changes in the statistics of PDF orientations, a maximum shock attenuation of 5 GPa seems to be the more realistic value.

The percentage of shocked quartz grains and the number of PDF sets per grain are more sensitive indicators of minor changes in shock pressure than pure PDF orientation statistics. The combination of detailed petrographic investigation and numerical modeling indicates that both of these approaches are essential to reconstruct the preimpact position of rocks and to characterize properly the shock pressure distribution at the scale of an impact structure. Our observations suggest that, in the case of the 10.5-km-diameter Bosumtwi impact structure, the uppermost rocks of the central uplift experienced shock pressures below 30 GPa, whereas pressures up to 40 to 45 GPa were recorded for the about-four-times-larger Puchezh-Katunki impact structure (*15*). Shock attenuation in the uppermost part of a central uplift has been, for the first time, constrained by detailed shock degree profiling at the microscale. Numerical modeling of this section of the central uplift has then established where this section of the central uplift was located before uplift formation, which was only possible once the shock regime had been established by micropetrography. The results imply that, for moderately sized impact craters, the rise of the central uplift is dominated by brittle failure, whereas in the case of larger impact structures, and also depending on rock proprieties, the uplifted, relatively stronger shocked rocks may behave in a more ductile manner.

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29. Drilling was funded by ICDP, NSF, the Austrian Fonds zur Förderung der wissenschaftlichen Forschung (FWF), the Canadian Natural Sciences and Engineering Research Council, and the Austrian Academy of Sciences. We thank DOSECC (Drilling, Observation and Sampling of the Earth's Continental Crust) for the drilling operations. This work was supported by the Austrian FWF (grants P17194-N10 and P18862-N10) and the Austrian Academy of Sciences. B.A.I. was supported by the Russian Foundation for Basic Science (RFBR grant 08-05-00908-a), and W.U.R.'s research is supported by the German Science Foundation (Deutsche Forschungsgemeinschaft) and Humboldt University of Berlin.

Supporting Online Material

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23 September 2008; accepted 10 November 2008
10.1126/science.1166283

The Spreading of Disorder

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Imagine that the neighborhood you are living in is covered with graffiti, litter, and unreturned shopping carts. Would this reality cause you to litter more, trespass, or even steal? A thesis known as the broken windows theory suggests that signs of disorderly and petty criminal behavior trigger more disorderly and petty criminal behavior, thus causing the behavior to spread. This may cause neighborhoods to decay and the quality of life of its inhabitants to deteriorate. For a city government, this may be a vital policy issue. But does disorder really spread in neighborhoods? So far there has not been strong empirical support, and it is not clear what constitutes disorder and what may make it spread. We generated hypotheses about the spread of disorder and tested them in six field experiments. We found that, when people observe that others violated a certain social norm or legitimate rule, they are more likely to violate other norms or rules, which causes disorder to spread.

In the mid-1990s, the mayor of New York and his police commissioner adopted a "Quality of life campaign." Attention was focused on fighting signs of disorder and petty crime. Graffiti was removed, streets were swept, and signs of vandalism were cleared. This initiative was based on the broken windows theory (BWT) of Wilson and Kelling (*1*). The BWT suggests that signs of disorder like broken windows, litter, and graffiti induce other (types of) disorder and petty crime (*2*). It was thought that removing these signs of disorder would take away an important trigger of disorderly and petty criminal behavior. After the introduction of the campaign, petty crime rates in New York dropped. Since then, approaches based on the BWT have become popular and have been adopted worldwide (e.g., in various cities in the United States, Great Britain, Netherlands, Indonesia, and South Africa).

BWT may be very popular, but it is also highly controversial. So far, it lacks empirical support, and it fails to specify what constitutes disorder. Studies aimed to test the BWT (*3*–*6*) have provided mixed results at best. The National Research Council (NRC) concluded that the research did not provide strong support for the BWT (*7*). There is also little evidence that broken window policing contributed to the sharp decrease in petty crime in New York (*8*–*10*). Moreover, to our knowledge, research on the BWT has so far been correlational, so conclusions about causality are shaky (*6*, *8*). The BWT suggests that a setting with disorder triggers disorderly and petty criminal behavior, but it might be the other way around or both may be caused by a third variable. Furthermore, the BWT gives no insight into what is and what is not a condition of disorder that will spread. Because the BWT forms the backbone of many cities' defense against the growing threat of disorder and petty crime, these shortcomings need to be addressed.

