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ABSTRACT

Moody Choice*

If choices depend on the decision maker's mood, is the attempt to derive any consistency in choice doomed? In this paper we argue that, even with full unpredictability of mood, the way choices from a menu relate to choices from another menu exhibits some structure. We present two alternative models of 'moody choice' and show that, in either of them, not all choice patterns are possible. Indeed, we characterise both models in terms of consistency requirements of the observed choice data.

JEL Classification: D01

Keywords: bounded rationality, procedural rationality, utility maximization, choice behavior

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1 Introduction

Mood affects choice. This relationship has been analysed extensively in psychology.[1] For example, mood has been shown to modulate variety seeking in consumer goods (Kahn and Isen [21]), aversion or propensity to risk taking (Williams and Voon [57]), dietary and exercise habits (Thayer [54], [55]). Positive or negative emotional reactions to economic conditions are demonstrated to affect strongly partisanship in elections (e.g. Clarke, Sanders, and Whiteley [9]). Good mood was found to decrease time preferences (Ifcher and Shaghaghi [19]), increase productivity (Oswald, Proto and Sgroi [46]), increase altruistic behavior in the dictator game (Capra [8]) and to increase generosity while bad moods increase reciprocity (Kirchsteiger, Rigotti and Rustichini [23]). The marketing literature on this topic is equally extensive, its broad focus being on how different moods and affective states condition product choice.[2]

The Oxford Dictionary of the English Language defines mood as 'a temporary state of mind or feeling'. So 'mood' as a notion subsumes its various incarnations of e.g. anxiety, savouring, dread.[3] Although there are many papers in the economics literature that deal with specific manifestations of mood and their effect on choice,[4] as far as we are aware there has been no attempt to model mood in a general and systematic way, independently of its various realisations.[5]

In this paper we formalise a notion of mood and we study how mood may affect an

[1] A sample of publications is: Erber, Wang and Poe[14], Isen [20], Kahn and Isen [21], Mayer, Gaschke, Braverman and Evans [32], Mittal and Ross [42], Nygren [43], Nygren, Isen, Tayor and Dulin [44], Williams and Voon [57].

[2] See e.g. Groenland and Schoormans [18], Lewinson and Mano [29] or Qiu and Yeung [47]

[3] A terminological note. 'Mood' is related to 'emotion', but even among psychologists the exact distinction between the two concepts is not settled, see e.g. Beedie, Terry and Lane [5]. Mood and emotion are both instances of 'affect', with mood tendentially interpreted as a more diffuse, prolonged and uncaused affect than emotion. Dickert [12] deals with the measurement of emotions, which also addresses the definitional challenge (i.e., what exactly is an emotion?). As in this paper we remain vague on issues of permanence, stability and cause, we might have used the generic term 'affect' instead of 'mood'. We have chosen the latter term because it is more recognisable and less awkward outside the field of psychology: 'affect' is 'a term that tends not to be used in everyday language to describe human experience and one that was not mentioned once by any of the 106 respondents in the present study.' (Beedie, Terry and Lane [5]). In this paper we rely mostly on the notion of 'mood as information' (see Schwarz and Clore [53]). See also Gardner and Hill [15].

[4] From Loomes and Sugden's regret theory [30], to Caplin and Leahy's psychological expected utility [7], and Köszegi's personal equilibrium [26] just to cite a few. See also Kliger and Levy [24] and the references in the recent survey by Rick and Loewenstein [48].

[5] The only exception is possibly the theory of psychological games introduced by Geanakoplos, Pearce and Stacchetti [16] and further developed by Battigalli and Duwfenberg [4]. There, though, psychological states are induced by 'the road not taken' in the context of a game. Here we backtrack one step, and focus on a single decision maker confronted with choices over alternatives, rather than strategies.

agent's choice. We present a model in which choice, even though subject to mood swings, need not be unpredictable. Even moody behaviour presents some systematic patterns, which can be identified by means of direct observable choice data. We assume throughout that the mood itself in which a choice is made is not necessarily observable: only the resulting choice is.

We posit that any general model of mood must identify a fixed component, invariant to mood; and a variable component, affected by the current psychological state. Our central modelling idea is that mood affects choice by controlling the *urgency of the attributes* sought in the available alternatives by the decision maker. A mood (such as loneliness) that induces a craving for sweet food, for example, is expressed 'operationally' in our model as the statement 'sweetness is an important attribute of what the agent is going to eat'.

