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Relating pattern deviancy aversion to stigma and prejudice

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What predicts people's powerful and universal dislike of social deviancy? Across six studies, aversion towards non-social pattern deviancy, for example, a row of triangles with one triangle out of line, predicted aversion towards stigmatized individuals, social norm breakers, statistically negative and positive deviants, and a racial minority group (Black individuals). The relationship between pattern deviancy and social deviancy aversion emerged across explicit and implicit measures, across cultures (United States and China), and was of a moderately large magnitude (meta-analytic effect size: $d = 0.68$). Studies 7 and 8 examined developmental differences. Older but not younger children's pattern deviancy aversion related to their dislike of social norm breakers. Although non-social pattern deviancy and social deviancy judgements may seem distinct given their differing domains, people's aversion towards non-social pattern deviancy and social deviancy consistently overlapped. These findings raise the possibility that pattern deviancy aversion plays an important role in stigmatization and prejudice.

An image of a Muslim woman next to a drag queen in the New York City subway went viral in March 2017. While some people felt little aversion to the scene, others reacted with open hostility. These differential reactions raise psychological questions: what underlies individual differences in people's dislike of societal outliers and, furthermore, why are social outliers stigmatized and discriminated against in the first place?

Two overarching theories identify origins of people's universal aversion towards social deviancy: people are motivated to avoid danger[1] and to uphold group functioning[2]. Complementary to these motivational and evolutionary origins, however, a basic and potentially more direct explanation of why people dislike social deviancy may exist. Disliking social deviancy may simply be predicted by a domain-general propensity to dislike pattern deviancy, that is, disliking violations of a repeated form or model. If true, disliking deviancy even in simple non-social patterns of geometric shapes should overlap with disliking social deviancy, for example, physical deviancy (such as dwarfism), character deviancy (such as addiction) and group-identity deviancy (such as minorities in the United States)[3]. Here, we specifically examine whether individuals' aversion towards non-social pattern deviancy and aversion towards social deviancy co-vary. Importantly, considering that disliking social deviancy plays a major role in stigmatization, prejudice, and discrimination[4–7], an overlap between pattern deviancy and social deviancy aversion would suggest that disliking pattern deviancy potentially relates to these processes as well.

In support of the hypothesized overlap between disliking non-social pattern deviancy and disliking social deviancy, independent bodies of research have observed that both pattern and social deviancy aversion emerge early in life. With respect to non-social pattern deviancy, 6 month olds dislike dissonance in auditory stimuli[8] and 12 month olds prefer vertical symmetry over asymmetry[9]. With respect to social deviancy, children around four years old exhibit prejudice[10,11], dislike and punish social norm violators[12,13], and hold a generalized bias against stigmatized individuals (such as the obese and the mentally ill)[14,15].

Research on people's preference for prototypicality across non-social and social domains additionally supports the proposed overlap between people's non-social pattern and social deviancy judgements. For instance, people prefer prototypical paintings and furniture[16,17] as well as prototypical faces[18,19]. Aside from prototype preference, prototype formation processes—which are active even in infants—appear to inform both evaluations of non-social stimuli (geometric shapes)[20] and social stimuli (faces)[21]. That similar processes inform both non-social deviancy and social deviancy judgements supports the possibility that individuals' aversion towards non-social pattern and social deviancy co-vary.

A linguistic overlap further supports the proposed relationship: people use similar terms to refer to both non-social and social deviancy. The terms 'weird' and 'strange' are applied to both non-social stimuli (weird art) and social stimuli (a weird person). Furthermore—and more specifically regarding pattern deviancy—certain expressions about social deviancy allude to pattern deviancy, for example, social 'outliers', staying 'in-line' and being a 'misfit'. Empirically documenting these linguistic overlaps, children, while not comprehending mental illness per se, apply labels used to refer to deviant objects, such as weird and strange when describing adults who manifest psychiatric symptoms[22].

Two additional empirical phenomena support the hypothesized overlap between non-social pattern and social deviancy aversion. First, judgements about deviant geometric shapes have been found to predict social judgements: individuals who report greater differentiation between perfect and imperfect, ambigious shapes are more politically conservative and exhibit decreased support for marginalized groups[23]. Second, four weeks after viewing an image of a truncated pyramid (where one side was askew), individuals high in prejudice were more likely to draw the pyramid from memory as having been symmetrical compared with individuals low in prejudice[24]. This study suggests that prejudice is associated with a lower tolerance for deviancy in simple geometric shapes.

To begin to explore whether non-social pattern deviancy aversion plays a role in social deviancy aversion—and potentially, therefore, in prejudice and stigmatization—we examined whether individuals' dislike of non-social pattern deviancy and social deviancy co-vary. To explicate, in the current article, we solely examined the correlational relationship between pattern and social deviancy

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aversion—we did not yet examine causation. Specifically, we conducted six studies examining whether individuals' dislike of non-social pattern deviancy relates to their dislike of social deviancy ($n = 815$), one meta-analysis of these findings (and Supplementary Studies 3 and 4; number of studies = 8; $n = 1{,}114$), and three developmental studies (studies 7a, 7b, and 8) examining children's pattern and social deviancy judgements ($n = 129$).

Results

Study 1. Participants reported their aversion towards images depicting non-social pattern deviancy. These images were taken from Buzzfeed.com articles about how irritating pattern deviancy can be. For example, one image depicted a cake cut at an unusual angle, ruining the circular symmetry of the cake. Participants reported how uncomfortable, annoyed, and anxious they felt in response to these images and in response to images of socially deviant individuals, that is, individuals stigmatized in society such as someone with a skin condition or someone cross-dressing[3].

Study 1 also included theoretically relevant control variables. Disliking pattern deviancy may reflect mental rigidity and a strong desire for order. For this reason—and because these tendencies have been linked to disliking social deviancy[25]—we included a measure of individuals' mental rigidity and desire for order (need for closure)[26]. We also assessed participants' neuroticism (people's tendency to respond negatively to threatening stimuli) because individuals may perceive pattern deviancy as threatening[27]. As expected, we found significant but small correlations between individuals' pattern deviancy aversion and need for closure (Pearson's $r = 0.17$, $P = 0.047$) and neuroticism ($r = 0.25$, $P = 0.004$). Pattern deviancy aversion did not relate to political orientation ($P = 0.669$); this null finding was replicated in nearly all of the other reported studies.

