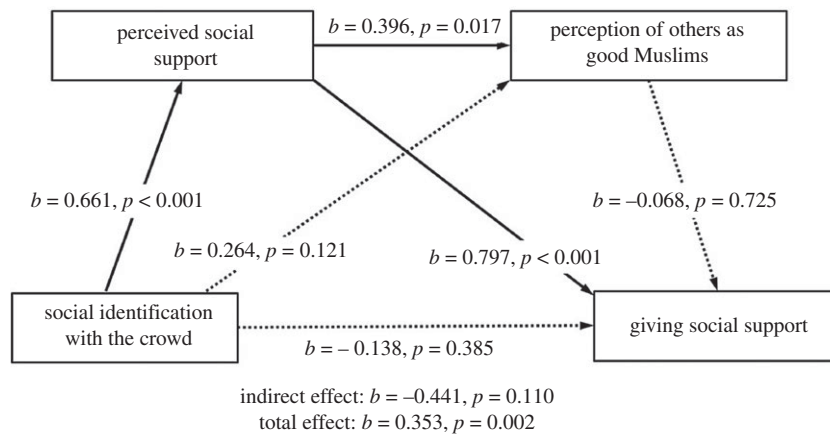**Figure 6.** Structural equation model for in the plaza.

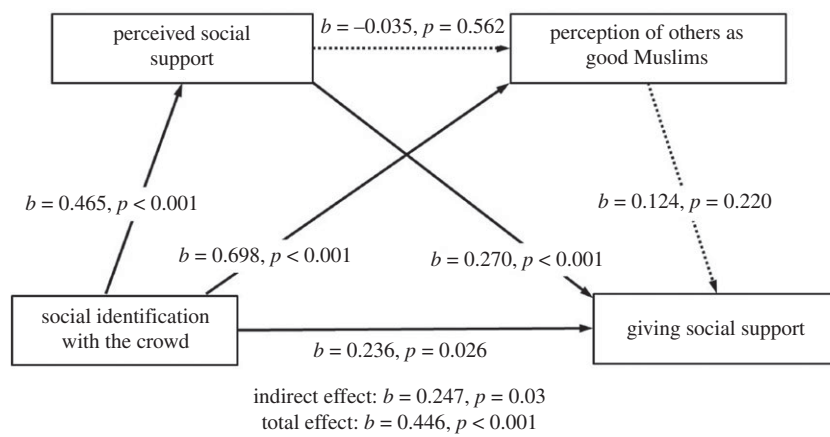**Figure 7.** Alternative model 1: inside the Grand Mosque.
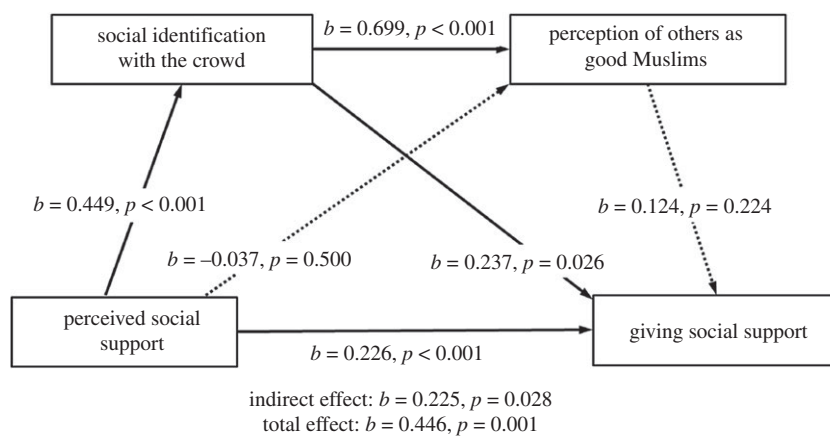

Figure 8. Alternative model 1: in the plaza.

