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Published in:
Springer Proceedings in Complexity

Modelling the Individual Process of Career Choice

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Abstract. Making a suitable career choice is a difficult task. Every year, many adolescents prematurely end their studies, commonly citing 'having made the wrong choice' as the main reason. This is a problem, both for the adolescents making these choices, and for society, which bears at least part of the cost of higher education. A thorough understanding of how adolescents make these career choices is essential to identifying the factors responsible for why the wrong choices are often made. Identity development theory emphasizes the role of exploration in career choice, but neglects many of the micro-level processes likely to play an important role. Similarly, traditional decision theory often focuses on optimization of choice, thereby neglecting the cognitive mechanisms that may explain deviations from optimal choice. Here, we present a novel computational approach to modelling long-term decision making. We combine elements of the macro-level theory on identity development with a firm rooting in micro-level cognitive processes. Specifically, we model decision making as an iterative process in which individuals can explore new options or more deeply investigate options that are already under consideration. The output of our model allows us to analyze how the quality of decisions depends on various factors, such as aspiration levels, the tendency to explore new options, and the ability to judge the fit of an option with one's interests and capabilities. We present some preliminary results that already show our approach can lead to surprising conclusions, encouraging further development of this model in the future.

Keywords: intra-individual computational modelling, information processing models, decision making, career choice, identity development.

1 Introduction

Choosing the right career is by no means a straightforward process for the vast majority of adolescents in Western cultures. At a relatively young age (typically between 16 and 20), students in secondary school are faced with making the important decision of choosing a major in higher education. For example, in the Netherlands, prospective students have to commit to a specialization even before entering university, choosing between more than a thousand relatively narrowly defined subjects.

For adolescents, making an important life choice out of so many options can be a daring task. This is not only difficult because of the sheer number of options, each with many facets, but also because adolescents are still very much in the process of identity development. Because of this, many adolescents do not have a clear idea of what their preferences and interests actually are; this makes the evaluation of options all the more difficult. Making such an important decision is further complicated by an imbalance in adolescent brain development: as limbic structures develop more quickly than prefrontal structures, rational cognitive control is limited, and emotional motivations are more likely to drive decisions (Casey, Jones & Somerville, 2011).

A recent study among Dutch students (ResearchNed, 2013) found that the most important reason for dropping out of higher education was having made a wrong education choice. Dropping out is a common phenomenon in Europe; 20% to 55% of university students do not complete their education (Quinn, 2013). Needless to say, this is a problem that not only frustrates adolescents, but also comes at a significant cost to society.

1.1 Identity development

Getting a clear idea of one's own interests is crucial in making a fitting career choice. Early identity development theorists Erikson (1968) and Marcia (1966, 1980) posited that ideas on 'who you are and what you want' develop mainly in adolescence through a process of exploration. Exploration is a broad behavioral construct: it can be defined as any kind of behavior aimed at eliciting information (be it cognitive, emotional or social in nature) about the self or the environment in order to make a decision about an important life choice (Grotevant, 1987). Different types of exploration have been distinguished (Luyckx, Goossens, Soenens & Beyers, 2006); an important distinction is between 'exploration in breadth' (globally investigating multiple options) and 'exploration in depth' (investing time and energy to gain more information on a particular option). Germeijs & Verschueren (2006) found that both types of exploration are important for developing suitable career commitments.

Although identity development theory is relevant for describing macro-level variables relevant to making a career choice, research in this field offers little theory or empirical data on what happens to individuals on a micro-level (Lichtwarck-Aschoff, van Geert, Bosma & Kunnen, 2008). Consequently, this framework does not provide a notion of what the basic mechanisms of career exploration are, and how individual differences in these mechanisms may affect the quality of choices made.

