# An approach to the ecological analysis of decisions

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*(Unrevised)*

## Abstract

A descriptive, agent-based, options-oriented methodology is developed for the ecological analysis of decisions and their proximal causes. The methodology rests on knowledge of both outcomes and their proximal causes for each option for each case. A dual-process approach is used to classify the proximal causes as *sufficient identifications* or *comparative selections*. Categories of sufficient identification are outlined accounting for both adoption and rejection of options. Alone or together, sufficient identifications and comparative selections are assumed to fully account for each option outcome and to mediate their distal causes. Models are developed to reveal changes in selection probabilities associated with the impact of each proximal cause for each option outcome for each case. When individual results are aggregated for groups and populations, patterns emerge of impacts and prevalence of the proximal causes and their effects. Example results from applying the methodology to election survey data are presented. Based on a model of prior indifference amongst options for each case, the results for the example data reveal very large impacts of sufficient identification relative to those of comparative selection.

Keywords: descriptive, options-oriented, dual process, agent-based, decision ecology

## 1 Introduction

This paper provides a descriptive agent-based methodology for the ecological analysis of decision outcomes and their immediate precursors. The goal is to explain the variable character of decision-making behaviour - where the automatic choices of some are the outcomes of others' reflective ponderings, while others, again, may mix reactive decisions on some alternatives with deeper analysis of others.[2] An options-oriented approach is developed to describe this behavior, option-by-option, case-by-case. In other words, the concern is with the casewise adoption and non-adoption across the alternatives and the dependence of each on differing precursors. Patterns and prevalence of positive and negative impacts by precursors on option outcomes emerge when these individual results are aggregated for groups and populations. Thus, the primary focus of this paper is on understanding decisions case-by-case and to use this to understand decisions within groups and populations i.e. agent-based modelling (Epstein, 2008).

Because options are ubiquitous in the presence of all behaviour, decision-making is viewed here somewhat less as a *particular* kind of behaviour than a way of looking at *any* behaviour in the presence of alternatives. A corresponding perspective is that of examining adoptive behaviour in terms of counterfactuals – the un-adopted alternatives. More specifically, decisions are viewed in relation to options, and, the differential

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[2] For the purpose of this paper the decisions for analysis are those that are observed – they may be final or interim, an intention or an outcome, etc. Indeed, their status for any set of observations may differ amongst cases. The status of the measured decisions will be largely a matter of research design and the collection of supplementary data, when required, for specifically determining decision status.

causation that leads to selections and non-selections. A decision for a case is seen to compose an array of outcomes equal to the number of available options with an associated array of determinant precursors.

Table 1 shows the decision-making orientation and the focus of this paper where the causes of selection and non-selection may vary in both kind and amount from option to option within each case.

Table 1: Example of causes with respect to option outcomes for a case

| **Decision by a single case** | | | |
|---|---|---|---|
| | | **Subject of this paper** | |
| Options | Distal causes | Proximal causes | Outcomes |
| 1 | N, P, Q … → | A → | Not selected |
| 2 | X, U, P … → | F,B → | Not selected |
| 3 | R, S, T ... → | A,B → | Selected |
| 4 | Q, P, S … → | C → | Not selected |

Decision-making research has tended to focus on the factors involved in the selection of *adopted* options. Non-selections are generally ignored. This would not matter if factors involved in non-selections could be explained as the complement of adoption e.g. selecting amongst options solely on the basis of utility. This is not seen to be a realistically defensible assumption for examining a full range of decision-making behaviours in "naturalistic" settings. Besides, non-selections are themselves a legitimate focus for research and may sometimes be more important than adoption.[3]

Dual-process approaches suggest the need for two decision-making structures to adequately describe decision-making amongst individuals (Kahneman, 2013; Sloman, 1996; Evans, 2008; Slovic et al, 2002; Redish & Johnson, 2007; Redish et al, 2008). But most dual-process models also explicitly account only for option adoption. This paper expands the range of immediate precursors to explain unselected options. This allows, in principle, an accounting for all decisions on all options for each case. Furthermore, the methodology detailed below embraces the entangled effects of immediate precursors within and between options.

The decision-making process is seen to have two parts – evaluation (Ajzen & Sexton, 1999) of one more options (the proximal cause), and selection (picking the outcome). An evaluation can range from simple recognition (or non-recognition) to extensive analysis, while selection can range from direct adoption/rejection (without comparison) to a comparison of alternatives again with associated adoption/rejection outcomes. The dual-process distinction, which reflects these two different types of processing, is closely

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[3] In marketing, for example, a common interest is to know why a product or service is not being purchased to know what changes are needed to improve market share,

aligned with the options-oriented approach developed in this paper. It may be seen to consist in determining whether options are selected or rejected on the basis of preference, or otherwise (Zajonc, 1980). Decisions based on preference are referred to as *comparative selections*.[4] Other decisions are *sufficient identifications* where each option is evaluated on an accept or reject basis (but not both) without regard for others.[5] *All* outcomes for each case are thus to be generally explained by these two *categories* of proximal cause which are sufficient, on their own or together, to render the decision-making disposition on any option as resolved.

The two proximal factors, sufficient identification and comparative selection, are seen as intervening between all distal causes influencing decision outcomes. This includes the effects of between-agent interactions in addition to the vast range of other possible influences. So the focus in this paper is on within-case processes and outcomes.

For any one analysis, the option array is taken to be the same for all examined cases i.e. the options of all cases as seen to be available by an independent observer. Such an array includes options which may be, for example, unknown, overlooked, or ignored or seen as irrelevant by some decision-makers. This is necessary to fully understand the casewise outcomes for each array and to provide insights on relations between selected and unselected options.

The adequacy with which the option array is defined in the context of a decision-making question is clearly critical to the adequacy of the resulting description of decision-making behavior. Ideally, the description should be complete. It is always possible to capture all alternatives by the use of a residual option i.e. “none of the other alternatives”. But, completeness is not the only criterion of descriptive adequacy. In particular, the option-set should reflect common perceptions of the selection context. An informal search of relevant alternatives would usually be sufficient. But formal preliminary research may be necessary to adequately delineate respondent perceptions of options.

