From Perplexity to Complexity?

A dynamic systems view of career complexity

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INTRODUCTION

Careers become increasingly complex – this claim frequently appears in career research literature since the early 1990s (e.g., Gibb, 1998; Gunz, Lichtenstein & Long, 2002; Kelly, Brannick, Hulpke, Levine & To, 2003). Compared to "traditional" career patterns, careers are nowadays more erratic and diverse than they were several decades ago. Various "change drivers" such as globalisation, technological change, shortening of product cycles etc. lead to radical organisational innovations which also affect individual career paths.

As some would even have it, there will be no more ordered "seasonal" structures in professional career in the future, which would make the term "career" in its traditional, linear meaning obsolete (see, e.g., the discussion in Collin & Young, 2000 or Hall, 1996). For some authors, the increased complexity of careers leads to fundamentally "new careers", with temporal structures characterised precisely by a lack of structure. Concepts like "*boundaryless careers*" (Arthur, Inkson & Pringle, 1999; Arthur & Rousseau, 1996), "*protean careers*" (Hall, 1996), "*post-corporate careers*" (Peiperl & Baruch, 1997), or "*chronic flexibility*" (Mayrhofer et al., 2000) emphasize this increase in career complexity. But this perspective in career research and its implicit or explicit "complexity hypothesis" (Strunk, Schiffinger & Mayrhofer, 2003) raises both theoretical and methodological issues.

On a theoretical level, the question arises to which extent the term "career" denoting a dynamic structure ("career line", Hughes, 1937; Hughes, 1958) loses its meaning if career patterns actually show no coherent dynamic pattern anymore, assuming that the range of meaningful dynamic patterns is limited to what is acknowledged as representing an ordered structure in the literature and does not include any haphazard "ad hoc pattern". Career literature is almost exclusively restricted to simple linear sequences (e.g., Miller & Form, 1951; Super, 1957) or cycles (e.g., Super, 1990) and offers hardly any mature attempts exploring process patterns beyond these (Gunz et al., 2002 being a notable exception). Conceptual clarity is another issue. If complexity is distinct from mere random processes (and careers being completely undetermined and random processes would make the concept of career somewhat questionable), this requires theoretical approaches that are able to conceptualise and meaningfully deal with these processes, such as synergetics (Haken, 1990) or chaos research (Schuster, 1995). On a methodological level, the main question is how complexity can be operationalised, measured and consequently compared across studies in a sound manner.

COMPLEXITY IN CURRENT CAREER RESEARCH

The "linear career path" as the norm

Classical works of career research such as the Chicago school of sociology (e.g., Hughes, 1937; Shaw, 1931) see careers as ordered chronological structures. Early studies aimed at identifying general patterns like distinct phases or cycles in the sequence of an individual's career and/or life (Adamson, Doherty & Viney, 1998, p. 253). Such patterns only make sense as a so-called career line (Hughes, 1937; Hughes, 1958) if they apply not just to some individuals but are prototypical for certain types of career (cf. Barley, 1989, p. 51, Sicherman & Galor, 1990, p. 170).

While the notion of career was not limited to occupational careers of "regular" employees in earlier times, but included the careers of criminals (Shaw, 1931; Sutherland, 1937), dancers-for-hire (Cressey, 1932), or marihuana smokers (Becker, 1953), later stages of career research focused on professional careers, especially in an organisational context (e.g., Becker & Strauss, 1956; Dyer, 1976; Glaser, 1968; Gunz, 1989; Hall, 1976; Hughes, 1951; Schein, 1978; Super, 1957), and with a focus mostly limited to linear upward mobility (for a detailed discussion of the linearity assumption in career models, see Buzzanell & Goldzwig, 1991).

Accordingly, two early models of professional careers (Miller et al., 1951; Super, 1957) adopt this linear perspective despite their markedly distinct theoretical foundation (sociology versus developmental psychology). Although the authors of both models were aware that not everyone is able (or willing) to successfully follow the supposed linear career path, exceptions rarely got research attention (Sullivan, Carden & Martin, 1998) and were mainly discussed as deviants and in combination with a lack of career success (cf. Smart & Peterson, 1997).