Demonstrating that individuals' dislike of pattern deviancy relates to their dislike of social deviancy, a linear regression revealed that participants' aversion towards non-social deviant patterns predicted their aversion towards deviant individuals (standardized beta coefficient, $\beta = 0.38$, $P < 0.001$). Critically, the relationship between pattern deviancy aversion and disliking commonly stigmatized individuals remained after controlling for neuroticism, need for closure, and political conservatism ($\beta = 0.33$, $P < 0.001$; see Table 1). We find pattern deviancy aversion to relate to disliking social deviancy neither via mental rigidity and desire for order nor via political conservatism[23,25].

Study 2. In study 2, we operationalized non-social pattern deviancy using patterns comprising static geometric shapes, such as circles or triangles. We did this because static geometric shapes generally lack social attributes[23]. Specifically, we created pairs of matched unbroken and broken pattern images (Fig. 1). By including images of unbroken patterns we controlled for participants' baseline aversion towards images depicting geometric shapes as well as reduced potential acquiescence bias—participant yay-saying and nay-saying. In a separate study (Supplementary Study 1), independent participants rated the broken patterns as more deviant than the unbroken patterns. Social deviancy aversion was measured in the same manner as in study 1 (images of stigmatized individuals). In a further separate study (Supplementary Study 2), independent participants rated these images of stigmatized individuals as more deviant than images of control individuals.

Crucially, participants' aversion towards broken over unbroken patterns predicted their aversion towards stigmatized individuals (for example, an individual wearing a tail) ($r = 0.53$, $P < 0.001$). We verified that these results were not due to participants merely imbuing the geometric shapes with social attributes, anthropomorphism—a mind-perception effect, or experiencing disgust in response to pattern deviancy and social deviancy (see Supplementary Study 3). In study 2, pattern deviancy aversion also predicted social deviancy aversion when pattern deviancy aversion was measured solely via mental imagery. Participants reported their aversion towards the following vignette: 'Imagine a collection of objects where all the objects are very similar to one-another… if one very different object is added to the collection then I would feel…' ($r = 0.59$, $P < 0.001$).

Study 3. Apart from disliking stigmatized individuals, does pattern deviancy aversion also relate to disliking other forms of social deviancy? Because norm breaking constitutes one major form of social deviancy[5], in study 3, we examined whether pattern deviancy aversion relates to a dislike of social norm breakers. Indeed, disliking deviancy in non-social geometric patterns predicted aversion towards someone in an imaginary society who had violated a social norm ($r = 0.33$, $P < 0.001$). We also examined whether pattern deviancy aversion predicts dislike of individuals who are statistically 'negative' and 'positive' deviants in society, for example, someone very unintelligent, poor, or overweight and someone very intelligent, rich, or skinny. Discomfort with pattern deviancy predicted aversion towards an imagined meeting both with negatively and positively deviant Americans ($r = 0.26$, $P = 0.006$ and $r = 0.25$, $P = 0.008$, respectively). These results did not change when controlling for variables that have also been found to predict dislike of social deviancy; that is, belief in a dangerous world[28], threat sensitivity[29], intolerance of ambiguity[30], and political conservatism (see Table 1). In support of pattern deviancy aversion being distinct from disliking unpredictability and ambiguity, pattern deviancy aversion did not relate to intolerance of ambiguity ($r = 0.13$, $P = 0.178$).

Study 4. Study 4 considered the relationship between individuals' implicit attitudes towards pattern deviancy and social deviancy, which were measured using implicit association tests (IATs)[31]. While the expression of explicit attitudes is intentional and conscious, the expression of implicit attitudes is unintentional and occurs outside of awareness[32]. Extending the generalized influence of pattern deviancy to the domain of implicit judgements, participants' implicit dislike of broken non-social patterns of geometric shapes predicted their implicit dislike of stigmatized individuals ($r = 0.25$, $P = 0.003$). These results indicate that the overlap between individuals' pattern deviancy and social deviancy aversion is not limited to explicit judgements and diminishes the possibility that the earlier studies were affected by experimental demand effects.

Study 5. Considerable evidence indicates that social deviancy aversion exists across cultures and is potentially universal[4]. Therefore, if pattern deviancy aversion is a basic factor predicting social deviancy aversion, pattern and social deviancy aversion should overlap across cultures. Study 5 assessed whether aversion towards broken non-social patterns (over unbroken patterns) predicts aversion towards stigmatized individuals in a sample of Chinese individuals (Chinese people residing in China). We chose a Chinese sample because United States and Chinese culture are distinct in numerous ways. For example, while Americans tend to adhere to individualistic values and engage in analytical thinking, Chinese people tend to adhere to collectivistic values and engage in holistic thinking[33,34]. Replicating studies 1–4, Chinese individuals' pattern deviancy aversion and social deviancy aversion strongly overlapped ($r = 0.54$, $P < 0.001$).