Of course, any set of outcomes may be limited by creating a forced-choice decision array. Here, some respondents may be unable to make *any* selection creating missing data, or, creating decisions which may not reflect realistic behaviour, on the part of those who would otherwise choose outside the delimited range.

The range of decision-making situations covered here are all-embracing – anything beyond the responses of the autonomic nervous system to life changing choices. However, the methods developed below are particularly suited to the analysis of data that can be readily obtained through surveys or in test settings.

## *2 Providing a structure for the analysis*

The analytical structure outlined below is an extended dual-process model the main elements of which may be further sub-divided to the level of analysis desired or practical.

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[4] The word “comparative” should not be taken to imply that that comparisons are limited to the options involved in any decision. It may also refer to independent standards that may be, for example, satisficing.

[5] This is not to be confused with evaluating an option to decide “Yes” or “No”. That decision would consist of looking at two options with respect to each other - a comparative evaluation. Sufficient identifications involve no consideration of alternatives. They are commonly associated with reactive evaluations to single options. Automatic adoption or automatic rejection of options are examples of sufficient identification.

For each case, selected and unselected options may be viewed as an array of decisions composing an entangled whole. To substantially unwind the complexity of relations with proximal causes, a fundamental distinction is made between outcomes which are dependent on the sufficient identifications and comparative selections that are assumed to mediate all decisions. Comparative selections can only be made on options that have not been eliminated or precluded by sufficient identifications, as will become obvious.

Implicit in the above is the view that understanding a decision involves the collection of multiple data items input to yield the option outcomes for each case. For example, an elaboration is required of the potentially relevant types of sufficient identification in the research design and the collection of data on each.

## 2.1 Sufficient identification

The defining characteristic of a decision made on the basis of sufficient identification is that it applies to an option's adoption or non-adoption, respectively, without comparison with any other option. Examples of sufficient identifications that may rule an option unselectable include: unawareness, non-recognition, non-recall, unfamiliarity, unavailability, inaccessibility, ineligibility, and exclusion (e.g. considered irrelevant or overlooked). Such option identifications exist prior to and *block* comparative selections amongst options to which they apply.

But, decisions based on sufficient identification may also rule an option automatically selected. For example, automatic selection of an option can result from behavioral scripts (Abelson, 1981), habits (Aldrich, Montgomery & Wood, 2011; Ji & Wood, 2007; Wood & Neal, 2009; Neal et al, 2011; Neal et al 2012), impulses, reflexes, rules, compulsions, and so on, and as portrayed in System 1 descriptions (Kahneman, 2013 & 2003). Automatically, such selections mean that all other options are ignored i.e. blocked. Likewise, when all options are blocked but one, the remaining option is sufficiently identified for automatic selection. Thus, all sufficient identifications determining selection or non-selection of an option can be accounted for, directly or indirectly, by blockage.

An analytical objective is to go beyond the broad bipartite classification and to classify each type of sufficient identification for each option for each case. Since each sufficient identification refers to an exclusive proximal cause, the aggregated analysis of these sources is a simple additive process for the same option across cases.

Blockages are seen to operate singly. For example, unawareness of an option is sufficient to preclude its selection. But removal of that block would not necessarily ensure comparative selection since any of the other blockages may come into play. Blockages may be viewed hierarchically or as consecutively structured, from awareness through recognition to familiarity to accessibility to relevance. Every element in such a structure would need to be absent, to enable a comparative selection.[6]

It is important to note that the presence of blockages on one or more options alters the selection probabilities for remaining options undergoing comparative selections for that case. This also means that between cases there will commonly be differences in the

[6] An acknowledgement of such relationships is also useful in the structuring of questionnaires so that positive identification of earlier blockages, in the proximal cause hierarchy, may eliminate the need to inquire about others – an aid to field efficiency.

comparative selection probabilities amongst options on account of such variations in blockage amongst alternatives.

Here are some descriptions of major sources of blockage and collection of relevant data.

*Blockages associated with lack of awareness*

Sometimes it will be appropriate to provide respondents with a prompt list to confirm recognition of each option. At other times the appropriate method will be to test recall of options within a given category. These answers can also be used for filtering further questioning which is especially useful where there are many options or extensive questioning on each option.

Awareness and subsequent formation of any set of options for comparative selection can be sensitive to issues of context and timing depending on the subject focus. For example, political poll results may vary partly on account of differential recall effects during the electoral cycle. Likewise options identified by respondents for consideration may be sensitive to question wording and prompting, recency of use, advertising, etc. (Nedungadi, P.,1990).

*Blockages associated with insufficient acquaintance*

There may be awareness of option but insufficient know-how, capacity, familiarity, or confidence to select an option. Usually, high-involvement evaluations such in buying a house or car, or choosing a travel destination, will require more information or experience than low-involvement decisions. Respondents may typically be sufficiently familiar with some options but not others. When respondents are lacking in familiarity with an option or options, they will prefer to say they don't know in response to a prompted list. The relevant options can be identified and treated as currently blocked on account of insufficient familiarity or awareness, as appropriate.

*Supply and demand constraints*

Here, options may be unavailable for selection on account of distribution or production constraints. Alternatively, options may be inaccessible due to personal circumstances or characteristics or conditions of supply. Options may be inaccessible on account of affordability, distance, and personal capabilities or disabilities, for example. Another constraint is ineligibility where access to an option is proscribed. For example, there may be the need for a ticket or coupon, being young or old enough, living in a specific place, being the right sex. Where potentially relevant to the research, such constraints need to be identified.

*Executive constraints*

An option in a given selection set may be eliminated from consideration (i.e. ruled out of contention). Elimination can occur when the respondent considers an option irrelevant, too unattractive or insufficiently attractive to be considered for evaluation along with other set members.