Recently, however, careers that deviate from the "single-organisation linear upward" path have become quite numerous, making it increasingly difficult to see them as individual exceptions. Examples in the literature are horizontal career moves, which have been ignored (or almost so) for a long time (Hall & Richter, 1990), and have but recently begun to gain status beyond indicating a lack of career success (Prince, 2002). Similar observations can be made for "premature" career plateaus (Ference, Stoner & Warren, 1977; Hall et al., 1990), transitions between different professions or organisations (e.g., Louis, 1980), or employment gaps resulting from unemployment (Latack & Dozier, 1986), parental leave, or sabbaticals, which are dealt with in more recent studies only (e.g., Reitman & Schneer, 2003; Schneer & Reitman, 1997).

"Complex careers" in contemporary literature

Although the question to which extent the former exceptions have become the rule remains a controversial issue (e.g., Guest & Davey, 1996, career literature has responded to the increased appearance of non-traditional, "complex" careers. On the one hand, concepts like the "*boundaryless career*" (Arthur et al., 1999; Arthur et al., 1996), "*protean career*" (Hall, 1996), "*post-corporate career*" (Peiperl et al., 1997), or "*chronic flexibility*" (Mayrhofer et al., 2000) have been introduced, acknowledging the growing importance of non-traditional career paths on a theoretical and conceptual level. On the other hand, there have been several attempts to examine career complexity empirically. For instance, Jepsen and Choudhuri (2001) distinguish between stable and unstable OCPs (Occupational Career Pattern), based on Holland's (1973) occupational typology. Although their approach allows a distinction between stable and "deviant" career patterns, the amount of complexity cannot be determined. Higgins (2001) sees the subjective perception of an objectively observable career transition as the central criterion of "complex" transitions. Similarly, Schneer and Reitman (1997) consider the importance of subjective criteria by counting the number of deviations (employment gaps) from a "promised", continuous career path for 116 MBAs who graduated around 1978. A different operationalization was chosen by Parnes (1954) and Smart and Peterson (1997), who suggest that complex career alterations require change on both of two levels: employer *and* task content/function.

To sum it up, many studies measure complexity by counting discrete transitions (e.g., Weick & Berlinger, 1989), which can be seen as a central hallmark of new careers (Weick, 1996) and distinguished along several criteria like extent, desirability or predictability. A similar approach is chosen by studies which refer to one of the abovementioned new career theories, with the criteria for discontinuities more closely linked to the underlying career theory (e.g., Boh, Slaughter & Ang, 2001; Dowd & Kaplan, 2005). An emphasis is put here on career movements between different employers and task fields, focusing on transitions between (instead of within) different organisations. Additionally, the role of the individual as his or her own active "career agent" is emphasised (e.g., Hall, 2003).

Limitations of contemporary approaches to career complexity

While the cited studies offer precise suggestions for operationalising career complexity, their applicability is often restricted to the study itself. Apart from the issue of generalisability, they lack a dynamic perspective which would be beneficial especially within the career context with its "built-in" longitudinal perspective. On closer scrutiny, there are at least four problems associated with the employed definitions and operationalisations of career complexity:

- **Deviation from the norm:** defining complexity as a deviation from a "typical" career path describes the disbandment of this career concept, but makes no statements about nascent, different dynamic patterns of new forms of career.
- **Limitations of an objective perspective:** identifying deviations from the norm based on objective career paths works only as long as there is an acknowledged norm for these paths.
- **Limitations of a subjective perspective:** attempts to grasp career complexity via subjective assessments of transitions or career paths run into difficulties if the frame of reference changes over time. And it usually does: a look into career literature shows how deviations are often disapproved at first and acclaimed later (e.g., Ference et al., 1977).
- **A dichotomous complexity perspective:** in the abovementioned studies, careers are either identified as corresponding to the norm or deviating from the norm. But the extent of the deviation for a single career is either not defined or bears no relationship to a possible increase in complexity.

Consequently, this raises the issue how the complexity of a career can be objectively conceptualised as a continuously measurable criterion of a dynamic structure examined as a whole, without depending on subjective assessment of the individual. We propose a conceptual framework that achieves this and also fits well with a classical concept of career theory.