Study 6. Because disliking social deviancy predicts prejudice and discrimination[6,7], pattern deviancy aversion may also relate to these processes. Researchers have pointed out that prejudice against Black individuals in the United States may be based on perceiving minority groups as socially deviant[6]. In study 6, we hypothesized that pattern deviancy aversion is associated with racial prejudice. We found pattern deviancy aversion to predict both implicit prejudice (measured using an IAT; $r = 0.20$, $P = 0.021$) and explicit prejudice

Table 1 | Summary of all studies

Study	*n*	Relationship between PDA and SDA		Pattern deviancy measure	Social deviancy measure	Sample type
		β	*P*			
Study 1[a]	134	0.38	<0.001	Buzzfeed images	Stigmatized individuals	Adults
		0.33	<0.001[b]			
Study 2[a]	98	0.53	<0.001	Pattern images	Stigmatized individuals	Adults
		0.59	<0.001	Written pattern description	Stigmatized individuals	Adults
		0.33	<0.001	Pattern images	Social norm breakers	Adults
		0.35	<0.001[b]			
Study 3[a]	108	0.25	0.008	Pattern images	Positive statistical outliers	Adults
		0.21	0.025[b]			
		0.26	0.006	Pattern images	Negative statistical outliers	Adults
		0.24	0.013[b]			
Study 4[a]	140	0.25	0.003	IAT (pattern images)	IAT (stigmatized individuals)	Adults
Study 5[a]	197	0.54	<0.001	Pattern images	Stigmatized individuals	Adults (Chinese)
		0.20	0.021	Pattern images	Implicit racial prejudice	Adults
Study 6[a]	138	0.18	0.032	Pattern images	Explicit racial prejudice	Adults
		0.21	0.009[b]			
Study 7a	40	–	–	Pattern images (forced choice)	–	Children
Study 7b	25	–	–	Pattern images	–	Children
Study 8	64	0.36	0.009[c]	Pattern images	Social norm breakers	Children

[a]These studies were included in the meta-analysis. [b]Denotes the correlation when controlling for other relevant measures. [c]Denotes the age × PDA interaction predicting attitudes about social norm breakers. PDA, pattern deviancy aversion; SDA, social deviancy aversion.

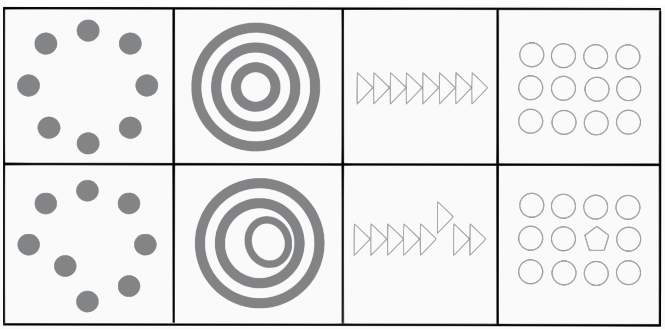

Fig. 1 | Pattern deviancy aversion measure. Examples of the pairs of unbroken and broken pattern images used to measure pattern deviancy aversion in studies 2–6. Each image was presented individually to participants.

(symbolic racism) against Black individuals ($r = 0.18$, $P = 0.032$; $r = 0.21$, $P = 0.009$ when controlling for participants' self-reported tendency to not discriminate against others).

Studies 1–6 consistently found people's aversion towards pattern deviancy (in everyday scenes and patterns of geometric shapes) to predict their dislike of social deviancy, including stigmatized individuals, social norm breakers, statistically negative as well as positive societal outliers, and members of a racial minority (Black individuals). The relationship between pattern and social deviancy aversion emerged across explicit and implicit measurement methods, as well as across collectivistic (Chinese) and individualistic (United States) cultures.

Meta-analysis. We conducted a meta-analysis of studies 1–6 (plus Supplementary Studies 3 and 4). This meta-analysis indicated a medium-to-large relationship between people's non-social pattern and social deviancy judgements (fixed-effect model: Cohen's $d = 0.65$; random-effects model: $d = 0.68$). These results are particularly noteworthy considering that in studies 2–6 we operationalized pattern deviancy as broken patterns of simple geometric shapes.

Studies 7 and 8. Even young children dislike social deviancy. Children as young as four years old exhibit prejudice, dislike social norm breaking, and dislike stigmatized individuals[10–15]. Yet, the origins of young children's dislike of social deviancy remain largely unexplored. As noted earlier, research indicates that in addition to disliking social deviancy, young children dislike pattern deviancy[8,9,16]. Given the overlap we observed between adults' pattern and social deviancy aversion, young children's pattern and social deviancy aversion may relate as well. We conducted three studies (studies 7a, 7b, and 8) with children aged four to nine to examine children's non-social pattern and social deviancy aversion.

In studies 7a and 7b, we investigated whether—parallel to adults (see Table 2)—children between three and six years of age dislike broken patterns of geometric shapes compared to unbroken patterns of geometric shapes. In doing so, we also attempted to verify that the non-social pattern deviancy stimuli used in studies 2–6 (the unbroken and broken patterns of geometric shapes) can be used to measure children's pattern deviancy aversion. In line with the findings of studies 2–6 and past research indicating that young children dislike dissonant sounds and asymmetry[8,9], studies 7a and 7b found that three to six year olds dislike pattern deviancy ($P = 0.003$, $d = 0.50$ and $P = 0.035$, $d = 0.45$, respectively; see Table 2).

Building on these results, study 8 examined whether children's pattern and social deviancy aversion overlap. Observing this relationship in four year olds would suggest that this overlap is early emerging, likely does not require schooling, and necessitates little explicit understanding of social deviancy. Alternatively, if only older children exhibit an overlap, a more developed understanding

Table 2 | Overall pattern deviancy aversion: participants' dislike of broken patterns over unbroken patterns

Study	*n*	Sample type	Pattern deviancy aversion			
			t	95% Confidence interval	*d*	*P*
Study 1	134	Adult	-	-	-	-
Study 2	98	Adult	7.61	0.72, 1.23	0.77	<0.001
Study 3	108	Adult	7.24	0.70, 1.24	0.70	<0.001
Study 4	140	Adult	24.56	0.70, 0.82	2.08	<0.001
Study 5	197	Adult	17.75	1.55, 1.94	1.26	<0.001
Study 6	138	Adult	10.08	1.01, 1.51	0.86	<0.001
Study 7a	40	Children	3.16	0.06, 0.29	0.50	0.003
Study 7b	25	Children	2.24	0.09, 2.19	0.45	0.035
Study 8	64	Children	-0.24	-0.34, 0.44	0.03	0.811

of social deviancy may be necessary for pattern and social deviancy judgements to relate. We assessed children's dislike of pattern deviancy in study 8 using the unbroken and broken patterns of geometric shapes validated in studies 7a and 7b. We assessed children's dislike of social deviancy via their dislike of social norm breakers. We operationalized social deviancy as social norm breaking because children as young as three years of age detect, understand, and object to the breaking of social norms[11,12,35]. Indeed, in our study, disliking social norm breakers did not vary as a function of age ($P = 0.536$).