To identify options excluded or eliminated it is necessary to ask which options the respondent would, or would not, consider, or, did or did not consider.

Indecision can be another form of executive constraint. Indecision attributable to inhibition, “can't say”, is a form of blockage. Indecision occurs explicitly when a respondent declares an inability to choose at all or amongst options. However, indecision can be more commonly associated with ambivalence or vacillation or equality of appeal i.e. “can’t choose between them”. Without appropriate questioning it will not be certain whether selections are attributable to blockage or comparative selections.

*Automatic identifications*

“Automatic” here should not be interpreted to universally mean unthinking or unconscious, or to refer to simple choices, although those are included (Bargh & Morsella, 2010; Bargh & Williams, 2006). There are also the decisions that Klein (2008) calls “recognition primed” made by experts in their field (e.g. by a fireman confronted by a specific fire or by triage nurses handling emergency cases).

When one option is automatically selected remaining options are blocked, being ignored. To differentiate automatic identifications from comparative selections when a respondent is asked to identify a selection it may be sufficient to ask, for example, “Did you automatically choose X?”, or, simply, “Did you consider any other options?” If the option is sufficiently identified then the remaining alternatives would be coded as “ignored” except where other blockages, treated as prior, have been identified e.g. “unaware” might be said to be prior to “ignored”.

## 2.2 Comparative selections

Comparative selections are based on relations between two or more options or options and a standard. Here, options are considered in terms of their relative attraction. Comparative selections apply only between two or more unblocked options.

Like sufficient identification, it is possible, in principle, to sub-categorize forms of comparative selection, for example, by the intensity and scope of the evaluation process, when suitable additional data is collected (Svenson, 1992) or other decision characteristics (e.g. Lau, Kleinberg & Ditonto, 2018, Gigerenzer & Goldstein, 1996; Gigerenzer, 2008).

For the purpose of analysis, selections may be set as directly stated by the respondent, or from intentions data, or, inferred from ratings or rankings, or, in the form of assigned probabilities summing to one amongst the options, either directly obtained, or, from an external model that may be based on distal variables.

The approach outlined in this paper offers no detailed explanation of how comparative selections are made. The approach here may be viewed as providing a meta-model into which alternative explanations of comparative selection may be plugged after removing decisions made by way of sufficient identification. The dual-process distinction has obvious implications for methods, such as conjoint analysis and discrete choice models, which assume all choices are based, directly or indirectly, on option comparisons.[7] A perhaps not uncommon assumption in many fields is that most decisions are based on comparative selections. But as the analysis provided below suggests, this assumption is probably not be well founded.

[7] This includes all methods based on evaluations of utility or other measures of appeal across options or aggregated attribute utilities.

## *3 Decision arrays, sufficient identifications and comparative selections*

The following table exemplifies the types of decision-making data covering both sufficient identifications and comparative selections. Such data can be readily captured through surveys. The data on the four options for each respondent show each decision's proximal cause together with the selection outcomes for each option, for each case.

Table 2: Example decision arrays with proximal causes

| | **Option 1** | **Option 2** | **Option 3** | **Option 4** |
|---|---|---|---|---|
| **Respondent A** | Less attractive<br><br>Not selected | Less attractive<br><br>Not selected | More attractive<br><br>Selected | Less attractive<br><br>Not selected |
| **Respondent B** | Ignored<br><br>Not selected | Ignored<br><br>Not selected | Automatic selection<br><br>Selected | Unaware<br><br>Not selected |
| **Respondent C** | Unaware<br><br>Not selected | Irrelevant<br><br>Not selected | More attractive<br><br>Selected | Less attractive<br><br>Not selected |

The table shows that to understand such decisions it is necessary to review the option arrays on decisions for each option for each case and not just the adopted option. In this way a complete explanation of both the selections and non-selections is obtained in terms of the range of proximal causes.

While every respondent selected Option 3, each arrived by a different path:

> **Respondent A** arrived at the decision using only comparative selection weighing only the attractiveness of all alternatives.
>
> **Respondent B** carried out no comparative selections, ignoring two alternatives and being unaware of a third while automatically accepting Option 3 – a decision based solely on sufficient identifications with alternatives being blocked.
>
> **Respondent C** was unaware of one option and ruled another out thereby increasing the likelihood of selection amongst the remaining options from 25% to 50/50. The adoption of Option 3 may be seen as the combined result of sufficient identifications and comparative selections.

The table illustrates the four ways in which the proximal causes influence the choice outcomes:

1. Blockage generates an option's rejection and prevents its comparative selection.
2. Blockage of alternatives generates an increased propensity for selection amongst options available for comparative selection.
3. Automatic identification generates option adoption and blocks all alternatives.

4. Comparative selection amongst two or more non-blocked options creates selection and rejection outputs.[8]

With these elements in place, each decision array provides a rich understanding of selection outcomes in terms of alternatives. The challenge is how to collect and model such compositional data in a way which, when aggregated, preserves this richness but remains comprehensible and manageable.

## *4 A design for analysis*

The analytical objectives for applying the models below may range from compositional analysis of proximal variables with respect to known outcomes, to global modeling of the proximal decision process with outcome predictions.

To summarise, satisfactory analysis of decision-making across a set of options requires:

1. *For each respondent*, a compete explanation of both selections and non-selections amongst a set of options resolving the entanglement or conditionality amongst varieties of proximal cause involving sufficient identifications and comparative selections.
2. *For samples and populations*, an analysis of the contributions of varieties of proximal cause to decisions based on sufficient identification and comparative selection, respectively, to both selections and non-selections of each option.

The approach here is to model the individual, and to aggregate through averaging of the components to the group level, using an analogous decision structure.