CAREER COMPLEXITY: A DYNAMIC SYSTEMS PERSPECTIVE

A classical career concept …

In 1957, Super presented the concept of *career patterns*, based on sociological studies on social mobility. He defines a career pattern as a „sequence of changes in occupational level or field made by an individuum during his[1] working lifetime“ (Super, 1957, in Jepsen et al., 2001, p. 4). The concept refers to the works of Miller and Form (1951), who classified careers of men by aspects like continuity, stability, and security, based on retrospective descriptions. Super (1957) condensed these analyses, positing four typical career patterns for men, and seven for women. Career patterns can be theoretically founded on a sociological and psychological perspective. From a sociological perspective, career patterns are socially constructed and shared representations of *typical* career paths, largely depending on social origin and identified talents. Personal goals and ambitions play a marginal role only.

From a longitudinal perspective, career patterns that develop over time led to the idea of *career pathways*, contingent sequences of professional positions which unfold before an individual while he or she "walks" the career pathway (Hogan & Astone, 1986). Career patterns where each position is a consequential result of its precursors (Wilensky, 1961) are called *orderly careers*.

Despite its sociological roots, the concept of *career patterns*, *career pathways* and *orderly careers* is close to a psychological perspective which emphasizes the importance of past and anticipated career experiences for career decisions (Jenkins, 1996). "Not only an option at one point but an entire sequence of options is being chosen" (Katz, 1993, p. 5, in Jepsen et al., 2001, p. 4). So, from both a sociological and psychological theoretical background, the idea of unfolding career paths, where each transition is substantially determined by previous career development (which in turn can be explained both by individual and/or socially shared ideas about "eligible" career steps), is a well-established concept in career research, with a firm theoretical foundation both from a sociological and psychological perspective. Additionally, it goes hand in glove with concepts that have been dealing with complexity on a methodically extremely sophisticated level for decades.

[1] Actually, the studies of Miller et al., 1951 and Super, 1985 examined male careers only.

… well suited to a dynamic systems perspective on career complexity

The question to which extent a system state can be predicted based on its previous states has been extensively researched by theories of nonlinear dynamic systems, which have their roots in the natural sciences and mathematics. Some date back several decades (e.g., algorithmic information theory: Chaitin, 1974; Kolmogorov, 1965; Zvonkin & Levin, 1970; or the *symbol dynamics* approach Morse, 1921; Morse & Hedlund, 1938). Some of these concepts have been developed within so-called chaos research (Schuster, 1995), the theory of dissipative structures (Prigogine, 1955), synergetics (Haken, 1990) or fractal mathematics (Mandelbrot, 1987). Although claims that these concepts will provide the answer to central questions in almost any scientific discipline (Horgan, 1995) have finally been shown to be unfounded (a critical view for career research is expressed, e.g., by Baruch, 2002), methods of nonlinear time series analysis and complexity analysis are quite common in empirical research in several disciplines. Examples from the social sciences are clinical psychology (Schiepek et al., 1997; Tschacher, Schiepek & Brunner, 1992), newer brain research (Freeman, 2000; Freeman & DiPrisco, 1986), sociology (Weidlich & Haag, 1983), organisation theory (Dooley, 1997; Morel & Ramanujam, 1999; Thiétart & Forgues, 1995), and economics (DeCoster, Labys & Mitchell, 1992; DeCoster & Mitchell, 1991). In career research, the use of these concepts has largely been restricted to metaphorical applications (e.g., Duffy, 2000; Lichtenstein, Ogilvie & Mendenhall, 2002; Parker & Arthur, 2002), with few serious empirical research efforts (e.g., Gunz et al., 2002).

The central aim of methods from dynamic systems theory is to measure the complexity of a dynamic process, without being restricted to a dichotomous variable (e.g., norm vs. exception). Unlike for traditional statistical measures (like means and standard deviations), the order of events plays a crucial role for these approaches. The following Figure 1 illustrates this by comparing three sequences (based on actual career data starting in the 1970s). In the first graph, the data are sorted; the second graph shows the actual sequence, while the third graph is randomly shuffled. Even from appearance, there are differences in complexity: the first sequence appears cleanly arranged, while the third sequence oscillates wildly, with the actual sequence in between. Still, despite their completely different appearance, all sequences have the same number of measurements, means and standard deviations.