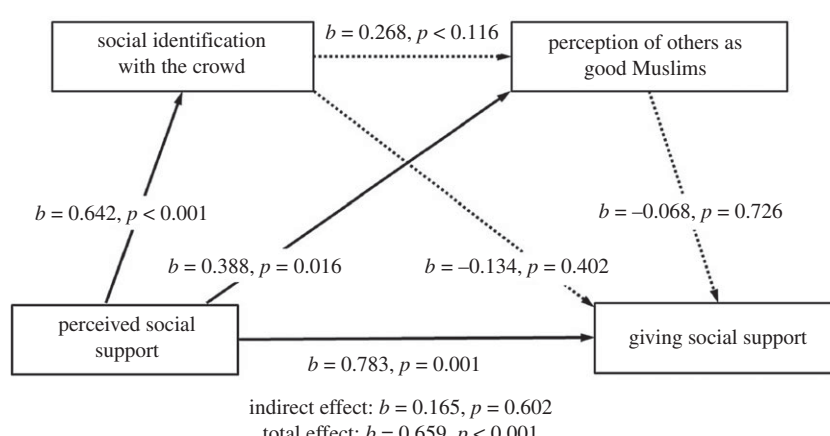**Figure 9.** Alternative model 2: inside the Grand Mosque.

Figure 10. Alternative model 2: in the plaza.

Table 3. Linear model of predictors of perceiving social support. $R^2 = 0.06$ for step 1; $\Delta R^2 < 0.01$ for step 2. s.e., standard error.

	step 1					step 2				
	b	s.e. B	β	p	95% CI for b	b	s.e. B	β	p	95% CI for b
constant	4.87	0.28		<0.001	(4.32, 5.42)	4.82	0.28		<0.001	(4.26, 5.38)
age group	0.09	0.03	0.09	0.002	(0.03, 0.15)	0.08	0.03	0.09	0.006	(0.02, 0.14)
gender	−0.05	0.06	−0.02	0.428	(−0.16, 0.07)	−0.06	0.06	−0.03	0.299	(−0.18, 0.05)
education	0.02	0.02	0.03	0.425	(−0.03, 0.06)	0.02	0.02	0.03	0.398	(−0.02, 0.06)
language (French versus rest)	−0.87	0.13	−0.26	<0.001	(−1.13, −0.61)	−0.93	0.14	−0.28	<0.001	(−1.19, −0.66)
Hajj service (non-Arab African versus rest)	0.28	0.13	0.08	0.035	(0.02, 0.54)	0.29	0.13	0.09	0.032	(0.03, 0.55)
performed Hajj before	−0.01	0.06	<−0.01	0.932	(−0.13, 0.12)	−0.01	0.06	−0.01	0.852	(−0.13, 0.11)
acquiescence	0.14	0.04	0.09	0.002	(0.05, 0.22)	0.14	0.05	0.09	0.003	(0.05, 0.23)
estimated density (persons per square metre)						0.03	0.02	0.05	0.134	(−0.01, 0.06)
Mosque versus plaza						−0.06	0.06	−0.03	0.306	(−0.19, 0.06)

$p = 0.90$, $z = 1.310$; perceived social support on giving social support via the perception of others as good Muslims, $b = 0.050$, $p = 0.118$, $z = 1.564$; perceived social support to giving social support via the perception of others as good Muslims and social identification with the crowd was non-significant, $b = 0.021$, $p = 0.237$, $x = 1.183$. The path model is presented in figure 4.

(i) Inside the Grand Mosque
The model fit for participants inside the Grand Mosque was AIC = 18 233.213, RMSEA = 0.064, SRMR = 0.048, CFI = 0.894, $\chi^2_{99} = 268.926$, $p < 0.001$. Most of the direct paths remained significant with the exception that the direct effect of perceiving others as good Muslims on social identification with the crowd became non-significant, $b = 0.224$, $p = 0.108$, $z = 3.629$, and all indirect pathways remained non-significant. Overall, the direct effect was significant, $b = 0.783$, $p < 0.001$, $z = 4.697$, but the indirect effect was non-significant, $b = −0.188$, $p = 0.351$, $z = −0.934$. The indirect path from perceived social support via perceptions that others are good Muslims to giving social support was non-significant, $b = −0.038$, $p = 0.712$, $z = 0.369$; the indirect path from perceived social support via identification with the crowd to giving social support was non-significant, $b = −0.069$, $p = 0.423$, $z = −0.801$, and the indirect path from perceived social support to giving social support via the perception of others as good Muslims and social identification with the crowd was non-significant, $b = −0.009$, $p = 0.601$, $z = −0.523$. The path model is presented in figure 5.