A way to proceed is to evaluate how the decision elements contribute negatively and positively to the likelihood of selection outcomes reflecting the four sources of influence described in the previous section. With this in mind a general model for a single option for a single case can be outlined as follows:

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Probability of option selection | = | Base probability | + | Adjustment for sufficient identification | + | Adjustment for comparative selection | + | Error term |

This requires a reference point for the base probability from which systematic effects deviate toward the outcome. One common frame of reference is indifference amongst the alternatives. Here, the base probability for each option's selection is equal to 1/N,[9] where N is the number of options, summing to unity across the options. So each option has the same initial probability of selection and the analytical interest is in how each option's observed selection probability deviates from this criterion, individual by individual, for each proximal cause. Alternative bases are considered later in the paper.

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[8] Note that ties are not automatically precluded. That will depend on both the nature of the decision involved and the research design.

[9] This has been variously described as the principle of indifference, the principle of insufficient reason, equiprobability, and the principle of maximum entropy.

If respondents' actual *stated* decisions are included in the calculation of the comparative selection adjustment, for the purpose of proximal cause compositional analysis, then the error term for the model drops out. Such an analysis would focus solely on the composition of the proximal causes contributing to the outcome.

The sum of the selection probabilities over the set of options for a case will sum to unity except where respondents select none of the options.[10] This latter can only logically occur when the options available are incomplete and the respondent could not select any stated option. Such cases can be said to have selected the residual option and reported separately.

The model set out above is also applicable to group or sample data for each option where the elements simply consist of the means for each term (including means of sub-components). In the case of group or sample data the probability of option selection is the sample or group share – commonly expressed as a percentage share.

## *5 The indifference model*

Below is the choice equation for one option of one case for the indifference choice model. This equation is repeated for each option and the sum of the equations for the decision-maker always equals unity when the options exhaust the domain.

Each of the terms mirror the general model described above. The second and third terms show how sufficient identification and comparative selection, respectively, contribute to deviations from a chance selection.

$$P(O_i) = \frac{1}{\sum O_i} + \left( \frac{S_i}{\sum S_i} - \frac{1}{\sum O_i} \right) + \left( E(O_i) - \frac{S_i}{\sum S_i} \right) + e_i$$

$P(O_i)$ refers to the probability of selection of option i. O refers to an option and S refers to an unblocked option. The sum of O is simply a count of the options in the option set, while the sum of S is the count of unblocked options. The sum of S is a minimum of one. $E(O_i)$ refers to the respondent's expected option selection probability. While $P(O_i)$ and $E(O_i)$ are referred to as probabilities, the individual measures may commonly be simply ones and zeros, indicating selection and non-selection.

If the respondent's actual choices are used for $E(O_i)$, then $E(O_i)$ would be equal to $P(O_i)$, and error term drops out. This may be done where the main interest is in a components of choice analysis, such as measuring the contributions of sufficient identification versus comparative selection or different types of blockage. But when the interest is in the total model, $E(O_i)$ remains an estimate and the error term is included (while the overall predictive adequacy of the model can be tested against known results for $P(O_i)$).

While the terms of the equation correspond to those in the general model, formally, the second term, of the four on the right, is simply the difference between the indifference base probability and the comparative selection base probability revealing the adjustment to be attributed to sufficient identification. The third term is simply the adjustment

[10] Even if the set is not exhaustive of the possible options, an analysis of a respondent may be regarded as technically complete insofar as no unspecified option is selected or assigned a non-zero probability for selection.

attributable to the difference between the base likelihood of a successful comparative selection and the predicted evaluative outcome probability.

The second term on the right is of special interest since it has the effect of eliminating the comparative selection of an option when blocked, while at the same time increasing selection probabilities by a corresponding amount shared equally across the non-blocked alternatives. For example, where there are three options and one is blocked, the blocked option's selection probability is reduced from 0.33 to zero, while the two alternative probabilities increase from 0.33 to 0.50.

Repeating the equation for each of the four options for Respondent C of Table 2 above yields the following results:

Option 1: 1/4 + (0/2 – 1/4) + (0 – 0/2) = 0.25 - 0.25 + 0.00 = 0.00
Option 2: 1/4 + (0/2 – 1/4) + (0 – 0/2) = 0.25 - 0.25 + 0.00 = 0.00
Option 3: 1/4 + (1/2 – 1/4) + (1 – 1/2) = 0.25 + 0.25 + 0.50 = 1.00
Option 4: 1/4 + (1/2 – 1/4) + (0 – 1/2) = 0.25 + 0.25 - 0.50 = 0.00

The non-selection of Options 1 and 2 were determined wholly by sufficient identifications while Options 3 and 4 were determined jointly by sufficient identifications and comparative selections.

Further to the general effects of blockage, different types of blockage may be involved and need to be accounted for separately. In such cases, an expansion of the above second term on the right of the choice equation is required as shown on the right-hand side of the following equation.

$$\left(\frac{S_i}{\sum S_i}-\frac{1}{\sum O_i}\right)=\left(\sum_{j=1}^{B}\left(\frac{\sum B_j}{\sum B}\left(\frac{S_i}{\sum S}-\frac{1}{\sum O}\right)\right)\right)$$

The term $B_j$ refers to a blockage of a particular kind, say, unawareness, while B refers to any blockage and the sum of B to all blocked alternative options. The left term is simply the self-weighted sum of the different blockage contributions on the right.

An additional component of compositional analysis is a separate accounting of positive and negative contributions of blockage to each option when aggregating over sample data. Here, the positive contributions add to an option's share while the negative contributions reduce share. When aggregated, options trade gains and losses in varying proportions adding clarity to the interpretation of compositional analysis for groups and populations.