The attribute 'variety' was more sought after, in an experiment (Kahn and Isen [21]), when a positive mood was induced by the experimenter: in our model this is represented by pushing 'variety' higher in the attribute urgency ranking. Similarly, a depressed mood, which is known to sometimes provoke overeating as a coping strategy (Thayer [55]), pushes down the attribute 'healthiness' when selecting a meal, and pushes up the attribute 'high sugar/fat content'. A less obvious example is that of a negotiator in an aggressive mood, who raises the bar to consider an offer acceptable: this can be modelled in our framework by pushing to the top all the 'deal-breaking' attributes which are sought in an offer. As a final example, one might argue that 'irrational exuberance' among financial operators (a memorable example of collective mood), consists at least in part of focussing more on the speculative prospects of large gains rather than on the danger of losses.

We distinguish between *mood* and *mindset*. We call 'mindset' the *set* of attributes (or properties) which are considered by an agent when making a choice, 'the things that make an agent tick'. A glutton would have to change his mindset/personality, not just his mood, to start paying attention to the fat content of his diet, and a foolhardy agent will ignore, in any mood, the safety features of his choices.

While the set of attributes that constitutes a mindset is fixed throughout all choices, how these attributes are ranked with respect to one another, i.e. the agent's mood, can vary across different choice problems: 'soothing' might be an attribute that the decision maker generally considers (i.e. it is part of his mindset), that it is pushed down in importance in a buoyant mood, when it is considered as a relatively minor attribute; but that becomes the most important attribute when in a dejected mood. This allows an agent that has a fixed set of values to make different choices under different moods: if a mood reorders the priority that each attribute possesses, then it is conceivable that one alternative that possesses the attribute that is top in a mood might be selected if available in that mood, but discarded when available under a mood that privileges a different attribute that this alternative does not possess.

So how are moods determined? We pursue two alternative modeling strategies so as to capture two distinct ways in which, we argue, mood may affect choice. The following examples illustrate.

Example 1 ***(Menu induced mood I)*** *A wine consumer has a mindset comprising the attributes {within a Tight budget}, {within a Loose budget} and {with a Great taste}, that is T, L and G, respectively. In a 'cool' mood, his top priority is to stick to a tight budget, so that he would first consider wines within the tight budget. However in a 'hot' mood meeting the taste feature becomes paramount, and the ranking of the attributes puts G on top, followed by L and T. Suppose that the 'hot' mood is triggered by the presence of a very expensive and top-of-the-range wine z, while otherwise he is in a 'cool' mood. Then, when z is not present, we would observe this consumer buying a mid ranging wine x that meets the tight budget rather than a better and more expensive wine y that does not; while if z is available we would observe our consumer buying y, which passes the great taste test, and discard x, which does not.*

Example 2 ***(Menu induced mood II)***[6] *A child has a mindset comprising {naughty food} and {mum's choice}. In a neutral mood he would put naughtiness on top, but in a docile mood he would put mum's choice first. Suppose that the docile mood is triggered by the presence of fruit juice. Then in a menu including fruit juice he picks more fruit and vegetables items, that mum would be happy with, than if we remove fruit juice from the same menu.*

Example 3 ***(Environment induced mood I)***[7] *A decision maker is recovering from surgery in hospital. His mindset comprises the two attributes {low chemical stuff in my body} and {getting stoned}. After being shown a humorous movie, {low chemical stuff in my body} is the most important attribute; while {getting stoned} is top after being shown an action movie. So in the first situation, when he is in a good mood, he only*

[6] This example is loosely based on the field evidence in Obadia et al [45], who study ordering patterns in paediatric hospital patients. The children ordered a mean of 5 servings of fruits and vegetables/day, which decreased to 3.5 servings when juice was removed.

[7] This example is based on the evidence in Rotton and Shats [49]: in a carefully designed field experiment conducted with 78 orthopedic patients recovering from surgery, they find that humor (i.e. exposure to humorous movies as opposed to action ones) reduced requests for minor medication. Interestingly, for those patients who had been unable to choose which humorous movie to watch out of a given list increased use of heavy analgesic.

asks for a low dose of pain killer (which satisfies the property of inserting limited amounts of chemical in the body), while after watching the action movie, when he is in a neutral mood, he asks for a higher dose of painkiller.