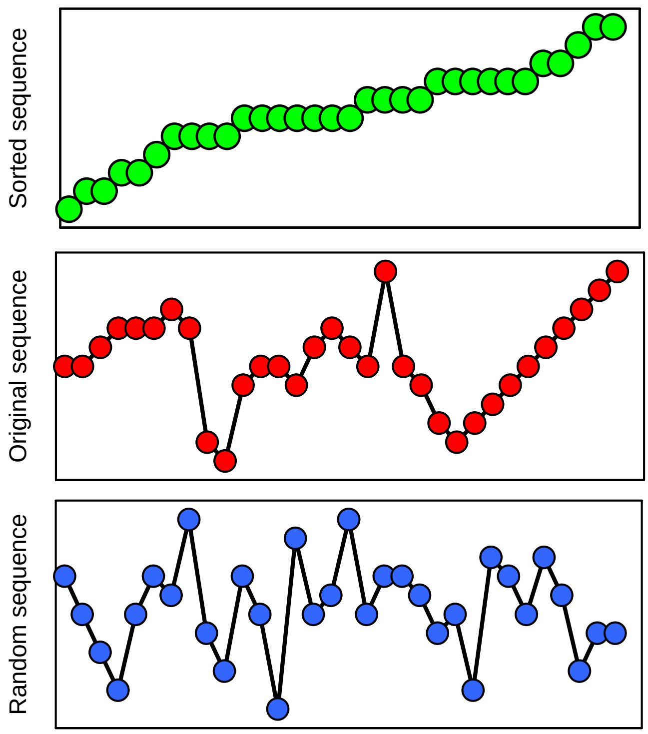

Figure 1: Order, structure and random in complex processes (illustrated by a time series on career satisfaction)

The differences in complexity result only from the different orders. While the first sequence shows a stable and predictable upward pattern, the third sequence shows no recognisable pattern at all, while the second, actual sequence appears partly "random" and partly predictable.

This issue of contingent (career) sequences is central to the concept of *career pathways* presented above. If the following career event in a sequence of events is determined by the previous events (as in the first graph), this suggests an *orderly career*. The less the previous sequence allows predictions about future events, the more complex the career pattern becomes.

Measuring (career) complexity

One approach to measure this sort of complexity is the so-called Kolmogorov-Sinai entropy (KS entropy). The idea of this concept can be explained by considering the so-called phase space, which contains all possible career paths (trajectories). Figure 2 shows three simple phase space representations. In the first graph, the position of the trajectories at t_1 is completely determined by their initial position at t_0 (KS entropy = 0). In the second graph, the trajectories diverge at t_1. The probability of the trajectories reaching at t_1 cells farther away from the initial cell depends on the KS entropy. This system dynamic is called deterministic chaos: the trajectories are not completely predictable, but not random either. In the third graph, the trajectories can reach all cells at t_1 with equal probability. This is a completely random and therefore unpredictable process (Schiepek & Strunk, 1994, p. 76; Strunk, 2004, p. 378; figure based on Schuster, 1989, p. 112).