In the present study, we conducted six field experiments that address these issues. Our first step was to conceptualize a disorderly setting in such a way that we can link it to a process of spreading norm violations. Social norms refer either to the perception of common (dis)approval of a particular kind of behavior (injunctive norm) or to a particular behavior common in a setting (descriptive norm) (*11*–*16*). Injunctive norms affect behavior because they provide information about which behavior is most appropriate in a

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given situation [e.g., (*17*–*19*)]. For example, the antilitter norm is a widely held injunctive norm [e.g., (*20*, *21*)]. The extent to which an injunctive norm affects behavior depends on how much the norm is on people's mind (*22*, *23*). For example, an antilitter norm will be more on people's minds when they see someone picking up a piece of litter (which shows disapprovement of littering) (*12*) or simply see a norm stated on a sign (*24*, *25*). Descriptive norms affect behavior because they provide information about which behavior is most common in a given situation. For example, a littered setting shows that it is common to litter and will therefore enhance littering (*11*, *26*, *27*). Similar to injunctive norms, the more conspicuous the descriptive norm, the more strongly it influences behavior. For example, the probability that a participant litters in a littered setting is enhanced when a lot of litter is present or when the participant watches someone littering (*11*). Injunctive and descriptive norms can be in conflict, as for example in a setting where it is common to litter even though littering is commonly disapproved of. Thus, settings described in BWT as disorderly (e.g., a littered setting) can be conceptualized as settings in which descriptive and injunctive norms are in conflict. The next question then is how behavior is influenced by such a setting.

Injunctive-norm information in a persuasive message is more effective when accompanied by descriptive norm information that is in alignment rather than in conflict with that message (*24*, *28*–*30*). For example, a sign drawing attention to the antilitter norm is more influential in reducing littering when placed in a nonlittered setting than when it is placed in a prelittered setting (*31*). Thus, a setting with graffiti, described by the BWT as a setting showing disorder, can cause the spraying of graffiti because it inhibits the injunctive antigraffiti norm. In honor of the individual who first described this process, we call this the Cialdini effect. The important question for the BWT is whether or not it also causes disorderly (or petty criminal) behavior in general. The question we will address is the following: Do more people litter or even steal in a setting where the antigraffiti norm (injunctive norm) is in conflict with the descriptive norm (setting shows it is common to spray graffiti)?

The Cialdini effect has its basis in people's tendency to reason "if a lot of people are doing this, it's probably a wise thing to do" and to do what they observe others are doing (*32*) However, we believe that there is another, goal-driven mechanism at work as well, which is particularly important for the spread of disorder. Much conformity to injunctive norms is the result of people pursuing the goal to act appropriately. However, people can also pursue a hedonic goal directed at feeling better right now or a gain goal directed at guarding and improving one's resources. All three goals can be in conflict, and the weakening of one is likely to bring another goal to the fore (*33*). In a given situation, the goal to act appropriately is weakened when people observe that others seemingly did (or do) not pursue the goal to act appropriately. In turn, a weakening of this goal strengthens conflicting hedonic and gain goals. For example, when people observe that others have painted graffiti where it should not have been painted, they actually observe inappropriate behavior. This, we predict, weakens their concern for appropriateness and strengthens the goal to do what makes them feel good (for example, by being lazy and throwing paper on the street) or the goal to gain resources (say by stealing). Thus people don't necessarily copy the inappropriate behavior they observe but let concerns other than appropriateness take center stage. In this way, one norm violation fosters violations of other norms, and disorder spreads from one kind of inappropriate behavior to other kinds. We call this the cross-norm inhibition effect. An important implication of this "goal-framing" theory for the BWT is that the effect should not be limited to social norms in the strict sense of the word but would also apply to all sorts of legitimate rules, such as laws, police ordinances, or even legitimate rules established by private companies.

To test this theory, we conducted controlled field experiments in common public spaces (*34*), that is, in locations where ordinary "broken window" kind of disorder could be observed.

Fig. 1.

Participants were people in the public space judged to be 18 years or older. There were no signs in any of the studies that they were aware of being observed by the experimenter. We distinguished between a contextual norm (which the participant witnessed having been violated) and a target norm (a violation committed by the participant).What we manipulated were the indications that the contextual norm was being violated. What we observed as a dependent variable was the relative number of individuals who then violated the target norm, which was inconvenient or costly to follow in this situation. We predicted that disorder (violation of contextual norm) would spread (violation of target norm). To study the robustness of this cross-norm inhibition effect, we conducted six different studies. For ease of description, let us call the situation in which the contextual norm is violated (i.e., inappropriate behavior by others is being displayed) the disorder condition and the one in which it is not violated the order condition. Other factors possibly influencing the results were kept constant between conditions (no signs of other norm or rule violations, same weather conditions, and same period of the day). A confederate posted out of sight observed whether participants did or did not violate the target norm. Gender was coded at first but turned out not to have any impact on the results and was dropped in later experiments. The arrangements in all experiments were such that it was virtually impossible for people not to notice the violations of injunctive norms (such as graffiti, wrongly parked bicycles, and firecrackers).