We found that the relationship between children's pattern and social deviancy aversion alters depending on age. The pattern deviancy dislike of older but not younger children predicted their dislike of social norm breakers ($\beta = 0.36$, $P = 0.009$). Older children (approximately seven to nine year olds) who disliked (liked) broken geometric patterns disliked (liked) social norm breakers ($\beta = 0.43$, $P = 0.007$). This pattern of results was not true for younger children (four to six year olds) ($\beta = -0.29$, $P = 0.165$; Fig. 2). These results were not due to younger children failing to understand the instituted, situational social norm (see Supplementary Note).

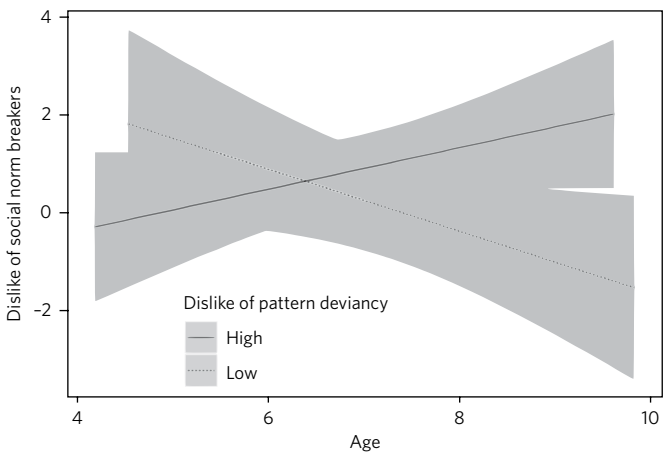

Fig. 2 | Study 8 interaction effect. Interaction between age and disliking pattern deviancy predicting disliking social norm breakers. Disliking pattern deviancy predicted disliking social deviancy in older children (+1 s.d. = 8.56 years old), but not in younger children (−1 s.d. = 5.5 years old). Grey shading indicates 95% confidence interval.

It is possible that younger children's pattern and social deviancy judgements did not overlap because, although our findings and past research indicate that young children dislike social norm breaking[12,13], young children may not categorize social norm breaking actions or norm breakers as socially deviant ('weird' or 'strange'). Two findings support this possibility. First, when asked to describe what they perceive as deviant behaviour in their peers, children under seven tend not to include social norm breaking actions in their responses, while older children do so[36]. Second, younger children are less likely than older children to infer dispositional attributes from the single action of another individual[37,38]. Therefore, even if they did perceive the social norm breaking 'action' as deviant, the younger children in our study still likely did not consider the social norm 'breakers' as deviant (we assessed children's dislike of social norm breakers). Considering these possibilities, the observed interaction effect tentatively suggests that people's pattern and social deviancy judgements overlap as they begin to understand and categorize actions and individuals as socially deviant. Future research should examine this possibility as well as whether children's pattern deviancy aversion predicts aversion towards other forms of social deviancy, for example, racial prejudice.

Lastly, regarding the presented developmental data, we note two limitations. First, younger children may have struggled with the complexity of the paradigm; future improved methods may be able to detect a relationship where our current methods could not[39]. Second, our study was not longitudinal. While our results indicate developmental differences, they do not indicate a developmental trajectory or a developmental change.

Discussion

Taken together, the current findings demonstrate a consistent overlap between individuals' dislike of non-social pattern deviancy and their dislike of social deviancy. Dislike of broken patterns in everyday scenes, geometric shapes, and a written vignette describing non-social pattern deviancy predicted dislike of stigmatized individuals, social norm breakers, statistically negative and positive societal outliers, and a racial minority in the United States. These results were observed across explicit and implicit judgements, across individualistic (United States) and collectivistic (Chinese) cultures, and in children older than six years old. Our findings suggest that people's responses towards simple, non-social pattern deviancy may play a role in the universal constructs of social stigma and prejudice.

One may argue that dislike of pattern deviancy predicts dislike of social deviancy merely because pattern deviancy overlaps with other predictors of disliking social deviancy. Disgust[40], sensitivity towards threat[41], conservatism[23,42], and disliking ambiguity and unpredictability[26,43], have all been shown to predict dislike of social deviancy. Importantly, however, when statistically controlling for these constructs, pattern deviancy aversion remained an independent and moderate-to-large predictor of social deviancy aversion. Pattern deviancy aversion thus entails an additional pathway towards stigmatization and prejudice beyond disgust, sensitivity towards threat, mental rigidity, and dislike of ambiguity and uncertainty. The control variables we included were disgust, sensitivity towards threat, belief in a dangerous world, neuroticism, political ideology, need for closure, intolerance of ambiguity, and disliking negative but not deviant stimuli (for example, bad weather) (see Supplementary Note). Future research should investigate how predictors of disliking social deviancy that we did not examine relate to pattern deviancy aversion.

The observed overlap between individuals' responses to pattern deviancy in the non-social domain (geometric shapes) and social domain (humans) is in harmony with a growing body of research observing physical–social overlaps. For example, individual differences in sensitivity to physical pain predict sensitivity to social pain (in the form of social rejection)[44], and increasing physical warmth

heightens individuals' perceived social warmth (feeling connected to other people) and vice versa[45,46]. These physical–social overlaps are paralleled in neural circuitry[46,47], tentatively indicating that a common neural basis for pattern deviancy and social deviancy judgements may exist.

There are several candidates for potential mechanisms underlying the observed relationship between pattern and social deviancy aversion: a scaffolded mind process, cognitive fluency, and disliking expectancy violations. First, people's attitudes towards non-social pattern deviancy may guide (that is, serve as a 'scaffold' for)[48] their evaluation of social deviancy, resulting in an overlap between dislike of pattern and social deviancy. Second, processing fluency—the ease with which information is processed[49]—may link pattern and social deviancy aversion because individuals who dislike disfluent non-social stimuli may also dislike disfluent social stimuli. Third, disliking expectancy violations[50] could qualify as a mechanism; the images of broken patterns in our studies may have violated participants' expectations and certain types of social deviancy may qualify as violations of expectations as well.