1.2 Information processing models

To be able to work towards policies to help adolescents make more suitable career choices, it is vital that we understand this decision making process in more detail. Decision science has a long tradition of modelling micro-level choice processes. Traditionally, the study of decision making has been dominated by classic expected utility theory. In this framework, decision making is presumed to be a rational process of optimization between available options, given a function determining the desirability (utility) of each option, based on various characteristics. Although framing decision making as a process of sampling and subsequent optimization may appear intuitively appealing, there is mounting evidence that very few human decision making processes can be adequately modeled in this way (Oppenheimer & Kelso, 2015). In fact, there is a growing movement of grounding models of decision making in basic non-linear cognitive processes (e.g. Decision Field Theory by Busemeyer & Townsend, 1993; Query Theory by Johnson, Haubl & Keinan, 2007), rather than assuming a 'black box' psychology that is an optimization machine. These information processing models are currently rapidly gaining ground (indeed, even causing a paradigm shift; Oppenheimer & Kelso, 2015).

1.3 Current study

Here, we introduce a novel approach to modeling decision making processes that combines macro level identity development theory with micro-level information processing models. In contrast to existing models on career choice, our approach allows us to study the effect of key factors within the process of exploration that may differ between individuals (such as aspiration level or clarity of preferences). In addition, by explicitly modeling the dynamics of decision making, we can gain insights in the process of decision making, and how different processes are related to different outcomes. Although our model is currently still under development, we have already produced some interesting preliminary results. For example, we observe conditions where it is always more beneficial to explore in breadth, than to exploit options in depth.

2 The model

We are developing an event-based simulation model of individual career choice processes in *C++*. The general assumptions of our model are partly grounded in information processing theory. Specifically, we model decision making as an iterative process proceeding for a number of time steps (following Query Theory; Johnson, Haubl & Keinan, 2007), and assume that time is limited (following Decision Field Theory; Busemeyer & Townsend, 1993). In line with personal identity development literature, we assume that there are two ways to investigate options: exploration (in which new options are sampled), and exploitation (in which options of particular interest are investigated in more depth). We further assume that individuals judge options by their perceived fit with their interests and capabilities; only options that are associated with a high perceived fit are exploited and eventually chosen.

We assume that the focal individual has a set of options (S) under consideration (where the size of S is limited to a maximum N; see Table 1 for an overview of model parameters and variables). In each time step, the individual explores a new option with probability m; this may lead to the addition of the newly explored option to S. With the complementary probability, she randomly exploits one of the options that is already in S. In the very first time step, the individual does not yet have any options under consideration, and can therefore only engage in exploration. In any time step, an option may be chosen. The model runs for a maximum of T time steps; if no option is chosen before time runs out, the individual is forced to choose the option in S with the highest perceived fit.

2.1 Exploration

Exploration is modeled as the random sampling of an option from a pool of potential options. We assume that each of the potential options has an 'objective fit' (x_o), drawn from a standard normal distribution. This is meant to reflect that some options are more suitable to the focal individual than others, and that options that fit very well or very poorly are rarer than options with an intermediate fit (other distributions can also be considered). We further assume that individuals are not able to directly perceive the objective fit of an option. Rather, their perceived fit (x_p) of an option is subject to some error, such that

$$x_p = x_o + \varepsilon, \tag{1}$$

where ε is drawn from a normal distribution with mean 0 and standard deviation a. The parameter a determines how accurately the individual is able to judge the fit of an option, which captures differences in level of identity development (i.e. how clearly defined own interests and preferences are). A newly explored option will be included in S if there are fewer than N options under consideration. Alternatively, the newly explored option may replace the option in S with the lowest perceived fit, if it has a higher perceived fit. Otherwise, the newly explored option is discarded.