(ii) On the plaza
The model fit for participants on the plaza was AIC = 32 835.680, RMSEA = 0.082, SRMR = 0.056, CFI = 0.857, $\chi^2_{99} = 417.163$, $p < 0.001$. There was a significant direct effect, $b = 0.266$, $p < 0.001$, $z = 5.742$, and a significant indirect effect, $b = 0.311$, $p = 0.007$, $z = 2.699$. The indirect effect from perceived social support to giving social support via perceptions that others are good Muslims was non-significant, $b = 0.034$, $p = 0.241$, $z = 1.171$, and the indirect path from perceived social support to giving social support via the perception of others as good Muslims and social identification with the crowd was non-significant, $b = 0.039$, $p = 0.105$, $z = 1.623$, but there was a significant indirect effect from perceived social support to giving social support via identification with the crowd, $b = 0.067$, $p = 0.033$, $z = 2.136$. The path model is presented in figure 6.[5]

Using the criteria for model fit set out by Hu & Bentler [36], where RMSEA < 0.06, SRMR < 0.08, CFI > 0.95, all models demonstrate modest fit. Based on Busemeyer & Diederich [37], where the lowest AIC value indicates the best model fit, we take the model for participants inside the Grand Mosque to be better than that for those in the plaza. It also has some larger β values. However, importantly, only the model for those on the plaza demonstrates the connection between shared social identity and giving social support. Consequently, only this model has an indirect effect from perceived support to giving social support.

(iii) Alternative models
To explore the order of the model variables, we also tested alternative models to explain giving social support. First, we tested a model from social identification with the crowd

Table 4. Linear model of predictors of reported giving social support. $R^2 = 0.09$ for step 1; $\Delta R^2 = 0.09$ for step 2; $\Delta R^2 = 0.17$ for step 3. s.e., standard error.

| | step 1 | | | | | step 2 | | | | | step 3 | | | | |
---	b	s.e. B	β	p	95% CI for b	b	s.e. B	β	p	95% CI for b	b	s.e. B	β	p	95% CI for b
constant	5.48	0.25		<0.001	(4.99, 5.96)	5.46	0.25		<0.001	(4.97, 5.95)	3.36	0.32		<0.001	(2.73, 4.00)
age group	0.07	0.03	0.09	0.004	(0.02, 0.13)	0.07	0.03	0.08	0.007	(0.02, 0.12)	0.05	0.03	0.06	0.053	(<−0.01, 0.10)
gender	−0.15	0.05	−0.09	0.003	(−0.25, −0.05)	−0.14	0.05	−0.08	0.007	(−0.24, −0.04)	−0.13	0.05	−0.07	0.010	(−0.23, −0.03)
education	0.04	0.02	0.07	0.018	(0.01, 0.08)	0.05	0.02	0.08	0.015	(0.01, 0.08)	0.04	0.02	0.07	0.016	(0.01, 0.08)
language (French versus rest)	−0.58	0.12	−0.20	<0.001	(−0.81, −0.35)	−0.53	0.12	−0.18	<0.001	(−0.77, −0.030)	−0.28	0.12	−0.09	0.019	(−0.51, −0.05)
Hajj service (non-Arab African versus rest)	0.01	0.12	<0.01	0.954	(−0.22, 0.24)	0.02	0.12	0.01	0.863	(−0.21, 0.25)	−0.04	0.11	−0.01	0.731	(−0.26, 0.18)
performed Hajj before	−0.20	0.05	−0.11	<0.001	(−0.31, −0.10)	−0.20	0.05	−0.11	<0.001	(−0.30, −0.09)	−0.16	0.05	−0.09	0.002	(−0.26, −0.06)
acquiescence	0.13	0.04	0.09	0.001	(0.05, 0.20)	0.11	0.04	0.08	0.009	(0.03, 0.18)	0.09	0.04	0.06	0.027	(0.01, 0.16)
estimated density (persons per metre²)						0.01	0.02	0.01	0.685	(−0.02, 0.04)	0.01	0.01	0.03	0.327	(−0.01, 0.04)
Mosque versus plaza						0.14	0.06	0.08	0.012	(0.03, 0.25)	0.13	0.05	0.08	0.011	(0.03, 0.24)
social identity with crowd											0.25	0.04	0.23	<0.001	(0.18, 0.32)
good Muslims											0.11	0.04	0.09	0.007	(0.03, 0.18)