## 6 *Additional comments on model*

It is important to recognise that the blockage section of the model only accounts for the effects of blockages identified as such. Blockages of interest may vary from study to study in both character and scope. Of course, as already mentioned blockages may be viewed as consecutive or hierarchical so that one unaccounted blockage may be accounted by another, consequential, prior or more general.[11] But if this does not occur

[11] An example of this occurs in the example analysis in the next section of this paper. There, it is likely that option unfamiliarity, as a blockage, is underestimated on account of under-response to the relevant questionnaire item. However, it seems likely that where this non-recording occurred the response would

the missing blockage effects will fall within the comparative selection component of the model. In other words, while the model would be mathematically complete, treating the decision as “conserved”, its explicit representation of all the blockage effects depends on overt inclusion. When known to be substantially incomplete, the category of “comparative selections” may be more accurately described as “other” proximal sources unaccounted for by the blockages explicitly included. The development of any specific model needs to be critically examined with this issue in mind.

It is not strictly necessary to have comparative selection data available to perform a compositional analysis of blockage. All options that can be comparatively evaluated are simply defined as options that are not blocked. So where data are only available for the first two terms on the right hand of the equation, the blockage components can still be analyzed for their composition.

## 7 *Choice components analysis - an example*

The example below shows the contributions of sufficient identification and comparative selection to party votes followed by analysis of sub-components of sufficient identification. Here, the respondents’ choices are taken as known, so, $E(A_i)$ will equal $P(A_i)$, the error term is dropped, and the analysis is purely compositional. Sampling errors for the adjustment coefficients will still apply to the sample data. The compositional analysis itself was performed using a freeware Excel VBA program designed for the purpose (Gardner, 2018).

### 7.1 The New Zealand Election Study 2008

The New Zealand electoral system is MMP, a system similar to that used in German federal elections. Proportional representation of parties is at the centre of the system. The 2008 election, the subject of this analysis, resulted in a change of government.

The New Zealand Election Study (2008) surveyed the electorate following the 2008 general election. The survey file contains data from a pre and post stratified random sample of 3042 respondents yielding a weighted data file. Amongst eligible voters, 2,592 cast a validated vote for one of the eight parties represented in parliament, 99% of all those voting. These are the parties and respondents included in the analysis below. The self-response questionnaire contains many details on respondent attitudes, behavior and circumstances. The survey was not designed with choice components analysis in mind but contains data suitable for demonstrating the approach.

### 7.2 Blockages

Three blockages are included in the analysis – unfamiliar, ignored, and overlooked.

**Unfamiliar:** Respondents were asked to rate their liking for each of the eight parties or to answer “don’t know” if unable. These “don’t know” responses have been used as a measure of unfamiliarity. This measure is not entirely satisfactory as about 5% of respondents gave neither a rating nor a “don’t know” indication for each party, suggesting that the measure is an underestimate.

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frequently be accounted as ignored or overlooked by the same respondents. In such cases an option blockage has been generated in the analysis but incorrectly classified as ignoring or overlooking if unfamiliarity is treated as prior to both, but still, nonetheless, included in the analysis as blockage..

For the purpose of the analysis, unfamiliarity has been assumed to be a proximal cause *prior* to both ignoring and overlooking and the data arranged accordingly. This means that the shares of blockage attributable to ignoring and overlooking have been reduced in favor of unfamiliarity as the determinant cause, where applicable.

**Ignored:** Respondents were asked if they considered voting for any party in addition to their selection. If not, all other parties were ignored and an automatic selection generated for the voted party. Ignoring all other parties than the one selected is the general complement of automatic selection.

**Overlooked:** Respondents who did not ignore all other parties were asked which party or parties they considered in addition to the one they selected. When one or more other parties were considered, unconsidered parties were treated as overlooked.

These three areas of blockage are fairly broad in character providing some confidence that the possible sources of blockage are well covered. There was no direct measure of party awareness available so that unfamiliarity covers both cases unaware of parties and those who did not feel they knew sufficient about them to make a comparative selection. The overlooking of parties involved ruling them out for what would be, at a deeper level, a variety of sources – all potentially available for a more detailed analysis.

## 7.3 Party by party data

Table 3 provides a complete breakdown of the comparative selections, automatic selections, and blockages for each party. In other words, it shows the dispositions of all voters with respect to each party. The electoral shares of party votes are shown on line 6.

Table 3: Voter evaluations and blockages by party for all voters (Percentages)

| | | Labour | National | Green | NZ First | Act | United Future | Maori | Prog-ressive |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Comparative selections - selected | 20.8 | 23.5 | 5.2 | 3.2 | 3.5 | 0.8 | 1.9 | 0.9 |
| 2 | Comparative selections - not selected | 12.1 | 8.8 | 11.5 | 5.3 | 8.5 | 3.0 | 5.9 | 2.5 |
| 3 | Automatic selections | 13.9 | 22.6 | 1.5 | 1.1 | 0.5 | 0.1 | 0.7 | 0.1 |
| 4 | Total looking at each party (1+2+3) | 46.8 | 54.9 | 18.1 | 9.7 | 12.4 | 3.9 | 8.4 | 3.4 |
| 5 | Total comparative evaluations (1+2) | 32.9 | 32.3 | 16.7 | 8.5 | 11.9 | 3.8 | 7.8 | 3.4 |
| 6 | Party vote share (1+3) | 34.6 | 46.1 | 6.7 | 4.3 | 3.9 | 0.9 | 2.5 | 0.9 |
| 7 | Unfamiliar | 0.6 | 1.2 | 4.9 | 6.7 | 10.9 | 17.7 | 11.9 | 25.2 |
| 8 | Overlooked | 26.8 | 26.8 | 41.3 | 48.0 | 42.1 | 45.9 | 46.3 | 42.5 |
| 9 | Ignored | 25.8 | 17.2 | 35.7 | 35.7 | 34.6 | 32.6 | 33.4 | 28.9 |
| 10 | Total blocked (7+8+9) | 53.2 | 45.1 | 81.9 | 90.4 | 87.6 | 96.2 | 91.6 | 96.6 |
| 11 | All voters (4+10) | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

There are two distinct general patterns. The two main parties, National and Labour, have disproportionately higher levels of selection than other parties by way of both comparative and automatic evaluations (lines 1 and 3). They also have lower levels of unfamiliarity, ignoring or overlooking than those voting for other parties (lines 7, 8, and 9). Only for National and Labour did approximately half of all voters even look at each party. For the other parties, from about one in five to less than one in twenty voters looked at each (line 4). Amongst the blockages, overlooking and ignoring, in that order, dominated unfamiliarity (lines 7 to 9). Unfamiliarity had very substantial effects on only two parties (line 7). Blockage played a major role in the outcomes for all parties. This includes the two main parties which particularly benefited from voters ignoring alternatives, most especially National (line 3). Only for the two main parties did comparative selections approach one-third of all voters (line 5). However, comparative selections played a relatively more important role in the selection of the minor parties (comparing lines 1 and 3) although they were less successful than the two main parties in converting comparative selections to votes (comparing lines 1 and 5).