In study 1, the setting was an alley in Groningen located in a shopping area and commonly used to park bicycles. In the order condition, the walls of the alley were clean (Fig. 1A), whereas in the disorder condition they were covered with graffiti (Fig. 1B). A standard prohibition sign (a round red sign with a round white center) with the text "Graffiti" pointed out the disapproved behavior. The sign was highly noticeable, and every subject entering the setting at least glanced at it. Participants ($N = 77$ in each condition) were all people who came to collect their parked bicycles. In their absence, a flyer with an elastic band had been attached to the handlebar of their bicycle. The flyer was white and thus very noticeable. It read: "We wish everybody happy holidays," signed with the name of a nonexistent sportswear shop. The flyer had to be removed by the participant to easily use the handlebar. Because there were no trash cans in the alley, "not littering" meant taking the flyer with them. We counted throwing the flyer on the ground or hanging it on another bicycle as littering.

The cross-norm inhibition effect of violating the antigraffiti norm on littering was quite substantial. Of the participants in the order condition (nongraffiti), 33% littered compared with 69% of the participants in the disorder condition (graffiti on the walls). The difference is highly significant [$\chi^2(1, 154) = 20.367$, $P < 0.001$]. In Groningen, littering is generally tolerated by the police so that the effect could not be explained by a guess on law enforcement, such as "if people haven't been caught painting graffiti, I will not be caught dropping paper."

We designed the next studies to include a variety of norms in order to address two questions. We wanted to determine whether the cross-norm inhibition effect was restricted to generally accepted social norms or whether, as expected by the goal-framing theory, it also extended to local ordinances by the police or even to normative requests set up by private companies. We also wanted to determine how far the influence would go. In other words, would a norm violation just affect relatively light infractions, such as littering, or would it go so far as to affect the willingness to violate such serious norms as "thou shalt not steal"?

For study 2, we used a police ordinance as a contextual norm and "no trespassing" (as ordered by the police) as the target norm in the setting of a car park. Thus, both contextual and target norms were not general social norms but rules set up by the local police for a particular local situation. A temporary fence (set up by us) closed off the main entrance for people who came to pick up their car, but a gap of about 50 cm was left open in the fence (Fig. 2). We attached two signs to the temporary fence just 60 cm apart and directly next to the gap. The right sign (our contextual norm) indicated that it was prohibited to lock bicycles to the fence. The left sign (our target norm) made clear that it was prohibited to use this entrance and that people had to use an alternative entrance to the car park, which required walking a 200-m detour. In the order condition, four bicycles standing 1 m before the fence were ostensibly not locked to the fence.

In the disorder condition, four bicycles were locked to the fence for everyone to see. The dependent variable was whether pedestrians conformed to the "no throughway" sign (the target

Fig. 2.

Fig. 3.

norm) and walked the 200-m detour to the temporary entrance that was pointed out by the sign. Violating the "no throughway" ordinance meant stepping through the gap in the fence. Subjects (N = 44 in the order condition and N = 49 in the disorder condition) were all people who came to collect their car from the car park. A group of people approaching the fence was counted as one subject.

Again there was a clear cross-norm inhibition effect. Of the participants in the order condition (where bicycles were not locked to the fence), 27% stepped through the gap in the fence, compared with 82% of the participants in the disorder condition (where the bicycles were attached to the fence). The difference is significant [$\chi^2(1, 93) = 27.791$, $P < 0.001$].

Would this also hold for a rule set by a private company that is not enforced with sanctions? In study 3, a parking garage adjacent to a supermarket and health club was used in which the contextual norm established by the private company is to return shopping carts to the supermarket after loading groceries into one's car. A very visible sticker with the text: "please return your shopping carts" attached to the entrance doors of the parking garage focused attention on this normative request (Fig. 3). In the order condition, the garage was clear of shopping carts that were not returned. In the disorder condition, there were four unreturned shopping carts standing around in disarray. The (unreturned) carts used in the disorder condition had no coin deposit system, so people were not financially encouraged to return them. To discourage people who just arrived from using the shopping carts and thus removing the disorder, we smeared the handle bars of the carts with petroleum jelly. Participants (N = 60 in each condition) were visitors of the supermarket and a health club who came to collect their car from the multilevel parking garage. Only people *not* using a shopping cart were included. The target norm was the anti-litter norm, already used in study 1. The dependent variable was whether or not participants who returned to their car littered a flyer (the same flyer as used in study 1) that was placed under the driver's side windshield wiper of their parked car. The results show that even with this private request, a considerable cross-norm inhibition effect could be observed. Of the participants in the condition without shopping carts, 30% littered the flyer, compared with 58% of the participants in the condition for which unreturned shopping carts were present. The difference is significant [$\chi^2(1, 120) = 9.766$, $P = 0.002$].