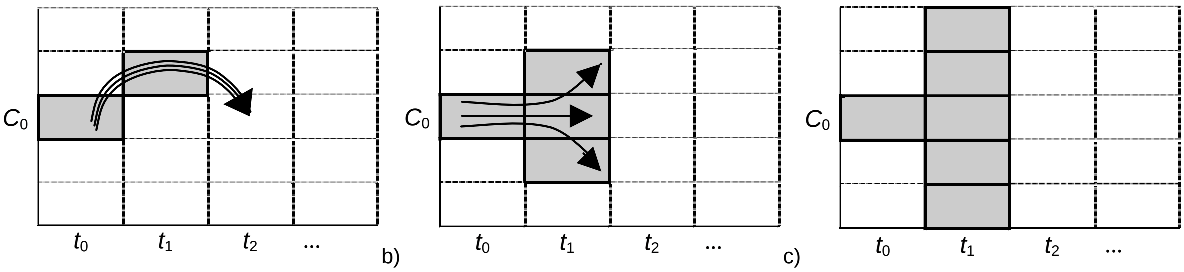

Figure 2: Representation of the concept of KS entropy

Several methods of computing KS entropy have been proposed (e.g., Frank et al., 1993). A quite simple method with moderate requirements concerning the quality of the data (rank scale data and only three or four time-steps can be sufficient) has been introduced some years ago: the so-called permutation entropy (Bandt & Pompe, 2002). It examines the frequency with which sequences of a predefined length appear in a larger pool of data. Explained in a slightly simplified manner, the algorithm works like this: For the short time series presented in Figure 1, for example, one might choose a length of four data points for a focus window. This focus window slides over the time series time step by time step, always logging four consecutive data points. In this way all possible four-point-sequences are recorded. For a time series with length N (N=32 in Figure 1) and a chosen sequence length n (n=4 in this example), this results in $N - n + 1$ sequences (here: 29). The frequency distribution of the short sequences is an indicator of the complexity of the time series. If all sequences are identical, there is no complexity. Regardless of the initial data point, the consecutive career always unfolds in the same way. In terms of career theory such a career can be see as a perfectly ordered one. By contrast, if no sequence is identical to another, the career unfolds completely differently depending on the starting point and thus shows maximum complexity.

But the probability for identical sequences is not only given by the complexity of the dynamics. It is also closely related to the data's scaling. So, before actually analyzing the frequency distribution, the values of the sequences are transformed into ranks, otherwise no pattern could be found for finely scaled data (like EEG data), as no sequence would be identical to another owing to the many decimal digits.

The complexity of the frequency distribution is then computed via Shannon's definition of information content (Shannon, 1948). According to this definition, the information content of a frequency distribution is equal to the sum (over all career patterns) of the probability of the appearance of one career pattern, multiplied with the logarithm of this probability. If the data contain only one career pattern, its probability is 1 (and the logarithm and therefore the information content are 0). Maximum values are attained when many patterns appear equally frequently and there is no dominating pattern. Such a configuration would hint at a random process. Calculating the logarithm to base 2 yields a permutation entropy value measured in bits.

For the time series shown in Figure 1 and a chosen sequence length of 4, permutation entropy is 2.6 bit for the sorted sequence, 3.8 bit for the actual data, and 4.5 bit for the randomly shuffled sequence, which corresponds well to the appearance-based results described above.

Going back to the career research concepts described above, these explanations should show that the definition of *orderly careers* as a logical, determined sequence of professional positions fits very well with the concepts of order and complexity provided by theories of nonlinear dynamic systems. In both cases, the core issue is the certainty and predictability with which a career path (trajectory) unfolds in phase space, i.e., the space of possible career movements/developments.

AN EMPIRICAL ILLUSTRATION

We applied the permutation entropy algorithm to actual career paths from the Vienna Career Panel Project (ViCaPP). Since 2000, ViCaPP has collected data on the careers of Austrian business school graduates. Our analyses are based on the comparison of the complexity of career paths during early career stages of graduates who completed their studies around 2000, 1990, and 1970, respectively. The sample sizes were 111 (87% male) for the 1970 cohort, 250 (62% male) for the 1990 cohort, and 111 (56% male) for the 2000 cohort.

For the elder cohorts (1990 and 1970), based on a curriculum-vitae-like list of professional activities for each person, their professional development was charted for each year since their graduation along several variables with a sampling frequency of one year. For the 2000 cohort, there are annual follow-up surveys with the same variables. At present, there are four sampling points available: for the first job after graduation; the job one year thereafter, and the following two career years. Some variables have not been collected separately for the initial job and one year later; we filled in these missing values by taking the value for the initial job. This actually created some "artificial" order for this cohort.

There were therefore four sampling points available for the youngest cohort, which were compared to the first four sampling points of the two other cohorts. For the latter two the whole career path could be analysed, too. In all cases, permutation entropy was calculated for a chosen sequence length of $n = 4$.

The analyses are based on twelve different time-series per person, representing her/his career patterns in time. The time series were generated by taking the values of various career related data and ratings on objective (income, number of subordinates, proportion of leadership tasks) and subjective career success (career satisfaction and perceived career success), career security, independence, and stability, closeness of professional relationships, and the amount of energy invested into one's job. The aim of this study was to explore whether careers have generally become more complex between 1970 and 2000, without selectively dealing with single career aspects.