## 7.4 The choice components compositional analysis results

Table 3 does not show how the elements combine across parties, within voters, to yield the shares shown in line 6 of that table. Specifically, it does not show how sufficient identifications (via blockage) and comparative selections combine, voter by voter, to yield selections over the voting population. This information is provided by the aggregation of data from the indifference model choice equation. The summary results are shown in Table 4. Here, interests focuses on the relative sizes of the adjustment coefficients, measured in percentage points, in the blockage and comparative selection rows for each party. (Whether the signs are positive or negative is a function of party share relative to the base. For the two main parties the blockage contributions are positive but negative for the others.) Everywhere the contributions of the blockage coefficients many times dominate those of comparative selections, except for the Greens.

Table 4: Global contributions to party shares of
blockage and comparative selections (Percentage points)

| | Labour | National | Green | NZ First | Act | United | Maori | Prog-ressive | |
|---|---|---|---|---|---|---|---|---|---|
| Base | 12.5 | 12.5 | 12.5 | 12.5 | 12.5 | 12.5 | 12.5 | 12.5 | 100.0 |
| Blockage | ***19.4*** | ***28.1*** | ***-3.4*** | ***-7.3*** | ***-6.5*** | ***-10.9*** | ***-8.3*** | ***-11.1*** | 0.0 |
| Comparative selection | ***2.7*** | ***5.5*** | ***-2.3*** | **-0.8** | ***-2.1*** | ***-0.7*** | ***-1.7*** | **-0.5** | 0.0 |
| Party shares | 34.6 | 46.1 | 6.7 | 4.3 | 3.9 | 0.9 | 2.5 | 0.9 | 100.0 |

Confidence intervals and statistical tests can be applied to the coefficients. Simply add the base to a blockage coefficient, or, add these two together to a comparative selection coefficient, and compute the standard error of a proportion. This can be used to compute, say, 95% or 99% confidence intervals to see whether a result is smaller than a coefficient’s absolute size indicating the statistical significance of that coefficient.  This method can be extended to each component, making up blockage or comparative selection. The coefficients shown in Tables 4 through 8 in bold italics are significant at the 0.01 level and those in just bold at the 0.05 level. These are two-tailed tests.

As the tables will make clear below, each of the blockage components are the outcomes of positive and negative contributions amongst the respondents – positive contributions from gains from blockage of alternatives and losses from blockage of the option itself. The Table 4 figures are the net results of the positive and negatives impacts shown separately in Table 5. Every party has both losses and gains from blockage, but their respective impacts are negatively correlated between the two most popular parties and the rest. Within the option set the total losses and gains always net out to zero but their respective sizes reveal the very substantial role of blockage in the reallocation of vote shares.

Table 5: Positive and negative contributions of blockage to shares (Percentage points)

| | Labour | National | Green | NZ First | Act | United | Maori | Prog-ressive | Totals |
|---|---|---|---|---|---|---|---|---|---|
| Losses from blockage of option | ***-6.7*** | ***-5.6*** | ***-10.2*** | ***-11.3*** | ***-11.0*** | ***-12.0*** | ***-11.4*** | ***-12.1*** | -80.3 |
| Gains from blockage of alternatives | ***26.1*** | ***33.7*** | ***6.8*** | ***4.0*** | ***4.5*** | 1.1 | ***3.1*** | 1.0 | 80.3 |
| Total blockage | ***19.4*** | ***28.1*** | ***-3.4*** | ***-7.3*** | ***-6.5*** | ***-10.9*** | ***-8.3*** | ***-11.1*** | 0.0 |

An important source of blockage gains is automatic selection, where all the alternatives of an option are blocked. Table 6 shows the gains attributable to automatic selections in relation to the total gain coefficients. The gains are most notable for National and Labour accounting for three quarters and two thirds of gains, respectively. The residual differences (not shown), are attributable to gains from the blockage of some, but not all, alternatives. These account for most of the gains of the other parties.

Table 6: Gains to blockage on account of automatic selections (Percentage points)

| | Labour | National | Green | NZ First | Act | United | Maori | Prog-ressive |
|---|---|---|---|---|---|---|---|---|
| Automatic selections | ***17.0*** | ***24.9*** | **1.7** | **1.6** | 0.7 | 0.1 | 1.0 | 0.1 |
| Gains from blockage of alternatives | ***26.1*** | ***33.7*** | ***6.8*** | ***4.0*** | ***4.5*** | 1.1 | ***3.1*** | 1.0 |
| Automatic selections as a percent of blockage gains | 65.0 | 73.7 | 25.1 | 38.9 | 15.0 | 13.6 | 32.9 | 12.1 |

Table 7 shows the contributions of each of the three blockage components to the total blockage contributions. As the subtotals show, the scale of contribution from unfamiliarity is substantially smaller than the contributions from overlooking and ignoring.[12] Overlooking is the largest blockage contributor. In this example the overall pattern of losses and gains for each blockage type is similar across the parties - smaller losses and much more substantial gains for Labour and National and larger losses and smaller gains for the rest. Labour and National had net gains of more than 3% points by being more familiar, about another 9% points from the overlooking of alternatives, and another 7% and 15% points respectively by their voters ignoring other parties.