The presented results are correlational. From them, one cannot draw inferences regarding any causal relationships between pattern deviancy and social deviancy aversion. If, however, future research were to observe a causal effect of pattern deviancy aversion on social deviancy aversion, interventions might be developed that reduce individuals' dislike of social deviancy by attenuating their pattern deviancy aversion. Such interventions could possibly even reduce people's levels of prejudice and discrimination.

Although non-social pattern deviancy aversion predicted unique variance in social deviancy aversion, pattern deviancy aversion likely does not relate to all forms of stigmatization and prejudice. For example, disliking pattern deviancy cannot explain the oppression of majority groups by minority groups (for example, apartheid in South Africa); in the case of apartheid, the dominant group was the pattern-deviant one (the minority). Furthermore, numerous cognitive processes, societal processes, and intergroup motives—irrespective of individuals' dislike of pattern deviancy—play a role in stigmatization and prejudice, for example, stereotyping and intergroup competition[51]. Consequently, we posit that while disliking pattern deviation may be sufficient to incite social stigma and prejudice, it is not necessary.

It is worth noting that the methodological paradigms of studies 1, 2, 3, and 5 may have positively contributed to the obtained effect sizes. These studies explicitly drew participants' attention to deviancy by, for instance, presenting participants with unbroken as well as broken patterns and making the deviancy manipulations highly explicit. For example, participants in study 3 were reminded numerous times that the social norm breaker had deviated from the norm. Furthermore, studies 1–5 assessed pattern deviancy and social deviancy aversion using similar methodologies, such as using the same items to measure aversion. Although study 6 allayed some of these concerns by using different methodologies (a race IAT and a measure of symbolic racism), future research should examine the generalizability of the observed effects regarding different methodologies, more real-world measures of social deviancy aversion, and behavioural outcomes of stigmatization and prejudice (discrimination).

The correlational results presented here provide the basis for future research examining whether pattern deviancy aversion motivates social deviancy aversion, prejudice, and stigma. For instance, pattern deviancy aversion could potentially explain people's prejudice against individuals who are deviant yet harmless, for example, individuals with dwarfism or individuals who identify with their non-biological gender. People tend to rationalize such prejudice by claiming that negatively deviant individuals, such as the mentally ill, are dangerous[52] and that positively deviant individuals, such as highly competent people, are cold and untrustworthy[53]. The research presented here, however, raises the possibility that a simple dislike of pattern deviancy plays a role in such prejudice.

Methods

Study 1. *Participants.* The relationship between pattern and social deviancy aversion would be psychologically and ecologically relevant if it were of moderate effect-size ($r = 0.30$). A power analysis revealed that we needed 109 participants to have 90% power at a 0.05 alpha level. We recruited 144 participants via Mechanical Turk (68 female). Participants (age: mean = 38.01, s.d. = 12.45) were living in the United States. Participants in all other studies, except for in study 5, were also living in the United States. Ten participants were excluded for failing attention check items. Study 1 and all the other reported studies were approved by the Human Subjects Committee of Yale University.

Need for closure. We included a validated short version of the need-for-closure scale[26]. The scale consisted of 15 items (for example, 'I don't like situations that are uncertain').

Neuroticism. We included a validated two-item neuroticism scale: 'I see myself as someone who… is relaxed, handles stress well' (reverse-coded) and 'I see myself as someone who… gets nervous easily'[27,54].

Political orientation. Participants answered the following questions on a Likert scale ranging from 1 (extremely liberal) to 9 (extremely conservative): 'In terms of economic issues, how liberal or conservative are you?', 'In terms of social and cultural issues, how liberal or conservative are you?' and 'Where on the following scale of political orientation would you place yourself?'

Pattern deviancy. We assessed participants' aversion in response to five images depicting non-social pattern deviancy (see Supplementary Methods for images). These images were taken from popular Buzzfeed.com articles presenting images depicting non-social pattern deviancy. For example, one of these articles was named: '31 things that will make any neat freak's eye twitch' (https://www.buzzfeed.com/erinchack/things-that-will-make-any-neat-freaks-eye-twitch?utm_term=.gjMkaOGJR#.xbwoO1jQY). Underneath each image, a prompt read 'The above image makes me…' followed by three statements assessing participants' discomfort, anxiousness, and annoyance in response to the image ('feel uncomfortable', 'feel anxious', and 'feel annoyed'). Participants answered on a Likert scale from 1 (not at all agree) to 7 (strongly agree). The images were presented in random order.

Social deviancy. Social deviancy aversion was measured identically to pattern deviancy aversion except that the images depicted deviant individuals (see Supplementary Methods for images). These images were validated as depicting socially deviant individuals in Supplementary Study 2.

Attention check items. We included a direct ('I was focused while filling out this survey') and indirect attention check item ('People vary in the amount they pay attention to these kinds of surveys… if you have read this question carefully, please write the word yes in the blank box below labeled other.'; see Supplementary Note for details). The same two attention check items were used as exclusion criteria in studies 2–6.

Procedure. Before beginning the study, participants gave informed consent (the same is true of all reported studies). Participants then completed the need-for-closure, neuroticism, and political orientation measures in random order. Thereafter, they completed the pattern and social deviancy measures in random order. Lastly, participants completed the attention check items and demographics (the same is true of studies 2–6). No consistent demographic effects were found across the reported studies (see Supplementary Note for details).

Study 2. *Participants.* A power analysis based on the findings of study 1 ($r = 0.38$) revealed that we needed to recruit 79 participants to have 95% power. We recruited 106 participants via Mechanical Turk (44 female; age: mean = 36.18, s.d. = 12.10). Eight participants were excluded for failing the attention check items.