to giving social support via perceived social support and the perception of others as good Muslims, again including the covariates of education, language, prior experience of the Hajj, and acquiescence (figures 7 and 8). The model fit for this version of the model for participants who responded inside the Grand Mosque was AIC = 18 250.279, RMSEA = 0.067, SRMR = 0.060, CFI = 0.913, $\chi^2_{99} = 285.992$, $p < 0.001$, and for participants in the plaza, AIC = 32 864.698, RMSEA = 0.089, SRMR = 0.065, CFI = 0.850, $\chi^2_{99} = 681.643$, $p < 0.001$. Second, we tested the model with the order of the original mediator variables reversed, from perceived social support to giving social support via social identification with the crowd and the perception that others are good Muslims (figures 9 and 10). The model fit statistics for respondents inside the Grand Mosque were AIC = 32 835.680, RMSEA = 0.086, SRMR = 0.056, CFI = 0.857 $\chi^2_{99} = 652.626$, $p < 0.001$, and in the plaza, AIC = 18 233.213, RMSEA = 0.064, SRMR = 0.048, CFI = 0.894, $\chi^2_{99} = 28.926$, $p < 0.001$. Overall, the fit statistics for the alternative models, though better on some criteria, were comparable and not an improvement on the hypothesized model.

4. Discussion

According to both participants' perceptions and researchers' estimates, the Grand Mosque was the most crowded location at the Hajj. Neither location (Mosque versus plaza) nor crowd density predicted perceptions of social support (which were relatively high across the sample). Examining participants' reports of their own cooperative behaviour allowed us to look more closely at the possible psychological processes involved. Participants reported giving more social support in the plaza than in the Mosque. The shared social identity variables—seeing others as good Muslims and identification with the crowd—were the strongest predictors of this self-reported cooperation. However, it is important to note that perceptions of cooperation by others were the same across locations, and the reports of giving help (and indeed the other measures) were all high both inside and outside the Mosque.

We found evidence for a process of cooperation involving shared social identity. In the first place, seeing others' supportive behaviour predicted perceiving others as good Muslims and identifying with the crowd. In the second place, identification with the crowd predicted giving social support—at least on the plaza. Moreover, on the plaza there was a significant indirect effect from seeing others' cooperative behaviour via shared social identity (identification with the crowd) and giving social support.

There is a substantial research literature on the spreading of cooperative (or 'generous') behaviour (e.g. [38,39]). The mechanism of 'spread' suggested by our analysis—shared social identity—is an alternative to those accounts that conceptualize it as form of 'contagion'. The 'contagion' concept implies that such behaviour spreads as a form of mimicry, or at least with little discrimination. By contrast the present account focuses on the way that others' (cooperative) behaviours tell us something about their category membership: whether they embody the values of a social category and indeed whether they are in our own group; if they are 'us', we feel more motivated to give them social support [29–31].

We suggested in the Introduction that experiences in the Mosque might be more varied than on the plaza: seeing the Ka'aba produces the most intense positive emotional experience, but there is also competition to get close, and some get inside only to find their view obscured. The present findings are consistent with the view that this 'mixed' experience is associated with less cooperative behaviour compared with being on the plaza; perhaps the more relaxed and 'homogeneous' experience of the plaza enables greater cooperation. This difference in behaviour and process between the two locations supports the overall thesis of this article that the psychological is in part a function of the spatial.

A limitation of the study is that we have no direct measures of competition or other mediating factors in the Mosque. We do know, from the analysis, that simple crowd density does not seem to differentiate behaviour in the Mosque versus the plaza. It may be possible to use the current dataset to explore further some of these questions, since it is now publicly available. However, we suggest that a different kind of study may be needed to examine the phenomenology of the Mosque experience to determine process in more detail. For example, rather than questioning pilgrims, research could take the form of an ethnography, in which the observing researcher acts as the research instrument.

