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Journal of Sociology 1985; 21; 431
DOI: 10.1177/144078338502100307

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ABSTRACT

This paper is concerned to illustrate a general theorem, that purely individual rational behaviour can produce aggregate social outcomes consistent with, perhaps even suggestive of, concerted collective action and discrimination. It is a formal, even formalistic, analysis and not the results of any empirical investigation, although these formal models are useful in understanding certain aspects of more complex social processes. To focus the discussion, I draw upon two areas that have in fact been the subject of considerable empirical research: residential segregation between racial groups, and gender segregation in the occupational structure. I discuss a restricted class of phenomena, amenable to rational choice theory, to demonstrate how actions which are rational at the individual level produce aggregate outcomes far more extreme than anyone intended or desired. A major implication of the analysis is that in order to realise more optimal outcomes the private actions of individuals need to brought into harmony through coordinated and collective action.

SIMULATED MODELS OF GROUP SEGREGATION

This paper is concerned to illustrate a general theorem, that purely individual rational behaviour can produce aggregate social outcomes consistent with, perhaps even suggestive of, concerted collective action and discrimination. It is a formal, even formalistic, analysis and not the results of any empirical investigation, although these formal models are useful in understanding certain aspects of more complex social processes.

To focus the present discussion, I draw upon two areas that have in fact been the subject of considerable empirical research: residential segregation between racial groups, and gender segregation in the occupational structure. I discuss a restricted class of phenomena, amenable to rational choice theory, to demonstrate how actions which may be quite rational at the individual level produce aggregate

outcomes far more extreme than anyone intended or desired. Moreover, these outcomes may give rise, *ex post facto*, to a not unreasonable suspicion that they resulted from coordinated rather than from uncoordinated actions. This class of problems is illustrated in a recent collection by Barry and Hardin, *Rational Man and Irrational Society* (1982). The discussion is primarily an exposition of arguments fairly well-known among economists but less well-known among sociologists, for whom some model of non-rational or irrational behaviour (for example, false consciousness) is more often invoked to explain social processes. Indeed, earlier this century Pareto invoked the demarcation line between rational and non-rational behaviour to distinguish market systems from social systems, and indeed economics from sociology (Fletcher, 1971, 585-9).

What follows borrows more from the so-called "charity principle" of economic theory, which assumes that behaviour is rational until proven otherwise. This use of rationality involves the two standard notions: first, consistency; and second, the choice of means appropriate to given ends, whatever they might be. Given those ends, and given the existence of one or another means of achieving them, it would not be rational (if I am to act consistently) to select a means known to be ineffective in achieving the ends in question. For example, if I wanted to get from Canberra to Sydney in the late afternoon, it would be rational to catch Ansett's Flight 366 rather than Flight 397, since, although the latter leaves fifteen minutes earlier, it happens to go to Melbourne. As the Chesire Cat remarked to Alice, if you don't mind where you end up, it does not matter in which direction you choose to go. But if you do mind, then means-end rationality is an appropriate strategy.

The paper is in two sections, each illustrating a different principle. The two sections are connected by an interest in segregation and by a simplicity in the underlying models used to explore segregation. The simulations are deliberately very simple, for two reasons. The first is practical: for purposes of exposition (and this is largely an expository paper), it is useful to restrict oneself to simple models, even though they do not incorporate all the complexity present in real-world situations. The second reason is more substantive: by simulating a simple model one can gain progressive insight into social processes by moving from the simple to the more complex. Moreover, one is able to test component parts of a more complex model for logical consistency and empirical plausibility before integrating the parts into a more complex whole (1).

RESIDENTIAL SEGREGATION

Over the past decade an economist, Thomas Schelling, has made a number of imaginative contributions to the analysis of sifting and sorting processes in human society — entirely without, I might add, the aid of an electronic computer. One of his earlier and lengthier discussions appeared in 1971, in the first volume of the *Journal of Mathematical Sociology*, and his collected writings on these and related issues have since been published in book form in 1978, under the title *Micromotives and Macrobehaviour*. Daniel Bell, in a recent overview of the social sciences in the United States since the second world war, singles out Schelling's general contribution in this area, notably Schelling's dictum that ". . . societal outcomes, when they are the sum total of interactive individuals, often lead to outcomes which none of the individuals desires" (Bell, 1982, 82). In exploring this assertion further I employ a computer simulation of Schelling's 1971 argument (2), and draw upon and extend a similar simulation recently published by Dethlefsen and Moody (1982).