Pattern deviancy. The five pattern deviancy images in study 1 were replaced with eight images depicting patterns of geometric shapes. We created these patterns in accordance with conceptualizations of pattern formation (based on repetition or rules) and pattern distortion (repetition or rule violation) in research on pattern recognition[55,56]. Specifically, after creating a pattern, we either distorted or transformed a shape in the pattern, for example, the type, size, or location of a shape, or did not alter the pattern. This methodology resulted in four images of patterns that were unbroken, for example, horizontally in-line geometric shapes or a collection of identical shapes, and four identical images except that the pattern was broken in some way, for example, a shape was shifted or a different shape was inserted (Fig. 1). We assessed participants' aversion in response to each of the unbroken and broken pattern images. Independent participants rated

the broken pattern images as more deviant than the unbroken pattern images in Supplementary Study 1 ($n = 42$).

We also measured participants' non-social pattern deviancy aversion via a written vignette. Participants reported their aversion towards the following situation: 'Imagine a collection of objects where all the objects are very similar to one-another… if one very different object is added to the collection then I would feel…'

Additional materials. The social deviancy measure and attention check items were as in study 1.

Procedure. Participants completed the pattern deviancy items, the written pattern deviancy item and the social deviancy items in random order (not blocked, all individual items presented in random order).

Study 3. *Participants.* We recruited 116 participants via Mechanical Turk (78 female; age: mean = 34.89, s.d. = 10.26) based on the power analysis used in study 2. Eight participants were excluded for failing the attention check items.

Belief in a dangerous world. We included the ten-item Belief in a Dangerous World scale (for example, 'Any day now chaos and anarchy could erupt around us. All signs are pointing to it')[28].

Behavioural inhibition system. We measured individuals' ability to regulate their negative affect in response to threatening stimuli via the seven-item Behavioural Inhibition System scale (for example, 'Even if something bad is about to happen to me, I rarely experience fear or nervousness')[29].

Tolerance of ambiguity. Ambiguity intolerance was measured using a standardized 13-item measure (for example, 'I don't tolerate ambiguous situations well')[30].

Pattern deviancy. The pattern deviancy measure in study 3 was that of study 2.

Social norm breakers. We measured participants' aversion towards fictional individuals who broke versus followed a social norm. Participants were told to 'Imagine a world inhabited by people known as Flurps. As long as anyone can remember, all the Flurps have lived in blue houses. Living in a blue house is an important part of Flurp tradition and culture.' Thereafter, participants were told, 'Imagine you come across a Flurp living in a green house. Remember, none of the other Flurps live in green houses. They all live in blue houses' and 'Imagine you come across a Flurp living in a blue house. Remember, all the Flurps live in blue houses.' Participants then reported their aversion towards the Flurp in each of these two scenarios by indicating their agreement to the statements 'This Flurp makes me feel uncomfortable', 'This Flurp makes me feel annoyed', and 'This Flurp makes me anxious' on a Likert scale from 1 (not at all agree) to 7 (strongly agree).

Statistically positive and negative societal outliers. We operationalized statistically positive and negative deviants as individuals holding attributes that most people aspire to have (wealth, intelligence, and a thin body) and not have (poverty, unintelligence, and being overweight). Specifically, we measured participants' aversion towards meeting someone either statistically above, at the exact level of or below the average intelligence quotient (IQ), income, and weight in the United States. For example, regarding IQ, participants read the following information: 'The average IQ in the United States ranges from 90 to 100.' The presented values were the actual average IQ, income, and weight (of women) in the United States in 2016. Thereafter, participants were told to imagine meeting a negatively deviant, average, and positively deviant individual: 'Please imagine you meet someone with an IQ of (50, 95 or 140, respectively). Remember the average IQ in the United States is around 90–100.' Participants then reported their aversion in response to each of these individuals (for example, 'This person makes me feel uncomfortable'). See Supplementary Methods for all materials.

Procedure. Participants completed the measures of ambiguity tolerance, belief in a dangerous world, behavioural inhibition system, pattern deviancy aversion, and social deviancy aversion in randomized order.

Study 4. *Participants.* A power analysis revealed that we needed 86 participants to have 95% power ($r = 0.42$; averaged effect sizes of studies 1, 2 and 3). We recruited 194 participants via Mechanical Turk (114 female; age: mean = 33.26, s.d. = 9.83) to account for participants failing to complete the IAT measures. Twenty-five participants were excluded for failing the attention check items. Twenty-nine additional participants were excluded for not completing either or both of the IAT measures or for receiving a non-calculable score, as determined by the revised IAT scoring algorithm[57], on one or both of the IAT measures.

Implicit pattern deviancy. An IAT was used to measure how much more strongly participants implicitly associate broken patterns (IAT label: 'Broken pattern') with negative words ('Negative') than unbroken patterns ('Unbroken pattern') with positive words ('Positive'). The negative words were agony, terrible, horrible, nasty, evil, awful, and failure. The positive words were joy, love, peace, wonderful, pleasure, glorious, and happiness. The broken and unbroken pattern images were those of studies 2 and 3.

Implicit social deviancy. The social deviancy IAT was identical to the pattern deviancy IAT except that the social deviancy labels were 'Stigmatized people' and 'Non-stigmatized people'. The stigmatized people images were the five social deviancy images included in studies 1 and 2. The non-stigmatized people images were images of five control individuals who, in Supplementary Study 2 ($n = 52$), were classified as less deviant than the deviant individuals (see Supplementary Methods for images).

Procedure. Participants completed the two IAT measures in randomized order.

Study 5. *Participants.* A power analysis revealed that we needed 86 participants to have 95% power ($r = 0.37$; averaged effect sizes of studies 1–4). To accurately estimate the effect size of the relationship between pattern and social deviancy aversion in a Chinese sample, however, we recruited 212 participants via Sojump—a Chinese data collection programme (107 female; age: mean = 33.00, s.d. = 6.46). Participants were residing in China. Regarding ethnicity, 98.5% identified as Han Chinese and 1.5% identified as a Chinese minority (non-Han). Fifteen participants were excluded for failing the attention check items.