Is disorder only linked to visual cues of norm violation? Would the cross-norm inhibition effect be of any influence when the contextual norm was merely audible? In our fourth study, we focused on a national law as a contextual norm. In Netherlands it is prohibited by law (with a €60 fine) to set off fireworks in the weeks before New Year's Eve. We wanted to find out, 2 weeks before New Year's Day, whether an offense against this national law would induce people to litter. In contrast to studies 1 to 3, the contextual norm was not made conspicuous (say by a sign stating the law). The law about fireworks is well known, and its violation itself would immediately make the law salient in people's mind. The setting we used was a bicycle shed located near a busy train station. The subjects (N = 50 in the order condition and N = 46 in the disorder condition) were all people who came to collect their parked bicycle. In the order condition, there was no sound of fireworks. In the disorder condition, we set off firecrackers (well within hearing distance of the participants but out of sight to prevent any visual cues). We observed whether participants littered a flyer (the same flyer as used in studies 1 and 3) attached to the handlebar of their bicycle. Of the subjects in the order condition (no fireworks set off), 52% littered the flyer compared with 80% of the subjects that heard fireworks being set off as they entered the bicycle shed. The difference is significant [$\chi^2(1,96) = 8.587$, $P = 0.003$].

For studies 5 and 6, the target norm was stealing, and we examined whether an envelope, visibly containing a €5 note and hanging out of a mailbox, would be stolen more often if a contextual norm was violated. The white (addressed) window envelope sticking out of a mailbox (situated in Groningen) was very noticeable for everyone approaching the mailbox, and it was clearly visible that the envelope contained a €5 note (Fig. 4). The participants were all people who singly passed the mailbox on foot (and the few who actually posted a letter). We conducted a baseline order condition (N = 71) in which the mailbox was not covered with graffiti and the ground around the mailbox was clean. We then conducted two disorder conditions: one in which the mailbox was covered with graffiti without litter on the ground (N = 60, study 5) and one in which there was no graffiti on the mailbox but the space around the mailbox was littered (N = 72, study 6). The circumstances of all three conditions in term of period of the day and weather were held constant. The dependent variable was whether or not people would steal the envelope. Leaving the envelope or pushing it into the mailbox was considered not stealing. Opening the envelope or taking it was considered stealing. Thus, we compared two disorder conditions to the baseline condition.

The study 5 results were quite dramatic. Of the participants in the baseline order condition (no graffiti, no littering), 13% stole the envelope compared with 27% of the subjects in the graffiti disorder condition. The difference is significant [$\chi^2(1, 131) = 4.122$, $P = 0.035$].

The results of study 5 proved to be robust. Compared with the baseline order condition (in which 13% stole the envelope), 25% of the subjects in study 6 stole the envelope in the litter disorder condition. The difference is again significant [$\chi^2(1, 143) = 3.545$, $P = 0.047$]. It is highly unlikely that this effect is due to a guess about the likelihood of law enforcement triggered by littering. People are not likely to infer a low likelihood of law enforcement against stealing from the fact that people littered the street, because in Groningen littering is generally tolerated by the police whereas stealing is not. The most likely interpretation of these results is, as before, that one disorder (graffiti or littering) actually fostered a new disorder (stealing) by weakening the goal of acting appropriately.

Our conclusion is that, as a certain norm-violating behavior becomes more common, it will negatively influence conformity to other norms and rules. The effect was not limited to social norms but also applied to police ordinances and even to legitimate requests established by private companies. The mere presence of graffiti more than doubled the number of people littering and

Fig. 4.

stealing. There is a clear message for policymakers and police officers: Early disorder diagnosis and intervention are of vital importance when fighting the spread of disorder. Signs of inappropriate behavior like graffiti or broken windows lead to other inappropriate behavior (e.g., litter or stealing), which in turn results in the inhibition of other norms (i.e., a general weakening of the goal to act appropriately). So once disorder has spread, merely fixing the broken windows or removing the graffiti may not be sufficient anymore. An effective intervention should now address the goal to act appropriately on all fronts.