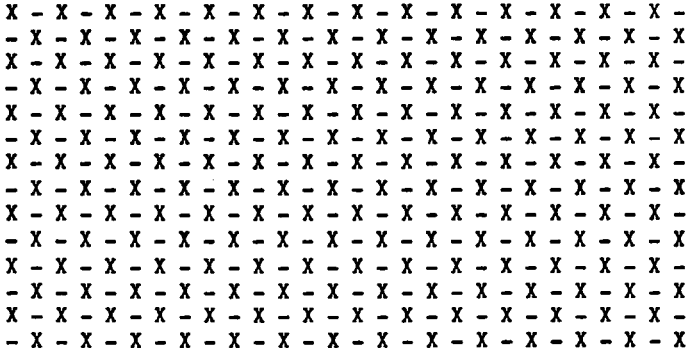
The mode of analysis itself is quite abstract, in the sense that the general logic can be applied to other situations involving two groups. The model requires that there should be two recognisable groups (e.g. skin colour groups such as blacks and whites; age groups, such as young and old; occupational groups, such as blue-collar and white-collar; gender categories; speech communities; and so on). In short we require only that a population can be exhaustively and visibly classified into one or the other category. Therefore, any "us versus them" dichotomy will suffice, be it women and men, core and periphery, insiders and outsiders, bourgeoisie and proletariat, or elite and mass — that is, any of those binary oppositions that we meet so often in the social sciences. It should go without saying that, even if only one of the two groups can be unambiguously defined by a clear membership criterion, the second group can be uniquely defined as its residue. The simple biblical injunction applies: if you are not with me, you are against me.

For simplicity of exposition we specify a residential neighbourhood populated by two racial groups: blacks and whites. We assume that they have certain preferences about who their neighbours are, preferences which in turn imply social, economic and cultural differences on which those preferences are based. But the essential premise is simply the existence of a preference for being with one's own kind, however "one's own kind" is defined. We are not, in this class of models, concerned with how such preferences come about in the first place, only with their existence in the here-and-now. The focus of attention is thus on the *re*production and not on the produc-

tion of group differences, and with this statement I imagine that I have lost the interest, if ever interest there was, of those concerned only with original sin, with so-called basic causes of the human condition as we know it. However, I simply reiterate that this discussion does not deal with all possible causes of segregation, only with one class of possible causes. I most readily concede that there are more important causes of segregation, including organized discrimination and economic inequality, the first having important implications for civil rights and the second important implications for social justice. While the present focus is on a third class of processes which for most times and places have certainly been less important than either organized discrimination or economic inequalities as causes of segregation. I, like Schelling (and the preceding passage draws heavily on his exposition), believe that this third class of processes — the uncoordinated rational behaviours of individuals and their aggregate outcomes — needs to be understood.

The initial conditions required by this simplified model are, then, that two identifiable groups exist, and that each has some specifiable set of preferences for living with their own kind as neighbours. We define, arbitrarily, a local neighbourhood as the immediate neighbours of any householder, that is, the eight dwellings abutting the reference dwelling in a residential grid. We could of course widen this definition, but that would not affect the essential logic of the model, although it would inform us about some of its dynamic properties. We can also vary the absolute size of the neighbourhood (small, medium, or large), the relative proportions of the two groups, and their preference sets (however, preferences are assumed to be reciprocal: if blacks want five of their neighbours to be blacks, then whites want five of their neighbours to be white; and so on). Let us explore such a simplified model to see what kinds of aggregate outcomes arise as a result of varying three basic parameters of the model (neighbourhood size, preferences, and relative group size).