Example 4 ***(Environment induced mood II)***[8] *A decision maker's mindset comprises the two attributes {large upside} and {limited downside}. Assume that this decision maker considers 'large' any monetary amount above \$30, and 'limited' any monetary amount above not exceeding \$5. Suppose he is choosing between a low risk lottery* $l = (\$16, 0.7; \$20, 0.3)$ *offering \$16 with probability* 0.7 *and \$20 with the complementary probability; and the high risk lottery* $h = (\$1, 0.7; \$38.5, 0.3)$ *offering \$1 and \$38.50 with probabilities 0.7 and 0.3, respectively. When in an angry mood, {large upside} becomes the prominent attribute, while in a fearful mood {limited downside} is the most prominent attribute. So when angry he picks* h *over* l*, since* h *has the attribute 'large upside' that* l *does not possess; while when fearful he picks* l *over* h*, since* l *has an 'limited downside', which is now the most important attribute, while* h *does not.*

In the first two examples, mood is triggered by the choice set under consideration. In the last two examples, mood is determined by factors exogenous to the choice problem (the 'environment'), and the agent is observed making choices from the same set in different moods. Yet, in most cases outside controlled experiments, we cannot observe the moods of an agent making a choice.[9] We provide a framework to capture both types of situations, and characterise each of the two alternative scenarios with restrictions on choice behaviour that we can test with (observable) choice data.

The two models are logically independent (section 5). The model in which mood is menu-induced is fully characterised by a new choice axiom that is intermediate in strength between two well-known standard consistency properties: it is weaker than the Weak Axiom of Revealed Preference (WARP) and stronger than Sen's property β (section 3). Concretely, the axiom implies that a moody agent will always express coherent 'behavioural indifferences': if he reveals himself willing to engage in a *sequence* of trades, say leading from x to y, then he will also be willing to engage in a *direct* trade between x and

[8] This example is based on the evidence in Kugler, Ordóñez and Connolly [27], who find that inducing moods of fearfulness results in the tendency to choose less risky lotteries as compared to the case when anger is the induced mood in an experiment with real monetary payments.

[9] In experimental situations several standard psychological devices are used to *trigger* a mood. A positive mood, for instance, may be triggered by a gift of candy-bars prior to the agent performing the task, or by asking the subject to recall a positive event. The triggering of moods in real-life situations is a more complex phenomenon, which we do not analyse in this paper. We do not take a position on whether such devices really trigger the asserted mood, or whether they do so for all subjects. Our arguments only presuppose that the agent is observed to make choices from the same set in different moods (whatever they are).

y. So in particular a welfare planner can still use, like with a standard agent, behavioral indifferences as a guidance (he cannot, however, use in the same way the agent's strict revealed preferences).

The second model, where mood is environmental, admits multiple observations of choice from the same feasible set (in different moods). We show that the set of possible choice observations (in all possible moods) fails to satisfy Independence of Irrelevant Alternatives and other consistency properties, yet is again characterized by a single property that is intermediate between two standard consistency properties: it is weaker than WARP and stronger than Property α. It states that if x is always rejected (in any mood) from a set A, then it is always rejected from any other set which contains *all* the alternatives chosen (in some mood) from A (section 4).

As we shall see, this in turn implies that, to an external observer, the choices of a moody agent appear as if the agent were maximising a utility function but committed occasional *mistakes* (picking alternatives that do not maximize utility). The error pattern, however, will satisfy the constraint that any alternative chosen by mistake in a large set can also be chosen by mistake in a smaller set. This is in agreement with some leading models of choice with error.

2 Mindset and mood

Fix a nonempty set of alternatives X. Given a set Σ including all nonempty finite subsets of X, a choice function on Σ is a map c that associates with each $A \in \Sigma$ (a feasible set, or *menu*) a nonempty set $c(A) \subset A$. The object $c(A)$ is interpreted as the agent's *observed* selection from A.