The results clearly support the assumption of increased complexity. For each variable, the permutation entropy increased for the younger cohorts. In order to get a clearer impression, the actual permutation entropy can be compared with its upper bound. This upper bound (the highest possible complexity) is attained in case of an equally distributed frequency distribution of the career sequences. The difference between the observed permutation entropy and its upper bound decreases for younger cohorts. This is best visible in the last column in Table 1, where the difference between observed and maximum permutation entropy is reported in units of maximum entropy (i.e., divided by the maximum entropy value), suggesting that the time series for the younger cohorts more and more resemble a random pattern instead of an "orderly" career, i.e., become more and more complex.

Item	n	Permutation entropy	Maximum permutation entropy	Difference	Difference/Maximum
2000					
1	138	3.4524	3.7004	0.2480	0.0670
2	142	3.5900	3.7004	0.1105	0.0299
3	142	3.5929	3.7004	0.1075	0.0291
4	141	3.5354	3.7004	0.1651	0.0446
5	141	3.5814	3.7004	0.1190	0.0322
6	137	3.5325	3.7004	0.1679	0.0454
7	57	4.2812	4.7004	0.4192	0.0892
8	100	5.1932	5.5236	0.3304	0.0598
9	103	5.1816	5.5236	0.3420	0.0619
10	103	4.9265	5.2854	0.3589	0.0679
11	102	5.2910	5.6147	0.3238	0.0577
12	89	3.1298	4.2479	1.1181	0.2632
Mean	12	4.1073	4.4249	0.3175	0.0706
SD	12	0.8139	0.8435	0.2748	0.0632
1990					
1	250	4.1712	5.4594	1.2883	0.2360
2	250	3.7964	5.2479	1.4516	0.2766
3	250	3.5314	4.8580	1.3266	0.2731
4	250	4.2362	5.3923	1.1561	0.2144
5	250	3.8064	5.1699	1.3635	0.2637
6	250	3.9167	5.2854	1.3687	0.2590
7	250	2.5994	4.4594	1.8601	0.4171
8	250	4.1471	5.3923	1.2453	0.2309
9	250	3.2458	4.7549	1.5091	0.3174
10	250	4.2550	5.4919	1.2369	0.2252
11	250	4.6866	5.6724	0.9859	0.1738
12	250	3.1505	4.8580	1.7075	0.3515
Mean	12	3.7952	5.1702	1.3750	0.2699
SD	12	0.5798	0.3606	0.2365	0.0659
1970					
1	111	2.1330	4.0000	1.8670	0.4667
2	111	2.5882	4.3219	1.7337	0.4011
3	111	1.9112	3.9069	1.9957	0.5108
4	111	2.7150	4.3219	1.6069	0.3718
5	111	2.1318	4.2479	2.1161	0.4982
6	111	2.8081	4.3923	1.5842	0.3607
7	111	2.4488	4.2479	1.7991	0.4235
8	111	3.1492	4.5236	1.3744	0.3038
9	111	2.4715	3.9069	1.4354	0.3674
10	111	2.8544	4.3219	1.4675	0.3396
11	111	2.9642	4.5850	1.6207	0.3535
12	111	2.2999	3.8074	1.5074	0.3959
Mean	12	2.5396	4.2153	1.6757	0.3994
SD	12	0.3757	0.2527	0.2312	0.0642

Table 1: Permutation entropy results

Item 1: Career (in)security
Item 2: Career (in)dependence
Item 3: How easily could an adequate alternative job be found?
Item 4: (In)stability of work content
Item 5: (In)stability of professional relationships
Item 6: How close are professional relationships (to supervisors, peers, key customers, investors etc.)?
Item 7: Number of subordinates
Item 8: Proportion of "life energy" invested into job
Item 9: Proportion of managerial/leadership tasks (as opposed to "hands-on" tasks).
Item 10: Career success as perceived by the professional environment
Item 11: Career satisfaction
Item 12: Total annual income

A comparison of means (Difference/Maximum across all twelve variables) shows the differences between the cohorts to be significant. By contrast, it cannot be tested whether the pattern for the 2000 cohort is significantly different from a purely random process owing to the small segment length (n = 4).