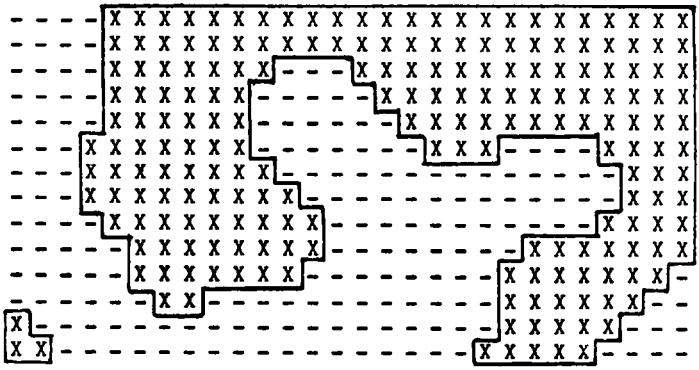
First we assume that the two groups are equal in size, that the neighbourhood is perfectly integrated, and that each group is content provided that they are not in a minority in their immediate locality. We define perfect integration with this eight neighbour scheme as alternating dwellings occupied by a black or white householder. This formulation satisfies the assumption that everyone wants a local neighbourhood in which they are not a minority: in each locality each black has precisely four black neighbours, just as each white has precisely four white neighbours. The only exception to this rule is around the perimeter, since each corner has only three neighbours and each dwelling along the edge has only five. In these locations householders will be content if, counting themselves, they are not in a



(Initial Planned Integrated Neighbourhood)

Initial Neighbourhood Characteristics:

PERCENT WHITE (X) IS	50
THE INTEGRATION INDEX IS	51
THE UTILITY INDEX IS	100.0
THE AVERAGE NO. OF UNLIKE NEIGHBOURS IS	3.8



(Final Segregated Pattern After Eight Moving Out/In Cycles)

Final Neighbourhood Characteristics:

PERCENT WHITE (X) IS	53
THE INTEGRATION INDEX IS	13
THE UTILITY INDEX IS	100.0
THE AVERAGE NO. OF UNLIKE NEIGHBOURS IS	1.0

Figure 1 Initial and Final Neighbourhood Patterns, Using Schelling's Deterministic Model.

minority. Otherwise, they will move out. The upper part of Figure 1 illustrates the pattern for a medium sized neighbourhood.

We now subject this utopian neighbourhood to a social process: some residents move out of the neighbourhood. We assume that over a year or two 10 per cent of householders move, perhaps because of a job change, perhaps because of a change in family composition or income. For the purposes of simulation, we move this proportion of residents randomly and instantaneously. Newcomers, with precisely the same preferences as those who left, inspect each vacancy. If a member of either race would be happy, a white or a black is assigned randomly. If neither would be happy it remains vacant. If only a black would be happy, a black householder moves in. And if only a white would be happy, then a white householder moves in. In principle, of course, each mover could be replaced by a person of the same race, in which event the neighbourhood would remain in integrated equilibrium. But that, statistically, is a very unlikely outcome. What is almost certain to happen is that some incoming residents will be of a different race from those who left, and their presence will set in motion a cumulative cycle of dissatisfaction among the other residents. So they in turn will move, the ripple of dissatisfaction will grow, and ultimately the neighbourhood will become almost entirely segregated.

Because the simulation depends on random processes, we need to run numerous trials, varying the initial random moves. A series of trials gives a range of results, and we are interested both in the range and in the average tendency. Numerous trials have been run for all three neighbourhood sizes: small, with about 100 dwellings; medium, with around 400; and large, with almost 900 dwellings. With one exception the average tendencies hold across different sized neighbourhoods. The exception is that the final relative propositions of each race oscillates over a wider range in small and, to a lesser degree, medium sized neighbourhoods, because the smaller the neighbourhood the larger is the proportion accounted for by the perimeter, and the rules for moves are slightly different for those residents. Over a series of trials in which the relative proportions of blacks and whites are initially set at 50:50, the final proportions mostly lie somewhere in the range of 45 to 55 per cent. However, as already indicated, the range is much wider in small neighbourhoods. In a few trials one group came to dominate the whole territory. But the important result is that the degree of integration inexorably declines, despite the fact that individual preferences remain unchanged. Whereas everyone would be happy if half their neighbours, but no more, belonged to a different race, a small random shock triggers a cumulative process in which individuals seeking only to satisfy their

preference not to be in a local minority produce a highly segregated neighbourhood. The aggregate outcome is a degree of segregation four to five times higher than all individuals would in fact tolerate.