Many of the questionnaire items were constructed for this survey (when no established scales were available), and for practical reasons some measures were brief. More importantly perhaps for our claims about process, this study was cross-sectional. Clearly, the correlational nature of the design means that, while there is evidence for the process of cooperation specified here, other configurations of the variables are possible. For example, we know from elsewhere that shared identity enhances expectations (and hence perceptions) that others will be supportive [6,7]; and we can infer that since giving social support is likely to encourage others to do the same, other starting points than perceived social support are possible. While the model tested here was a little better than the alternatives we looked at, other alternatives are possible. The present design decision was again due to practical constraints, for running a panel study (to allow cross-lagged analysis) presented insurmountable difficulties.

Finally, this analysis had a relatively narrow scope. There are other collective-behavioural features of the Hajj that are practically as well as theoretically important which we could have investigated. These include the preference of Shia Muslims to pray in the open at the Mosque, for example. A prediction of self-categorization theory would be that, by gathering together to pray in the open, the Shia identity might become more salient than the superordinate Muslim identity, due to both comparative and normative fit [23]. However, investigating this question must wait for a future study.

The relation between architecture and (collective) behaviour has long been noted, both generally [40] and in relation to Islamic design [41], with its characteristic feature of symmetry. Open spaces, for example, can facilitate interaction [42], and the design of the Grand Mosque and plaza offer examples where this is the case. There is also a clear association between certain architectural features and (disordered) behaviour in emergency evacuations [8]. Disasters at Hajj locations and other pilgrimages have been linked to collective behaviour [43], often with the implication that crowds at these holy sites lack the critical judgement necessary for coordinated conduct [7,13,43]. The present study suggests an alternative view of

the relation between collective behaviour and disaster risk reduction in crowded locations, which side-steps attempts to define rationality (versus 'panic') in these contexts (cf. [8]), through the use of the concept of social identity. As well as explaining disasters, we need to explain the fact that most of the time the Hajj crowd is orderly. Shared social identity in a crowd is an established predictor of cooperative and coordinated behaviour and can therefore help explain that orderliness. Space and place (for example carrying out rituals in spiritually important buildings) can serve to enhance the salience of social identities [44]. These points are relevant to the planning for mass gatherings [34], to crowd safety management training [7], and in computer simulation in planning [45]. Most crowd plans and simulations assume simply that a crowd is a large number of people in the same place. The social identity concept suggests, and our findings evidence, that collective behaviour—behaving *as* a crowd, rather than simply as individuals in the same location—varies according to the context, and therefore that this should be a fundamental assumption of planning.

5. Conclusion

A questionnaire survey of 1194 pilgrims at the Hajj to Mecca found that pilgrims perceived the Grand Mosque as a very crowded ritual location. Pilgrims were more likely to report giving support to others in the Mosque itself than in the plaza outside; crowd density did not appear to be a factor in the explanation; shared social identity explained more of the variance than both location and density. There was also evidence of a process of cooperation: perceiving others give support predicted shared social identity which predicted giving help to others. This predictive pattern only occurred in the plaza, and suggests the role of place and space in modulating identity processes.

Endnotes

[1]The Islamic calendar is lunar, so the date of the Hajj changes year by year in the Gregorian calendar.
[2]The Hajj rituals last for 5 days, but pilgrims gather in a crowd at the Holy Mosque to take part in *tawaf* in the days beforehand and immediately afterwards.
[3]It makes intuitive sense to assume that people willing to participate in a survey may be more dispositionally cooperative than others. Given that response rates correlated with age, education and gender, we compared participants in each of these on giving social support to test for demographic evidence of such a bias. See the electronic supplementary material for details.
[4]We report results for this analysis carried out without the covariates in the electronic supplementary material.
[5]See the electronic supplementary material for additional analysis in which we test a version of the model without the variable 'others are good Muslims'.

References

1. Clingingsmith D, Khwaja AI, Kremer K. 2009 Estimating the impact of the Hajj: religion and tolerance in Islam's global gathering. *Q. J. Econ.* **124**, 1133–1170. (doi:10.1162/qjec.2009.124.3.1133)

2. General Authority for Statistics. 2017 *Hajj statistics*. Riyadh, KSA: General Authority for Statistics.

3. Helbing D, Johansson A, Al-Abideen HZ. 2007 Dynamics of crowd disasters: an empirical study. *Phys. Rev. E Stat. Nonlin. Soft Matter Phys.* **75**, 046109. (doi:10.1103/PhysRevE.75.046109)