2.2 Exploitation and choice

When exploitation occurs, one of the options in S is selected for further investigation. In this case, the individual randomly draws an option from the options in S that have a perceived fit that exceeds their first aspiration level (t_1). This first aspiration level is meant to reflect the idea that individuals will only exploit options that they are at least moderately interested in. Through exploitation (be it hands-on experience with the option, discussing the option with friends, further reading, or otherwise), the individual may update her perceived fit of the option so that it eventually comes closer to the objective fit. Exploitation occurs in a similar fashion as exploration, but past experience is taken into account when updating the perceived fit of the option. Specifically, the updated perceived fit (x_p') depends on the previous perceived fit (x_p) as follows:

$$x_p' = \frac{\rho r x_p + x_o + \varepsilon}{\rho r + 1} \quad (2)$$

where ε denotes an error term drawn from a normal distribution with mean 0 and standard deviation a (as in equation 1), ρ represents a recency factor (ensuring that a new experience is weighed more heavily than experiences in the past), and r denotes the number of times the option has already been evaluated in the past (this ensures that the influences of new experiences diminishes as the total experience with an option increases). Over time, repeated exploitation will lead x_p to approach x_o. If the perceived fit of any of the options in *S* exceeds a second aspiration level t_2, the individuals decides for this option. If time *T* has run out before an option has exceeded t_2, the option in *S* with the highest perceived fit is chosen.

2.3 Simulation set-up

There may be variation between individuals in the number of options that they are able to consider at the same time (*N*), the time and effort they invest in the decision making process (*T*), the accuracy with which they are able to judge the fit of an option (*a*), their tendency to explore new options relative to their tendency to exploit options already under consideration (*m*), the emphasis they place on recent experiences with an option, relative to experiences further in the past (ρ), and their aspirations levels, both for whether they are willing to consider an option at all (t_1), and for their final choice (t_2). With this in mind, we have run preliminary simulations exploring a relatively wide range of parameter settings for *a* (number of parameter settings [n] = 51), *m* (n = 51), t_1 (n = 4), and t_2 (n = 4). For now, we have kept three parameters constant: *T* (100), *N* (3) and ρ (0.5). For each of the in total 41,616 parameter combinations, we have run 1,000 replicate simulations (a total of 41,616,000 simulations).

3 Preliminary results

Figure 1 shows a single simulation run of the model. Although this specific run may of course not necessarily be illustrative of the overall patterns, it does give an intuition for how our way of modeling long-term decision making can lead to patterns that would not be observed with more classical optimization-based approaches. For example, if individuals have trouble accurately assessing the fit of an option (*i.e.*, they have a relatively high value of *a*), they may choose an option that is actually below their aspiration level for making a final choice (t_2), even if they may have been likely to explore a better option before time runs out. In figure 1 for example, the purple option is chosen, even though the objective fit of that option is below t_2. For illustrative purposes, the dynamics of the simulation after the moment of choice are also shown (even though the choice cannot change after this point). After the moment of choice, the perceived fit of the purple option drops below t_2. Also, at a later point, a much better option than the purple option is explored (the turquoise option). This illustrates that if an aspiration level is relatively low, especially in combination with a low accuracy of estimating options, this can lead to relatively poor choices.

Figure 2 shows an overview of simulation outcomes across a relatively wide range of parameter combinations. Perhaps not surprisingly, individuals tend to make poor choices if they have a very low aspiration level for their final choice (t_2). However, if this aspiration level is very high, their choices are not necessarily good either. This is probably because with too high aspiration levels, combined with a low tendency to explore (m), individuals may 'get stuck' in investigating options that will not cross their choice threshold, until time runs out and they are forced to choose the best of inferior options.

Under the current assumptions, the effect of the first aspiration level (t_1, determining whether options are worth exploiting) is more clear; as it increases, choices generally tend to be better. There seem to be some interesting interaction effects for individuals who have high standards for choosing an option (t_2) but relatively low standards for considering one (t_1). If these individuals can accurately estimate the fit of an option, exploiting options does not seem beneficial; this will not improve the subjective fit as this is already close to the objective fit, and the individual has a better chance of finding a good option by exploring a lot. In contrast, individuals who are relatively inaccurate (high a) seem to be better off exploiting options in depth, as this improves their estimation of the objective fit, decreasing their initial inaccuracy and making it more likely to choose a fitting option. In general, it seems to be more beneficial to be more accurate. Surprisingly however, we also observe a small range of conditions, when the exploration tendency (m) and the first threshold (t_1) are low, in which better choices are made by individuals with who are less accurate in estimating the fit of an option.