To build a model of moody choice, we assume, as in Mandler, Manzini and Mariotti [34] (MMM), that the agent makes choices by sequentially going through a checklist of 'properties' of alternatives (properties are intended as synonymous with 'attributes'). At each step, he discards the alternatives that do not possess the relevant property. In spite of being procedural, that decision model is shown in MMM to be essentially equivalent to ordinary preference maximisation: an agent has a checklist if and only if he maximises a preference relation. Any checklist corresponds with a preference, and viceversa. However the checklist model has richer primitives than ordinary preference maximisation. It is this feature that permits to distinguish, unlike with a preference, between the more stable traits of the agent's personality (mindset), and the more variable aspects (mood).

We identify a property with the set of alternatives that possess that property. So formally a property is simply a subset $P \subset X$, and we say that x has property P whenever

$x \in P$. E.g. the property 'sweet' consists of all the objects in X which are sweet.

A **mindset** $\Gamma \subset 2^X \backslash \varnothing$ is a set of mutually distinct properties. A mindset Γ is **nested** if for all $P, Q \in \Gamma$ we have either $P \subset Q$ or $Q \subset P$.

Given a mindset Γ, a **mood** is a well-order $<$ of Γ.[10] Given $<$, a property P in Γ is **finite** if the set $\{Q \in \Gamma : Q < P\}$ is finite.

3 The mood is determined by the menu

We first examine a model in which the mood depends on the choice set. Multiple choices from a choice set are allowed, and they are interpreted as being made always in the same mood (the one triggered by the choice set itself). For this reason, given a mindset Γ and a set $A \in \Sigma$, we denote by $<_A$ the well order of Γ induced by A (which we refer to as 'a mood for A'). Denote by P_0^A the first property in mood $<_A$ (the $<_A$ −least element of Γ).

A **variable checklist** is a pair $\left(\Gamma, \{<_A\}_{A\in\Sigma}\right)$ of a mindset and a collection of moods, one for each choice set.

Given $A \in \Sigma$ and a variable checklist $\left(\Gamma, \{<_A\}_{A\in\Sigma}\right)$, define inductively:

$$S_A\left(P_0^A, <_A\right) = A$$

and

$$\text{For all} P \in \Gamma \backslash P_0\text{: } S_A(P, <_A) = \begin{cases} \bigcap\limits_{Q <_A P} S_A(Q, <_A) \cap P & \text{if } \bigcap\limits_{Q <_A P} S_A(Q, <_A) \cap P \neq \varnothing \\ \bigcap\limits_{Q <_A P} S_A(Q, <_A) & \text{otherwise} \end{cases}$$

That is, when facing the choice set A, the agent's mood for that set identifies the order of the properties in the checklist. The agent scans the checklist, and when considering each property he only retains the alternatives which have that property, if any. Otherwise he retains all the alternatives that have survived until that stage. Then the agent moves to next stage.

When convenient we omit denoting the well order in the sets $S_A(P, <_A)$ and simply write $S_A(P)$.

[10] A well-order $<$ on a set Y is a a linear order (complete, transitive and antisymmetric relation) with the property that any subset of Y has a $<$-least element.

Definition 1 *A choice function c on Σ* ***has a variable checklist*** *if there exists a variable checklist $\left(\Gamma, \{<_A\}_{A\in\Sigma}\right)$ such that for all $A \in \Sigma$, for some finite property $P \in \Gamma$,*

$$\begin{aligned} S_A(P) &= S_A(Q) \text{ for all } Q \in \Gamma \text{ with } P <_A Q \\ c(A) &= S_A(P) \end{aligned} \tag{1}$$

In words, a choice function has a variable checklist if only and all those alternatives that are chosen from a set are in the 'last' survival set constructed on the basis of the relevant mood. Observe that since the P in the definition is required to be finite, the procedure always terminates in a finite number of steps, although in principle we allow the agent to be described by an infinite number of properties (for example if he discriminates continuously along a certain dimension or characteristic). This finite termination aspect seems a crucial element of realism. For future reference we also define choice functions with variable checklists without this property (i.e. allowing P in definition 1 not to be finite) as having a **long variable checklist**.

As we said already, here it is potentially possible that each set triggers a different mood, i.e. a different order in which the various properties are considered. To the contrary, MMM consider checklists that are independent of the choice set.