The bottom part of Figure 1 gives a typical result. The integration index is initially at a maximum of 50 per cent, indicating that half of all possible neighbours are of a different race from any reference householder. Except for the edges and corners, every black and every white has four neighbours who are of the same race, and four who are different. But as a result of a small proportion of residents moving out, this index ultimately falls dramatically to only 13 per cent. Similarly, the average number of dissimilar neighbours drops from almost four (it is not exactly four because around the perimeter residents do not have eight neighbours) to around one, or only one-quarter the number that any individual would tolerate. Note, however, that the utility index does not differ, a finding discussed in more detail below (residents have a utility of one if they are not in a local minority, and zero if they are. Both neighbourhoods shown in Figure 1 are in stable equilibrium, since no-one is in a local minority).

These simulations suggest a number of empirical generalisations. The first is one just mentioned: individuals, pursuing their own value for living in a locality where they do not constitute a racial minority, produce an aggregate outcome that is sub-optimal. Whereas everyone would be just as happy living in an integrated setting, the uncoordinated pursuit of individual interests produces a massive trend towards segregation. Second, as the relative sizes of the two groups diverges from 50:50, the degree of segregation must increase, because there are too few of the minority group to share around. The minority becomes more segregated from the majority as it becomes smaller relative to the majority. Third, the more demanding either group is for neighbours of the same race, the more rapid is the spiral towards extreme segregation. Specifically, when the joint demands of both groups exceeds 100 per cent (that is, when both groups demand to be a local *majority*), almost total segregation is the inevitable result, even when both groups are equal in size at the outset. In most real life situations, of course, the minority is substantially smaller than the majority in the society as a whole, and then the movement to segregation is rapid and extreme.

Doubtless there are other generalisations that could be made by varying systematically other features of neighbourhoods and groups, but perhaps it is more appropriate to summarise the conclusions so far. The first is that even under these simplest of circumstances, individuals pursuing their own self-interest, in the absence of mutual coordination, will reliably produce a collective outcome that no individual intended or sought, an outcome, moreover, that is sub-

optimal in terms of the maximum integration each group would tolerate. The "invisible hand" is not only unseen but it is also unseeing: an initially integrated neighbourhood, once disturbed, cannot recover its initial equilibrium. Second, the simulations expose as simplistic any notion that conflict between groups is a necessary condition for large-scale social change. One need go no further than a newspaper report (*Canberra Times*, 30 May 1983) for an example of this kind of fallacy. The report is of a talk given by Professor Ronald Sackville, Chairman of the New South Wales Law Reform Commission, and was headlined: "Hawke theory of consensus sinister". Sackville was reported as saying: "the pursuit of consensus is a recipe for maintaining the *status quo*. He said that conflict was necessary if there was to be change". But as the segregation simulations demonstrate, chance factors can be quite effective in disturbing the *status quo* and in provoking large-scale cumulative change. Thirdly, these simple models emphasise the point that without coordination the rational pursuit of individual interests can produce outcomes that are undesirable from a collective point of view.