4 Concluding remarks

At present, our results are too preliminary to come to any definite conclusions about the workings of our model, and how it may illuminate long-term choice processes. In the coming time, we intend to develop this model further, and aim to investigate the effect of variation in the parameters we have so far kept constant (N, T, and ρ). In later stages of the model, we may consider stronger effects of first experiences (as in Query Theory), and extensions of the model from a more developmentally oriented perspective. For example, it may be interesting to consider if the objective value of an option is not constant, but may change through identity development. In addition, we may consider extensions of the model to include interactions between options, and cognitive biases. Having said that, our first results already suggest that the parameters of our model affect the outcome in relatively complex ways – even for the relatively simple first model presented here. Encouraged by these first results, we are eager to present our model to a larger audience, and incorporate any feedback in the further development of this model.

Table 1. Parameters and variables of the model.

Parameter	Description
T	The number of time steps available for exploring/exploiting options before a decision has to be made.
N	The maximum number of options the individual can have under consideration at any point in time.
m	The probability with which the individual explores a new option in any time step. With the complementary probability, the individual exploits an option already under consideration.
a	The standard deviation of the normal distribution from which perception errors are drawn (the mean of this distribution is 0). The perception error determines the distance of the perceived value of the fit of an option from the objective fit. With increasing a, the individual is less accurate in her assessment of the fit of an option.
t_1	The first aspiration level. If the perceived fit of an option exceeds this number, the individual takes this option under consideration.
t_2	The second aspiration level. If the perceived fit of an option exceeds this number, the individual chooses this option.
ρ	The recency factor. This number determines the weight past experiences relative to the current experience with an option. If smaller than one, the recency factor leads individuals to discount the past.

Variable	Description
S	The set of options under consideration.
x_o	The objective fit of an option.
x_p	The perceived fit of an option.
r	Number of times an option has been exploited.