Table 7: Positive and negative contributions
of blockage components to shares (Percentage points)

| | | Labour | National | Green | NZ First | Act | United | Maori | Prog-ressive | Totals |
|---|---|---|---|---|---|---|---|---|---|---|
| Unfamiliarity: | Losses | -0.1 | -0.2 | -0.6 | -0.8 | **-1.4** | ***-2.2*** | **-1.5** | ***-3.1*** | -9.9 |
| | Gains | ***3.9*** | ***3.7*** | 1.0 | 0.5 | 0.3 | 0.1 | 0.3 | 0.1 | 9.9 |
| | Totals | ***3.8*** | ***3.5*** | **0.3** | **-0.3** | **-1.0** | ***-2.1*** | **-1.2** | ***-3.1*** | 0.0 |
| Overlooking: | Losses | ***-3.4*** | ***-3.3*** | ***-5.1*** | ***-6.0*** | ***-5.3*** | ***-5.7*** | ***-5.8*** | ***-5.3*** | -39.9 |
| | Gains | ***12.1*** | ***12.5*** | ***4.8*** | ***2.6*** | ***3.8*** | 1.0 | ***2.3*** | 0.8 | 39.9 |
| | Totals | ***8.8*** | ***9.2*** | **-0.4** | ***-3.4*** | **-1.5** | ***-4.7*** | ***-3.5*** | ***-4.5*** | 0.0 |
| Ignoring: | Losses | ***-3.2*** | ***-2.1*** | ***-4.5*** | ***-4.5*** | ***-4.3*** | ***-4.1*** | ***-4.2*** | ***-3.6*** | -30.5 |
| | Gains | ***10.1*** | ***17.5*** | 1.1 | 0.8 | 0.4 | 0.1 | 0.5 | 0.1 | 30.5 |
| | Totals | ***6.8*** | ***15.4*** | ***-3.4*** | ***-3.6*** | ***-4.0*** | ***-4.0*** | ***-3.7*** | ***-3.5*** | 0.0 |
| Blockage: | Totals | ***19.4*** | ***28.1*** | ***-3.4*** | ***-7.3*** | ***-6.5*** | ***-10.9*** | ***-8.3*** | ***-11.1*** | 0.0 |

The overall pattern of the above analysis is dominance of blockage as an influence across the options. It is a picture that strongly contrasts with common views on what determines electoral outcomes. It shows that, from the perspective of initial indifference, what is not considered by way of comparative selection is far more important than what is. Here, the absolute role of sufficient identifications had about six times the impact of comparative selections.

## *8 The general priors model*

The indifference model provides a special viewpoint from which to assess the effects of the proximal causes of decisions. The indifference model holds all option prior probabilities equal. Other perspectives can be obtained by changing the prior probabilities of the base while still summing each case to unity over the options. The

[12] On the one hand the role of unfamiliarity is increased on account of its being treated as a prior blockage to overlooking or ignoring blockages when these are present, but, on the other, is probably underestimated in the survey on account of the non-response as discussed above.

indifference model is founded on non-informative priors. Alternative priors may be seen as informative, for example, by basing them on how respondents voted at a previous election or how selections were made in a poll.

Here is the choice equation for one option for one case, for the general priors model:

$$P(O_i) = R_i + \left( \frac{R_i S_i}{\sum (R_i S_i)} - R_i \right) + \left( E(O_i) - \frac{R_i S_i}{\sum (R_i S_i)} \right) + e_i$$

The prior probability for an option is $R_i$. While the indifference model is always computable, zero priors in the general model are problematic and can yield incorrect or insoluble results. For example, an automatic selection with a zero prior will yield a successful comparative selection when there is nothing to compare! This problem of the zero prior is resolved with Cromwell's rule (Lindley, 1991) by substituting a tiny but non-zero probability, say, one in a million.[13] Cases unable to make any selection from the available options are excluded from the analysis and separately accounted.[14] As with the indifference model, if the respondent's stated selection is used for $E(O_i)$, then $E(O_i)$ equals $P(O_i)$ and error term drops out, and the analysis becomes purely compositional.

For each case, when there are different types of blockage to be accounted separately, where an option is selectable but alternative options are blocked, then an extension of the above second term is required as shown on the right-hand side of the following equation. The left term is simply the priors weighted sum of the different blockage contributions on the right.

$$\left( \frac{R_i S_i}{\sum (R_i S_i)} - R_i \right) = \left( \sum_{j=1}^{B} \left( \frac{\sum B_j}{\sum B} \left( \frac{R_i S_i}{\sum (R_i S_i)} - R_i \right) \right) \right)$$

## *9 Example comparison of general priors and indifference models*

Table 8 provides a comparison of global results for an informative priors model with an indifference model analysis. The sample for this analysis has been limited to those cases voting for one of the eight parliamentary parties in both the 2005 and 2008 elections. These 2,273 cases represent 85% percent of the weighted sample. How these voters cast their votes in 2005 is set out in the first row of data i.e. the priors base.

The major differences between the bases for each analysis, and within the priors base, make the results very different. With the indifference model the absolute roles of blockages were about six times those of comparative selections. For the informative priors model the absolute values for blockage and comparative selections are much more

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[13] Zero priors can be expected to be common when data is coded "1" for selected and "0" for not selected. It may seem logically inconsistent to regard a statement of "not selected" as having a non-zero probability, but any real-world observation has a non-zero probability of either being falsely recalled, stated, or perceived or of being recorded, transposed or encoded incorrectly, for example. It is true that adding a very small probability will sum the probabilities to greater than one at the level of the $n^{th}$ zero plus one but at the reporting level unity will be the result. It is arguable whether an impossible selection has any place in a realistic analysis (see "0 and 1 are not probabilities" at: http://lesswrong.com/lw/mp/0_and_1_are_not_probabilities/ )

[14] As with the indifference model, this is obviated by including an exhaustive set of options.

similar. But, in the informative priors model, Labour loses share through both blockage and comparative selection. National gains similar amounts through both. Meanwhile, the smaller parties make a mixture of small losses and gains from both sources. This contrasts with the uniformly negative effects of both sources in the indifference model that stem from the smaller parties shares of the total yielding negative deviations from the base.