4. Moore J. 2009 What caused the Hajj tragedy? *Newsweek*. See http://www.newsweek.com/what-caused-hajj-tragedy-376267.

5. Still GK. 2014 *Introduction to crowd science*. Boca Raton, FL: CRC Press.

6. Alnabulsi H, Drury J. 2014. Social identification moderates the effect of crowd density on safety at the Hajj. *Proc. Natl Acad. Sci. USA* **111**, 9091–9096. (doi:10.1073/pnas.1404953111)

7. Drury J, Novelli D, Stott C. 2015 Managing to avert disaster: explaining collective resilience at an outdoor music event. *Eur. J. Soc. Psychol.* **4**, 533–547. (doi:10.1002/ejsp.2108)

8. Chertkoff JM, Kushigian RH. 1999 *Don't panic: the psychology of emergency egress and ingress*. Westport, CT: Praeger.

9. Shariati A. 2005 *Hajj: reflection on its rituals*. Houston, TX: Islamic Publications International.

10. Ministry of Foreign Affairs. 2014 The service of Islam and Muslims. See http://embassies.mofa.gov.sa/sites/NewZealand/AR/AboutKingdom/KingdomAchievments/Pages/default.aspx/.

11. Peters FE. 1994 *The Hajj: the Muslim pilgrimage to Mecca and the holy places*. Princeton, NJ: Princeton University Press.

12. Alnabulsi H. 2015 The crowd psychology of the Hajj. PhD thesis, University of Sussex, UK.

13. Memish ZA, Stephens GM, Steffen R, Ahmed QA. 2012 Emergence of medicine for mass gatherings: lessons from the Hajj. *Lancet Infect. Dis.* **12**, 56–65. (doi:10.1016/S1473-3099(11)70337-1)

14. Sim F, Mackie P. 2015. The language of the masses. *Public Health* **129**, 1429–1430. (doi:10.1016/j.puhe.2015.10.005)

15. Drury J, Stott C. 2011 Contextualizing the crowd in contemporary social science. *Contemp. Soc. Sci.* **6**, 1–15. (doi:10.1080/21582041.2011.625626)

16. Stott C, Drury J. 2017 Contemporary understanding of riots: classical crowd psychology, ideology and the social identity approach. *Public Understand. Sci.* **26**, 2–14. (doi:10.1177/0963662516639872)

17. Le Bon G. 1895 *The crowd: a study of the popular mind*. Dunwoody, GA: Norman S. Berg.

18. Allport FH. 1924 *Social psychology*. Boston, MA: Houghton Mifflin Co.

19. Hopkins N, Reicher SD, Khan SS, Tewari S, Srinivasan N, Stevenson C. 2015 Explaining effervescence: investigating the relationship between shared social identity and positive experience in crowds. *Cogn.*

12

rstb.royalsocietypublishing.org   Phil. Trans. R. Soc. B 373: 20170240

Emotion **30**, 20–32. (doi:10.1080/02699931.2015.1015969)

20. Khan SS, Hopkins N, Reicher S, Tewari S, Srinivasan N, Stevenson C. 2016 How collective participation impacts social identity: a longitudinal study from India. *Polit. Psychol.* **37**, 309–325. (doi:10.1111/pops.12260)

21. Neville F, Reicher S. 2011 The experience of collective participation: shared identity, relatedness, and emotionality. *Contemp. Soc. Sci.* **6**, 377–396. (doi:10.1080/21582041.2012.627277)

22. Tajfel H, Turner JC. 1979 An integrative theory of intergroup conflict. The social psychology of intergroup relations. In *The social psychology of intergroup relations* (eds WG Austin, S Worchel), pp. 33–47. Monterey, CA: Brooks/Cole.

23. Turner JC, Hogg MA, Oakes PJ, Reicher SD, Wetherell MS. 1987 *Rediscovering the social group: a self-categorization theory*. Oxford, UK: Basil Blackwell.