Figure 3 shows that the careers of the 1970 cohort (topmost sequence) are consistently more ordered than for the 1990 cohort (second, shorter sequence). It is also visible that the complexity decreases slightly during the 1970 and 1990 careers, while career entry becomes more and more complex, depending on the "date of entry". Each dot represents a sequence of four career years. For the 2000 cohort, only one such sequence was available per person.

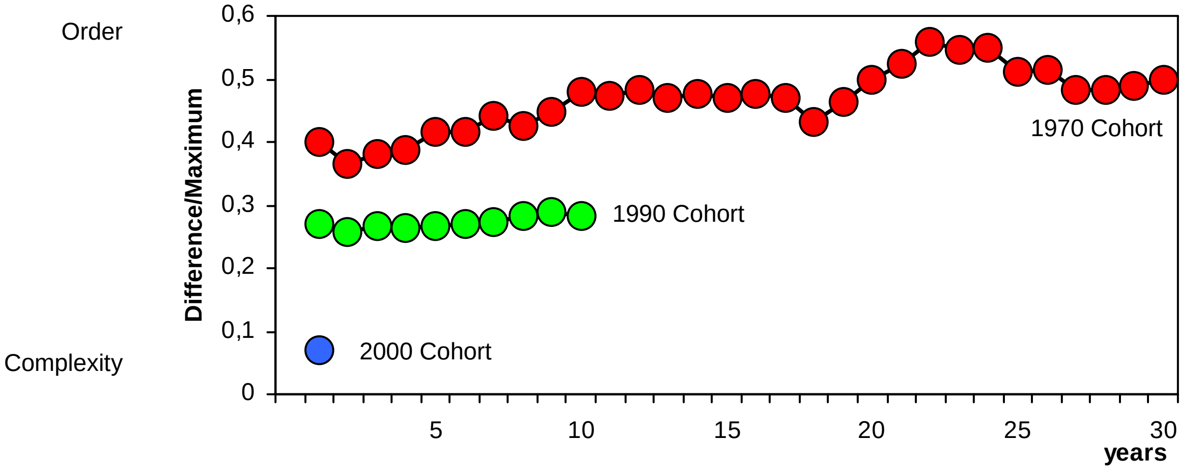

Figure 3: Complexity patterns for the three cohorts

Discussion and Outlook

Beginning with the classic works of the Chicago school (e.g., Hughes, 1937; Shaw, 1931), careers have been conceived as ordered chronological structures. Early studies aimed at identifying generalisable dynamic patterns in the individual sequences of professional roles and experiences(e.g., Adamson et al., 1998, p. 253). These sociologically oriented career conceptions led to the idea of *career pathways*, unfolding like a script or contingent role description as an individual "walks" it (Hogan et al., 1986). *Career patterns* where certain sequences of positions determine the further career development (Wilensky, 1961) are sometimes labeled *orderly careers*. These concepts form a framework that fits very well with concepts and methods of nonlinear dynamic systems. Based on these methods, the complexity of careers can be determined by counting the number of career patterns contained in a career (or several careers of a sample). One or few dominating career patterns suggest a "career-logical" pathway, an *orderly career*.

For illustration purposes, we examined the career paths of three cohorts of business school graduates. The results showed an increase in career complexity for the younger cohorts, in accordance with the "complexity hypothesis" and earlier results (for the former graduate cohorts only) from nonlinear dynamic systems analyses (Strunk, 2005; Strunk, Mayrhofer & Schiffinger, 2004a, b; Strunk et al., 2003; Strunk, Schiffinger & Mayrhofer, 2004). The advantage of permutation entropy is its suitability for short time series. It might even be possible to conduct reasonable analyses on individual careers from the 1990 and 1970 cohort. This could shed light on issues like gender differences in career complexity, or whether complexity influences career success outcomes like income or satisfaction.

One caveat to be mentioned here refers to the data collection process. While for the former graduates the whole careers were surveyed retrospectively, the data for the 2000 cohort were collected via annual surveys. It stands to reason that a retrospective view leads to less varied results, e.g., as a result of a stable internal frame of reference. The ongoing annual data collections include the 1990 cohort as well. In some years, we should therefore be able to examine whether and to which extent the results are influenced by methodical artefacts.

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