Pattern deviancy. The pattern deviancy measure was identical to study 2 except it had been translated to Mandarin by a native speaker.

Social deviancy. The social deviancy measure was identical to study 2 except it had been translated to Mandarin and also included the control faces used in study 4.

Procedure. Participants completed the pattern and social deviancy items in random (pre-assigned) order. This random order was the same for all participants due to the limitations of the Sojump software.

Study 6. *Participants.* A power analysis revealed that we needed 90 participants to have 95% power ($r = .36$; meta-analytical estimate calculated before the inclusion of this study in the meta-analysis). We recruited 208 participants via Mechanical Turk (116 female; age: mean = 34.71, s.d. = 10.63) given the high exclusion rate in study 4, which also included an IAT measure. Fifty-three participants were excluded for failing to complete the race IAT or for receiving a non-calculable score[58]. Seventeen additional participants were excluded for failing the attention check items.

Pattern deviancy. We measured participants' aversion towards ten images depicting broken and unbroken patterns of geometric shapes. Under each broken and unbroken pattern image was a prompt that read, 'The above image makes me…' followed by four statements ('feel anxious', 'feel annoyed', 'feel secure', and 'feel calm'), which participants answered on a Likert scale from 1 (not at all agree) to 7 (strongly agree). We included the secure and calm questions to include reverse coded items to reduce response bias. We also measured participants' attitudes towards the pattern images. Participants responded to each image: 'I like the above image' and 'I dislike the above image' and reported how much they liked and disliked the specific geometric shape that was causing the pattern distortion in the broken patterns (and the identical shape in the unbroken patterns). For example, participants responded to the items: 'I like the triangle that is three triangles from the right' and 'I dislike the triangle that is three triangles from the right'. Given that these specific items would have been difficult to create for the spiral and dots pattern images used in studies 2–5, we replaced these images with ones similar to the row of triangles. All images were presented in random order.

Implicit racial prejudice. Participants' implicit negative associations towards Black individuals were measured using an IAT. This IAT was the same as in study 4 except it included images of Black and White individuals and the IAT labels were changed to 'Black' and 'White'.

Explicit racial prejudice. Participants' explicit prejudice towards Black individuals was measured using the symbolic racism scale[58]. The scale consists of eight items (for example, 'It's really a matter of some people not trying hard enough; if Blacks would only try harder they could be just as well off as Whites'), which were scored using the Likert scale from 1 (strongly disagree) to 4 (strongly agree). Because individuals often self-regulate their explicit racial prejudice, we also included an item measuring participants' self-reported efforts to not discriminate ('I am very careful not to discriminate against other people'), which was scored on a Likert scale of 1 (strongly disagree) to 7 (strongly agree).

Procedure. Participants completed the symbolic racism scale, pattern deviancy measure, and race IAT in the aforementioned order.

Meta-analysis. *Materials.* Eight studies were included in the meta-analysis: studies 1–6, Supplementary Study 3, and Supplementary Study 4—a study that failed to observe a relationship between pattern deviancy and social deviancy judgements.

We included this null finding in the meta-analysis to provide a more accurate effect size estimate and to reduce potential 'file-drawer' bias (the exclusion of null findings from published papers)[59].

Meta-analytical approach. We conducted two meta-analyses: a fixed-effect model and a random-effects model[60]. In performing these analyses, we followed meta-analytical methods recommended for 'mini' meta-analyses within a single paper[61]. See Supplementary Note for details.

Study 7a. *Participants.* A stopping rule was used for data collection in study 7a: the number of three and four year olds that visited a developmental psychology laboratory in a northeastern university throughout the summer of 2016. The study included 40 three and four year olds (20 female; age: mean = 3.95, s.d. = 0.49).

Pattern deviancy. Two matched pairs of broken and unbroken pattern images (triangle and circle pairs from studies 2–5) were presented in randomized order and shown to children in a vertical format on a sheet of paper. Which image was located above the other was randomized. The experimenter read the following for each image: 'Here's a picture—which one do you like more? This one or this one.'

Study 7b. Study 7b was analogous to study 7a except it included a continuous measure of pattern deviancy aversion and was conducted with four to six year olds.

Participants. The stopping rule in study 7b was the number of children in junior kindergarten and kindergarten whose parents completed informed consent at a private school in New York City. Participants ($n = 25$; 12 female) were between four and six years old (mean = 4.92, s.d. = 0.58).

Pattern deviancy. The pattern deviancy measure was that of study 7a, except for three changes. First, we replaced the unbroken and broken pattern images with those of studies 2–5 that were not used in study 7a. Second, the images were presented individually rather than in a forced choice format. Third, children's pattern deviancy judgements were assessed using a continuous measure. For each picture, the experimenter asked: 'Do you like this picture?' Children answered 'Yes' or 'No' and were then asked to indicate on a three-point scale (1 = a teeny tiny bit, 2 = a little bit, 3 = a lot) how much they liked (or did not like) the picture.

Study 8. *Participants.* A power analysis revealed that we needed approximately 54 participants to have 95% power. This power analysis was based on an earlier, incorrect effect size estimation of the average effect size of studies 1–5 ($r = 0.45$). However, as this power analysis was conducted a priori, we report the original estimate here. We recruited children ranging from four to ten years old as we wished to examine developmental differences. Sixty-nine participants (32 female; age: mean = 7.03, s.d. = 1.53) were recruited in a New York City park and at a museum near a northeastern university. Three participants were excluded when their birthdays revealed they were actually over ten years old. Two participants were excluded for failing the comprehension check items (although including these participants did not change the results).

Pattern deviancy. The pattern deviancy measure included the items of study 7a. These items were presented in the format of study 7b (continuous measure).