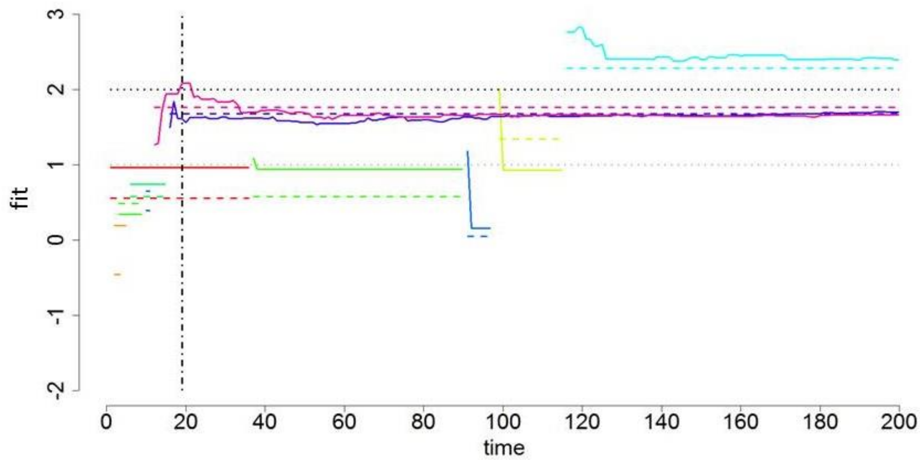

Figure 1. A single simulation run of a career choice process over time. Each pair of solid and dashed lines with matching colors represents an option in *S*. Solid lines represent the perceived fit of options (x_p), dashed lines represent their objective fit (x_o). The horizontal grey dotted line represents the first aspiration level (t_1); the horizontal black dotted line represents the second aspiration level (t_2). The vertical dot dashed line represents the moment a decision is made (after which the career choice process ends, but we show this to illustrate the dynamics of the model). Options with a perceived fit below t_1 are not exploited; all solid lines below t_1 are unchanging (note that this may occur even if the objective fit does exceed t_1; see the lime-colored option around t=100). Options with a perceived fit above t_1 are exploited (their perceived fit changes over time, and tends to approach the objective fit). When the perceived fit of an option exceeds t_2, that option is chosen. Parameter values for this simulation run are as follows: $T = 200$; $N = 3$; $m = 0.1$; $a = 0.5$; $t_1 = 1.0$; $t_2 = 2.0$; $\rho = 0.9$.

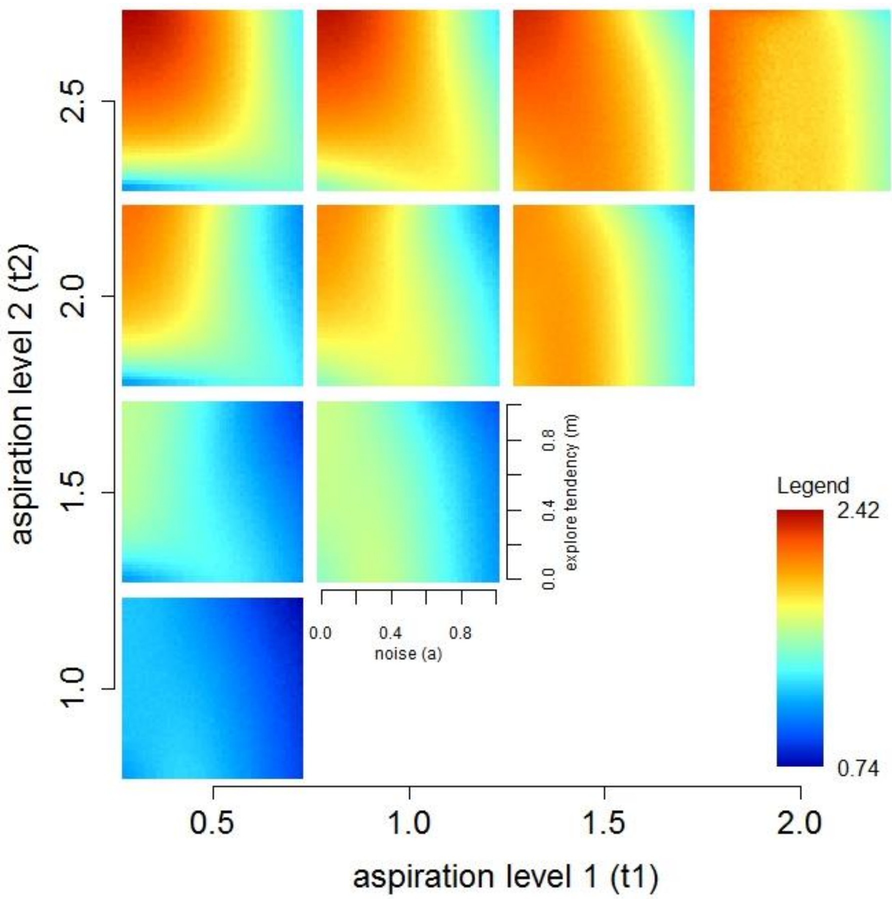

Figure 2. The effect of aspiration level (t_1 and t_2), exploration tendency (*m*), and accuracy of judging the fit of options (*a*) on the objective fit (x_o) of the final choice. For each parameter combination (a total of 41,616), colors indicate the average objective fit of the final choice across 1,000 replicate simulations, red indicates choices with a high objective fit, blue indicates choices with a low objective fit. In each subgraph, ranges of 51 values of both *m* and *a* are depicted (both varying with step size 0.02, between 0.0 and 1.0). Parameter combinations for which t_1 is equal to or exceeds t_2 have been omitted.

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