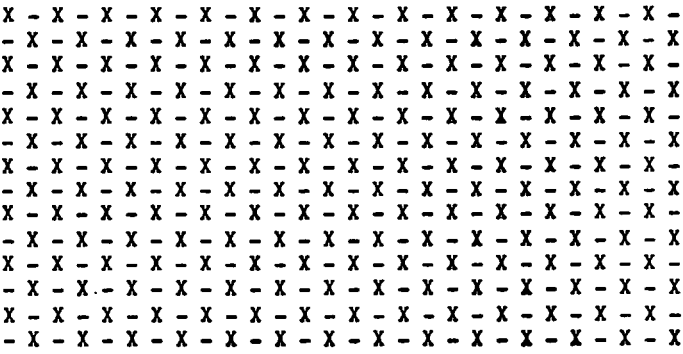
This notion of "undesirable from a collective point of view" needs further elaboration, because it leads to a modification of this Schelling model (3). The reason that this model produces such extreme results is that his actors have one goal, and one goal only: they seek merely to avoid minority status. They do not in fact care if, in avoiding minority status, they produce integration *or* segregation. They *tolerate* integration if that happens to come about, but they do not *seek* integration as a personal value. Even if they start from an integrated situation, once that situation is disturbed they see no value in recapturing it, although there is a remote chance that it might re-occur "naturally". In this sense this Schelling model is a rational choice version of original sin: once the State of Nature (in this case, integration) has been disturbed, these morally deficient individuals cannot reconstruct it.

We can appreciate more readily why these individuals are "deficient" if we recast the analysis in terms of individual utility. In the model just analysed, all householders have maximum utility if, and only if, they are not in a local minority. But once they find themselves in a minority status, their utility is zero and they move until they find a locality where their utility is again maximised. They are indifferent to any other outcomes that might be produced as a by-product of their goal-seeking behaviour, and they are as tolerant of integration as they are of segregation. Their utility is at a maximum whether half of (or indeed *all* of) their neighbours belong to the same race, and they make no distinction between these two very different states of affairs. Schelling's myopic actors do not carry about with them any internal-

ised "collective" value in favour of integration, with the result that, even though they are not particularly prejudiced *against* persons of a different race, they are not disposed actively to seek their company. So even if we start from a utopian integrated neighbourhood, once it is disturbed there is only the remotest chance that it could ever be reconstituted, at least under these assumptions. This myopia of Schelling's actors is the reason why the utilities indices are the same for both the neighbourhoods shown in Figure 1, even though one is integrated and the other is highly segregated.

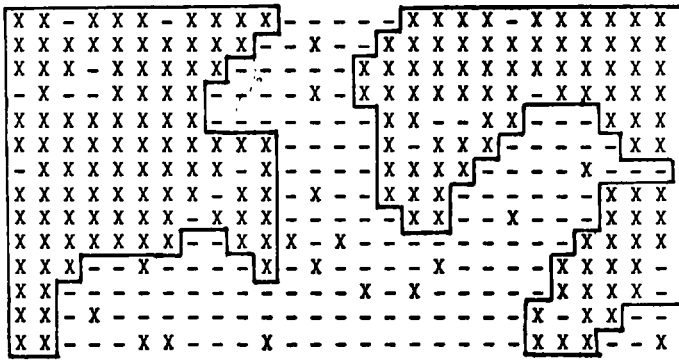
We can, however, relax Schelling's conditions by building into the model less restrictive assumptions. We can, for example, substitute probabilistic preferences for deterministic ones, making it less certain that residents will move when they find themselves in a minority status, and we can also give them a preference for integration (4). That is to say, we can allow residents to seek a specific degree of racial heterogeneity among their neighbours by assuming some dislike of total segregation. Even under these relaxed assumptions, however, the results are generally similar, although less extreme. Provided only that the preference for similar neighbours outweighs the preference for dissimilar neighbours, the collective outcome, in the absence of coordination or cooperation, will always be greater segregation than any individual intended or desired.

The difference between the ideal and the real can be made as large or as small as desired, depending on how we choose to balance individual preferences for integration and against segregation. In the Schelling model, there is no protection against segregation: there is no explicit utility gained by living in an integrated neighbourhood, merely an aversion for being in minority status. But if integration is a collective value, then it should be internalised in the value systems of at least some people in the society. My modification of the Schelling model incorporates such an assumption into individual behaviour. As a consequence, the ultimate degree of segregation is not so extreme, but the neighbourhood is never in stable equilibrium (because nobody is ever totally content). Even on these relaxed assumptions, the degree of segregation produced is considerably greater than that required by individual preferences. However, whereas in the Schelling model there is no decrease in subjective utility between the initial and the final residential pattern, in the modified model there is indeed a significant decrease in utility. But while integration is individually preferred to segregation, individual action cannot achieve the maximum utility obtainable. In other words, Schelling's general conclusion stands, and only through coordination could a better outcome be secured.