Social deviancy. The social deviancy measure assessed dislike of social norm breakers. We chose to assess dislike of social deviancy in this way because even young children express an understanding of—and spontaneously infer—social norms[13,35]. Specifically, we chose to examine gender social norms. However, because children's judgements about how boys and girls act differs with age[62–64], we chose to flip what are considered typical gender norms (for example, children were told that boys in a school wear pink bows and dance ballet). This manipulation allowed us to measure dislike of situational deviancy (an act labelled as deviant in a specific situation) rather than, as measured in studies 1–6, societal deviance (deviance widely perceived by society)[65]. To create the instituted, situational social norm, we relied on a rule-based manipulation: young children follow rule manipulations in social and moral norm tasks[66]. Our manipulation was successful. Children disliked boys and girls who broke the instituted social norm; that is, they disliked boys who wore blue baseball caps and played football and girls who wore pink bows and danced ballet.

Children were told about an imaginary school: the Tam School. At this school, the teacher—Mrs Taylor—made the rules and all of the students liked Mrs Taylor. Mrs Taylor said that boys should wear pink bows in their hair and do ballet, whereas girls should wear blue baseball caps and play football. We also informed participants that the boys and girls at the Tam School were very happy and that most children followed Mrs Taylor's rule.

To ensure that all participants understood the flipped gender social norm, we included comprehension checks. The experimenter asked children two questions after hearing the story: (1) 'Who at the Tam School plays football and wears blue baseball caps?' (with the answers 'Girls' or 'Boys') and (2) 'Who dances ballet and wears pink bows?' (with the answers 'Girls' or 'Boys'). These two questions were randomized.

Thereafter, participants were told about four children who go to the Tam School. Two of these children—a girl and a boy—followed the social norm. Two other children, however—again a girl and a boy—did not follow the social norm. Participants were asked whether they liked each of these children (with the answers 'Yes!' and 'No!'). If they responded yes (no), they were then asked how much they liked (did not like) the child (1 = a teeny tiny bit, 2 = a little bit, 3 = a lot).

Procedure. Children completed the pattern deviancy measure and then the social deviancy measure.

Life Sciences Reporting Summary. Further information on experimental design is available in the Life Sciences Reporting Summary.

Data availability. The datasets of the presented studies are available from the corresponding author on request.

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Author contributions

A.G. developed the study concept and design. Testing and data collection were performed by A.G., J.M. and Y.W. under the supervision of J.A.B. A.G. completed the data analysis and interpretation. A.G. and J.M. drafted the paper and J.A.B. provided critical revisions. All authors approved the final version of the paper for submission.

Competing interests

The authors declare no competing interests.

Additional information

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Experimental design

1. Sample size

Describe how sample size was determined.

Sample sizes for Studies 1 through 6 and Study 8 were determined by conducting a-priori power-analyses using GPower 3.0. All these studies were sufficiently powered. A stopping rule was instituted regarding the sample sizes of Studies 7a and 7b.

2. Data exclusions

Describe any data exclusions.

Participants in Studies 1 through 6 were excluded if they failed one or both of our attention check items. No participants were excluded in Studies 7a and 7b. Two participants were excluded in Study 8 for failing a comprehension check. Three further participants were excluded for falling outside of the specified age-range.

3. Replication

Describe whether the experimental findings were reliably reproduced.

The observed relationship between pattern deviancy and social deviancy aversion was conceptually replicated across Studies 1 through 6 and Study 8. Studies 7a and 7b did not assess this relationship.

4. Randomization

Describe how samples/organisms/participants were allocated into experimental groups.

There were no experimental groups because the current research was correlational. However, we made sure that the measures presented to participants were randomized in numerous different ways across the studies.

5. Blinding

Describe whether the investigators were blinded to group allocation during data collection and/or analysis.

Blinding was not relevant because there was no group allocation.

Note: all studies involving animals and/or human research participants must disclose whether blinding and randomization were used.

6. Statistical parameters

For all figures and tables that use statistical methods, confirm that the following items are present in relevant figure legends (or in the Methods section if additional space is needed).

n/a	Confirmed
☐	☒ The exact sample size (*n*) for each experimental group/condition, given as a discrete number and unit of measurement (animals, litters, cultures, etc.)
☐	☒ A description of how samples were collected, noting whether measurements were taken from distinct samples or whether the same sample was measured repeatedly
☐	☒ A statement indicating how many times each experiment was replicated
☐	☒ The statistical test(s) used and whether they are one- or two-sided (note: only common tests should be described solely by name; more complex techniques should be described in the Methods section)
☐	☒ A description of any assumptions or corrections, such as an adjustment for multiple comparisons
☐	☒ The test results (e.g. *P* values) given as exact values whenever possible and with confidence intervals noted
☐	☒ A clear description of statistics including central tendency (e.g. median, mean) and variation (e.g. standard deviation, interquartile range)
☐	☒ Clearly defined error bars

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Software

Policy information about availability of computer code

7. Software

Describe the software used to analyze the data in this study.

SPSS and R

For manuscripts utilizing custom algorithms or software that are central to the paper but not yet described in the published literature, software must be made available to editors and reviewers upon request. We strongly encourage code deposition in a community repository (e.g. GitHub). *Nature Methods* guidance for providing algorithms and software for publication provides further information on this topic.

Materials and reagents

Policy information about availability of materials

8. Materials availability

Indicate whether there are restrictions on availability of unique materials or if these materials are only available for distribution by a for-profit company.

There are no restrictions on the availability of the materials. The materials are readily available from the authors.

9. Antibodies

Describe the antibodies used and how they were validated for use in the system under study (i.e. assay and species).

N/A

10. Eukaryotic cell lines

a. State the source of each eukaryotic cell line used.

N/A

b. Describe the method of cell line authentication used.

N/A

c. Report whether the cell lines were tested for mycoplasma contamination.

N/A

d. If any of the cell lines used are listed in the database of commonly misidentified cell lines maintained by ICLAC, provide a scientific rationale for their use.

N/A

Animals and human research participants

Policy information about studies involving animals; when reporting animal research, follow the ARRIVE guidelines

11. Description of research animals

Provide details on animals and/or animal-derived materials used in the study.

N/A

Policy information about studies involving human research participants

12. Description of human research participants

Describe the covariate-relevant population characteristics of the human research participants.	All relevant information on the human research participants included (e.g., demographics) can be found in the Main Text and Supplements.