The similar contributions of both blockage and comparative selection are perhaps somewhat unexpected. Behaviors associated with sufficient identifications seem intuitively less likely to shift relative to comparative selections. The substantial role of blockage in the changes revealed by the informative priors model is explicable, in part, by the three years between measures, allowing for the marked attitudinal realignments shown for the two principle parties. Also, special features may underlie the electoral dynamics of this particular electoral cycle e.g. changes in party leadership.

Table 8: Priors and indifference models compared - global contributions to party shares of blockage and comparative selections (Percentage points)

| Informative priors model | Labour | National | Green | NZ First | Act | United | Maori | Prog-ressive | Totals |
|---|---|---|---|---|---|---|---|---|---|
| Priors base | 49.6 | 33.9 | 4.8 | 5.3 | 2.9 | 2.0 | 0.9 | 0.7 | 100.0 |
| Blockage | ***-7.3*** | ***6.8*** | 1.0 | ***-1.4*** | 0.5 | **-0.6** | ***1.0*** | 0.0 | 0.0 |
| Comparative selection | ***-6.5*** | ***5.3*** | 0.6 | 0.1 | 0.4 | ***-0.6*** | ***0.5*** | ***0.3*** | 0.0 |
| Party shares | 35.8 | 46.0 | 6.3 | 3.9 | 3.8 | 0.8 | 2.4 | 1.0 | 100.0 |
| **Indifference model** | **Labour** | **National** | **Green** | **NZ First** | **Act** | **United** | **Maori** | **Prog-ressive** | **Totals** |
| Indifference base | 12.5 | 12.5 | 12.5 | 12.5 | 12.5 | 12.5 | 12.5 | 12.5 | 100.0 |
| Blockage | ***20.1*** | ***28.6*** | ***-3.6*** | ***-7.9*** | ***-6.8*** | ***-11.0*** | ***-8.4*** | ***-11.0*** | 0.0 |
| Comparative selection | ***3.2*** | ***5.0*** | ***-2.6*** | -0.7 | ***-1.9*** | ***-0.7*** | ***-1.7*** | **-0.5** | 0.0 |
| Party shares | 35.8 | 46.0 | 6.3 | 3.9 | 3.8 | 0.8 | 2.4 | 1.0 | 100.0 |

Each model is appropriate to its context – the indifference model providing a basic understanding of the overall forces as work at any given time, and the informative priors model, revealing the proximal sources of change from one time to another. Further exploration of the results is possible via sub-analysis of models by sub-groups or via connection of the proximal with distal variables.

## *10 General discussion*

To summarize, the procedures outlined above involve the application of a descriptive, agent-based, options-oriented methodology for the ecological analysis of decisions and their proximal causes. Emphasis has been placed on analysis of all option outcomes for each case to obtain a complete picture of the decision. A dual-process approach was used to classify the proximal causes of single option decisions, on the one hand, and multi-option decisions, on the other – namely, sufficient identifications and comparative selections. These two factors are seen to mediate all distal causes of decision-making. Sufficient identifications can be measured both directly and indirectly by way of blockage of comparative selections. However, blockage amongst alternatives means that any remaining comparatively selectable options are more likely to be adopted – so either sufficient identification or comparative selection, or both, can play a role in each option outcome. The choice equations operationalize and integrate these elements, with the inclusion of a reference base, to show how the proximal causes of selection create deviations from indifference amongst the alternatives or from informative priors. The choice of the reference base determines the perspective or frame of the analysis and influences the character of the corresponding results.

There are a variety of sources of sufficient identification, each one enough to resolve an option outcome, either positively or negatively, wherever applicable. Negative categories of sufficient identification include lack of awareness, familiarity, supply and demand constraints, and executive constraints, while automatic adoption is positive. In principle, comparative selections could also be sub-classified. These classifications make possible the sub-analysis of each of the dual processes revealing the influence of each on individuals or groups or populations.

Compositional analysis, as described above, is relatively simple and straightforward. But full modeling of decisions would additionally involve measurement issues surrounding predicted selections and issues concerning the treatment of selection ties when present (Söderlund, 2009). These issues are not unique to the models described in this paper and have not been considered here. However, it should be noted that the dual-process distinction and the option-by-option data are capable of playing an important role in the allocation of undecided cases of comparative selection amongst options when attempting to estimate option shares.[15] This is important because ties are commonly implicit in the, say, one-fifth to one third of respondents to be found in the "don't know" or "can't say" categories.

To conclude, the options oriented approach outlined in this paper suggests an analogy with the physics concept of "conservation". Indeed, within quantum physics there is the notion of "conservation of probability", which, as here, must always sum to unity. There is also the idea of "probability flux" which describes the "flow" of probabilities – an idea analogous to the coefficients in the choice equations. So, decision-making may be characterized as follows where the options on each side remain the same but their probabilities can vary with the constraint that each side sums to one.

$$(O_1 + O_2 + O_3 + \ldots O_n)_{d1} = (O_1 + O_2 + O_3 + \ldots O_n)_{d2}$$

The differences in probability between corresponding options on each side are the sum of the change coefficients for sufficient identification and comparative selection. The terms $d_1$ and $d_2$ may be taken to refer to different times or changes in reference frame (e.g. from an indifference base to measured status). As with the conservation of energy where energy can be neither created nor destroyed, only transformed, so is the case with a given set of options. But while the application of energy in the process of work leads to

[15] Allocation of comparative selection "undecideds" on the basis of the distribution of the comparative selection "decideds" is likely to yield more accurate results than those based on the total sample "decideds", for example.

dissipation and entropy, decision-making commonly leads in the opposite direction, towards a focus for action, a *concentration* of “psychological energy”.

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