(Initial Planning Integrated Neighbourhood)

PERCENT WHITE (X) IS	50
THE INTEGRATION INDEX IS	51
THE UTILITY INDEX IS	95.0
THE AVERAGE NO. OF UNLIKE NEIGHBOURS IS	3.8



(Final Partially Segregated Pattern After Twelve Cycles)

PERCENT WHITE (X) IS	56
THE INTEGRATION INDEX IS	27
THE UTILITY INDEX IS	77.5
THE AVERAGE NO. OF UNLIKE NEIGHBOURS IS	2.0

Figure 2 Initial and Final Neighbourhood Patterns, Using A Modified Probabilistic Model

OCCUPATIONAL SEGREGATION BY GENDER

The logic of simulation can be used to explore other kinds of segregated outcomes, such as gender segregation in the labour force. This model makes somewhat different initial assumptions from the residential segregation model but is similar in making few of them. We posit two groups, young women and young men training to enter the labour market. We omit all reference to prospective employers, thereby eliminating employer discrimination from the model. We similarly omit all reference to potential co-workers, so that co-worker discrimination is eliminated. The simulation results reflect only the operation of training choices. The question of how those choices are made is not explained by the model, which focusses rather on how far differences in choices are implicated in the reproduction of gender segregation in the labour force. Obviously, a full explanation requires prior analysis of how choices are made and of the constraints that operate to channel young workers into training programs. But as in the previous simulation, we start from the existence of such differences. Real-world bases for developing such a model can be found in several sources. I cite just two, a recent American study of the expectations of high school seniors, and an Australian study of apprenticeship applications.

According to the American study, about three in every four girls rated as "important", for a job they would prefer to enter, the fact that it involved ". . . meeting and working with sociable and friendly people", compared with only three in every five boys. On the other hand, twice as many boys as girls rated as a "very important" life goal that of ". . . having lots of money" (National Center for Education Statistics, 1982, 24-5). The Australian study documents the well-known fact that very few girls compared with boys apply for apprenticeship training: according to figures for New South Wales in 1981–2, only 8 per cent of all apprenticeship applications were from girls, and in three out of every four of those cases the application was to enter ladies' hairdressing (Foster, 1984, 18).

The model that follows simply explores the implications of such different attitudes and choices. We translate preferences into worker requirements, in terms of the sort of aptitudes, skills, and interests that different jobs involve, in this case the degree to which particular jobs do, or do not, require a significant degree of involvement with Data, People, or Things (Broom et al., 1977, Chapter 7). We then model different combinations of preferences among young women and young men in terms of their preparation and training for the world of paid work. The question posed is simply: of every 100 persons training to enter the labour market, how many of those preparing for a job which

has a significant degree of involvement with Data will be girls, and how many will be boys? In other words, the question invites an answer as to how presumed differences in tastes affect occupational preferences. While this language is voluntaristic, there is no necessary implication that choices are freely made. Obviously, occupational choices are heavily conditioned by wider social conventions and restrictions, but an analysis of such constraints is not the present focus.

The next step is to ask the same question in relation to tastes for jobs with significant degrees of involvement with People and with Things. Dichotomising each of these three workers requirements we derive an eight-fold typology, the last cell of which is a null category: there are no jobs which do not have some worker requirements, be it so humble as mere physical strength. Of course, for many prospective entrants to the labour market there are no jobs, so that this "empty" category can also be seen as "occupied" by unemployed youth. The present simulation is restricted only to those with jobs, and therefore approximates a supply-side analysis. The model can be extended to consider the demand side as well, by imposing restrictions on the kinds of jobs that are available to be filled by new entrants to the labour market, by making assumptions about the rate and direction of occupational change, and by treating the eighth (null) category of the typology as an unemployment pool.