24. Haslam SA. 2004 *Psychology in organizations: the social identity approach*, 2nd edn. London, UK: Sage.

25. Jetten J, Haslam C, Haslam SA. 2012 *The social cure: identity, health, and well-being*. Hove, UK: Psychology Press.

26. Shayegh J, Drury J, Stevenson C. 2017 Listen to the band! How sound can realise group identity and enact intergroup domination. *Br. J. Soc. Psychol.* **56**, 181–196. (doi:10.1111/bjso.12175)

27. Reicher SD. 1984 The St Pauls riot: an explanation of the limits of crowd action in terms of a social identity model. *Eur. J. Soc. Psychol.* **14**, 1–21. (doi:10.1002/ejsp.2420140102)

28. Stott C, Ball R, Drury J, Neville F, Reicher S, Boardman A, Choudhury S. In press. The evolving normative dimensions of 'riot': toward an elaborated social identity explanation. *Eur. J. Soc. Psychol.* (doi:10.1002/ejsp.2376)

29. Levine M, Manning R. 2013 Social identity, group processes, and helping in emergencies. *Eur. Rev. Soc. Psychol.* **24**, 225–251. (doi:10.1080/10463283.2014.892318)

30. Drury J, Cocking C, Reicher S. 2009 Everyone for themselves? A comparative study of crowd solidarity among emergency survivors. *Br. J. Soc. Psychol.* **48**, 487–506. (doi:10.1348/014466608X357893)

31. Ntontis E, Drury J, Amlôt R, Rubin GR, Williams R. 2018 Emergent social identities in a flood: implications for community psychosocial resilience. *J. Community Appl. Soc. Psychol.* **28**, 3–14. (doi:10.1002/casp.2329)

32. Pandey K, Stevenson C, Shankar S, Hopkins NP, Reicher SD. 2014 Cold comfort at the Magh Mela: social identity processes and physical hardship. *Br. J. Soc. Psychol.* **53**, 675–690. (doi:10.1111/bjso.12054)

33. Drury J, Reicher S, Stott C. 2003. Transforming the boundaries of collective identity: from the 'local' anti-road campaign to 'global' resistance? *Soc. Movement Stud.* **2**, 191–212. (doi:10.1080/1474283032000139779)

34. Hopkins N, Reicher S. 2016. Adding a psychological dimension to mass gatherings medicine. *Int. J. Infect. Dis.* **47**, 112–116. (doi:10.1016/j.ijid.2015.12.017)

35. Ministry of Economy and Planning, Central Department of Statistics and Information, Saudi Arabia. 2012 *Statistics for 2012 Hajj*. Mecca, KSA: Ministry of Hajj.

36. Hu L, Bentler P. 1999 Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. *Struct. Equ. Model.* **6**, 1–55. (doi:10.1080/10705519909540118)

37. Busemeyer JR, Diederich A. 2014 Estimation and testing of computational psychological models. In *Neuroeconomics*, 2nd edn (eds PW Glimcher, E Fehr), pp. 49–61. Amsterdam, The Netherlands: Academic Press.

38. Tsvetkova M, Macy MW. 2014. The social contagion of generosity. *PLoS ONE* **9**, e87275. (doi:10.1371/journal.pone.0087275)

39. Woo J, Kwak BI, Lim J, Kim HK. 2015 Generosity as social contagion in virtual community. In *Social Informatics. SocInfo 2014. Lecture Notes in Computer Science*, vol. 8852 (eds L Aiello, D McFarland), pp. 191–199. Cham, Switzerland: Springer. (doi:10.1007/978-3-319-15168-7_24)

40. Canter, DV, Craik KH. 1981 Environmental psychology. *J. Environ. Psychol.* **1**, 1–11 (doi:10.1016/S0272-4944(81)80013-8)

41. Serageldin I. 1995 Architecture and behaviour: the built environment of Muslims. *Architect. Behav.* **11**, 17–30.

42. Gifford R. 2014 Environmental psychology matters. *Annu. Rev. Psychol.* **65**, 541–579. (doi:10.1146/annurev-psych-010213-115048)

43. Burkle FM. 2010 Ram Janki Temple: understanding human stampedes. *Lancet* **377**, 106–107. (doi:10.1016/S0140-6736(10)60442-4)

44. Dixon J. 2001. Contact and boundaries. 'Locating' the social psychology of intergroup relations. *Theor. Psychol.* **11**, 587–608. (doi:10.1177/0959354301115001)

45. Templeton A, Drury J, Philippides A. 2015 From mindless masses to small groups: conceptualising collective behaviour in crowd modelling. *Rev. Gen. Psychol.* **19**, 215–229. (doi:10.1037/gpr0000032)