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35. We thank the University of Groningen for providing us the necessary means to complete this project. We also thank J. W. Bolderdijk, T. Postmes, J. A. Rothengatter, J. Thøgersen, and four anonymous reviewers for their helpful comments.

Supporting Online Material

www.sciencemag.org/cgi/content/full/322/5908/1681/DC1
Materials and Methods

5 June 2008; accepted 31 October 2008
10.1126/science.1161405

Germ Cell–Intrinsic and –Extrinsic Factors Govern Meiotic Initiation in Mouse Embryos

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Retinoic acid (RA) is an essential extrinsic inducer of meiotic initiation in mammalian germ cells. However, RA acts too widely in mammalian development to account, by itself, for the cell-type and temporal specificity of meiotic initiation. We considered parallels to yeast, in which extrinsic and intrinsic factors combine to restrict meiotic initiation. We demonstrate that, in mouse embryos, extrinsic and intrinsic factors together regulate meiotic initiation. The mouse RNA-binding protein DAZL, which is expressed by postmigratory germ cells, is a key intrinsic factor, enabling those cells to initiate meiosis in response to RA. Within a brief developmental window, *Dazl*-expressing germ cells in both XX and XY embryos actively acquire the ability to interpret RA as a meiosis-inducing signal.

Diploid eukaryotes generate haploid cells via meiosis, a program of two successive cell divisions preceded by one round of DNA replication. The onset of this program is referred to as meiotic initiation. In mammals, debate has focused on whether meiotic initiation is promoted by factors extrinsic or intrinsic to germline cells (*1*–*6*). Meiotic initiation in female mice, commencing at embryonic day 12.5 (E12.5) (*7*, *8*), is induced by an extrinsic factor, retinoic acid (RA) (*8*–*10*), but RA alone cannot account for the exquisite temporal and cell-type specificity of meiotic initiation. Although diverse somatic cell types are exposed and respond to RA during mammalian development (*11*), meiotic initiation is limited to the germ line. Indeed, embryonic germ cells do not respond specifically to RA until their migration ends, at the developing gonad. Does meiotic initiation in mammals also require an intrinsic competence factor expressed in germ cells? Consider the yeast *Saccharomyces cereviseae*, in which meiosis is induced by a nutrient-depleted environment (*12*). For an *S. cereviseae* cell to be competent to initiate meiosis in response to this extrinsic cue, the cell must express the a/α mating-type heterodimer (*13*). We wondered whether an analogous interplay of extrinsic and intrinsic factors governs meiotic initiation in mammals.

We considered the possibility that the *Dazl* (*Deleted in azoospermia-like*) gene might be an intrinsic meiotic competence factor, given the location and timing of its expression. In both XX and XY mouse embryos, germ cells begin to express *Dazl* at about the time of their arrival at the gonad, between E10.5 and E11.5 (*14*). No somatic lineage has been shown to express *Dazl* (*15*). Furthermore, *Dazl*-deficient mice are infertile because of germ cell–differentiation defects (*16*–*19*). These defects are more consistent and pronounced in inbred C57BL/6 mice (*19*) than in noninbred mice (*16*–*18*). Accordingly, we analyzed *Dazl* function in inbred C57BL/6 animals.

We began by testing whether germ cells survive in *Dazl*-deficient embryonic ovaries as germ cells of *Dazl*-deficient C57BL/6 embryonic testes undergo apoptosis, beginning by E14.5 (*19*, *20*). We detected two germ cell markers—endogenous alkaline phosphatase (AP) activity (*21*) and mouse *vasa* homolog (MVH) protein (*22*)—in the ovaries of wild-type and *Dazl*-deficient embryos (fig. S1, A and B). We also found MVH protein in wild-type and *Dazl*-deficient neonatal ovaries (fig. S1C), which indicates that *Dazl*-deficient ovarian germ cells survive embryonic development (fig. S1, A and B) and persist through birth (fig. S1C).

We then compared the nuclear morphology of germ cells in wild-type and *Dazl*-deficient ovaries at E15.5. By this stage of development, many germ cell nuclei in wild-type ovaries exhibit the chromosome condensation that characterizes early meiotic prophase (Fig. 1A). By contrast, germ cells in *Dazl*-deficient ovaries do not display such condensation (Fig. 1A), which suggests that *Dazl* function might be required for meiotic prophase to occur. We then examined the expression of *Stra8*, which is required for premeiotic DNA replication and the subsequent events of meiotic prophase in germ cells of embryonic ovaries (*8*). As expected,

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