The conclusions to be drawn from such a simulation are scarcely startling, but they are more extreme than one might intuitively guess. One obvious inference is that only when there are no differences in training decisions between young women and young men will there be no occupational segregation. But once we introduce even quite small gender differences in training decisions, a significant degree of occupa-

Table 1 Distribution of the Australian Labour Force, 1971 Census, Classified According to Worker Requirements

Worker Requirements*	Males	Females	Persons
Data, People, and Things	1.5	1.6	1.5
Data and People Only	21.2	30.0	24.0
Data and Things Only	33.1	8.9	25.4
Data Only	11.6	30.1	17.5
People and Things Only	0.8	1.9	1.2
People Only	2.1	7.7	3.9
Things Only	29.7	19.8	26.5
N in 000s (100%)	3,350	1,569	4,919

* A worker requirement is shown if the job has a significant involvement with Data, People, or Things. That is to say, the first category contains jobs with with a significant involvement with all three requirements, while the last category contains jobs with only a significant involvement with Things. See Broom et al., 1977: Chapter 7.

tional segregation results. The simulation program allows the user to experiment with more or less extreme assumptions (5).

The rest is a matter of simple logic. At the time of the 1971 Census of Australia, the Index of Dissimilarity between the occupational distributions of men and women was 34 per cent, as measured in terms of the seven-cell typology described above (see Table 1). That is to say, one in three workers would have needed to change job type to equalise the occupational distributions of Australian women and men. We can simulate this degree of dissimilarity using the following assumptions. First, assume that women have a stronger preference than men for working with people, such that 65 out of every 100 trainees for jobs with a significant involvement with people are women. Second, assume that women have a mild distaste for working with data (45 of every 100 trainees are women, and 55 are men). Finally, assume that men have a stronger preference for working with things (of every 100 trainees for a job with a significant involvement with things, 60 will be men and only 40 will be women). The interplay of these differences is sufficient to generate the degree of occupational segregation that actually characterised the Australian labour force at the beginning of the 1970s.

The important conclusion to be drawn from this example is not that this particular combination of differences represents the actual social processes that produced occupational segregation. The historical record provides abundant evidence about the role of direct as well as indirect discrimination affecting the range of jobs effectively open to women and to men. The point is more formal: provided only that we allow the possibility that the members of different social categories develop and act upon diffferent tastes and preferences, segregation between categories will result. Equally importantly, we cannot infer from the segregated outcome alone, just as we could not in the residential segregation example, the processes that produced it. In the residential choice example, the segregated outcome arose purely from the uncoordinated actions of individuals, although it was consistent with collusive, and discriminatory, behaviour as well. Similarly in the occupational example, the segregated outcome is consistent with discrimination by employers although the model involves no such behaviour. Of course, the different training choices of women and men might well result from *prior* discrimination in terms of private intentions, generate collective outcomes which most would regard as socially undesirable. A major implication is, therefore, that to achieve more optimal outcomes the private actions of individuals need to be brought into greater harmony through coordinated and collective action.

NOTES

1. A longer term aim is to use simulation techniques as a means of exploring the stability of different models of social processes, by estimating models of, say, the stratification order, and then introducing systematic and random changes to some of its features, to explore consequences for substance and theory. In addition to such sensitivity analyses, simulation can also serve as a proxy for experimentation, as a way of answering "what if" questions about the future and "what if" counterfactuals about the past.
2. Copies of the program are available on request from the author. It is written in MBASIC for implementation on an Osborne 1, and can be used for interactive teaching and learning. The less general program by Dethlefsen and Moody was implemented on an Apple (to judge from the screen control commands).
3. I should emphasise that Schelling deals with a wide range of segregation models and not just the one discussed here.
4. In the modified model the probabilities for staying and moving have a maximum of 0.95 and a minimum of 0.05, and vary according to how many neighbours are of a different race. The probabilities are weighted slightly in favour of having an equality or majority of similar neighbours, but a significant minority of persons will not tolerate large-scale segregation. There is of course a very large range of possible scenarios, of which this is only one. Scattered empirical evidence suggests that black Americans overwhelmingly prefer mixed neighbourhoods. Whites are less tolerant of black neighbours but still tend to favour greater integration than presently exists. See Farley *et al.* (1979).
5. This program is also interactive and is available on request from the author.

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