Definition 2 *A choice function c on Σ* ***has a checklist*** *if it has a long variable checklist $\left(\Gamma, \{<_A\}_{A\in\Sigma}\right)$ with $<_A=<_B$ for any $A, B \in \Sigma$.*[11]

A choice function c having a checklist expresses the classical notion of rationality in economics, preference maximisation. A choice function c maximises a preference if there exists a weak order[12] $\succsim$ on X such that, for all $A \in \Sigma$, $c(A) = \{x : x \succsim y \text{ for all } y \in A\}$

Theorem 1 *(MMM): A choice function c on Σ has a checklist if and only if it maximises a preference.*

A choice function may have a variable checklist even when it has no checklist:

Example 5 *A consumer enters an 'exuberant' mood when he faces large menus or menus composed entirely of luxury items, but is in a thrifty mood when a thrifty item is available in a small menu. As a consequence he will for instance choose an expensive food item in a hefty restaurant list, and a modest entree in a shorter one. Formally, let $X = \{x, y, z\}$*

[11] To be precise, this definition refers to 'extended checklists' in MMM. Since in this paper we will not need to distinguish between extended and other types of checklists, we omit the adjective.

[12] A weak order is a a complete transitive relation.

and let $\Sigma = 2^X \backslash \varnothing$*, where* x *and* y *are luxury items,* z *is thrifty, and only the grand set is large. So*

$$\begin{aligned} c(X) &= c(\{x,y\}) = \{x,y\} \\ c(\{x,z\}) &= c(\{y,z\}) = \{z\} \end{aligned}$$

The choice function c *cannot maximise any weak order (*$c(X) = \{x,y\}$ *would imply* $x \succsim z$ *while* $c(\{x,z\}) = \{z\}$ *would imply* $z \succ x$*) and therefore by the previous theorem it cannot have a checklist. Nevertheless it has the variable checklist* $(\{\{x,y\},\{z\}\},<_A)$ *with the mood* $\{x,y\} <_A \{z\}$ *for* $A \in \{X,\{x,y\}\}$ *and the mood* $\{z\} <_A \{x,y\}$ *for* $A \in \{\{x,z\},\{y,z\}\}$*.*

3.1 A moody agent does not necessarily make moody choices

Mood is not necessarily expressed in observable choice behaviour. In particular, mood is of consequence only when the properties cannot be ranked as more or less permissive, i.e. when they are not nested.

Example 6 *Suppose that we observe*

$$\begin{aligned} c(\{x,y,z\}) &= c(\{x,y\}) = c(\{y,z\}) = y \\ c(\{x,z\}) &= z \end{aligned}$$

We could infer that the mindset is $\{\{y\},\{y,z\}\}$ *with mood* $\{y\} <_A \{y,z\}$ *for all* A*, but we could equally well apply the opposite mood* $\{y,z\} <_A \{y\}$ *and still retrieve the same choice data.*

When the mindset is nested, the agent's mood does not affect choice: a moody agent behaves exactly like a non-moody agent.

Proposition 1 *Let* c *be a choice function that has a variable checklist with nested mindset. Then* c *maximises a weak order* $\succsim$ *on* X*.*

(All proofs are in the Appendix). A leading example of nested properties is provided by a textbook utility maximiser who uses as properties the upper contour sets of the utility function. This case has a natural procedural interpretation: the agent is in fact a satisficer who at each stage t sets a threshold numerical satisfaction target s_t. At stage

t, the agent keeps only the satisficing alternatives (those that meet the target s_t), if any, and otherwise he keeps all of them. In the next stage he revises the satisfaction threshold. There is no need to specify the revision rule, precisely because the properties are nested. The maximal alternatives (in terms of the numerical measure) in a set will never be eliminated: if when considering a property P the set of survivors from the previous stages contains some alternatives that are in P, then the maximal alternatives must be among them. The mood, in this interpretation, manifests itself in the initial property s_1 and the revision rule adopted: sometimes (e.g. when he is in an impatient mood) the agent will start with ambitious targets, and sometimes with more modest ones; sometimes he will react to the lack of satisfactory alternatives by radically revising down the target, and sometimes he will hold firm. This agent is moody as well as procedural but his choice behaviour never appears to be swayed by his mood.

The fact that the agent changes choice after mood alteration may be used as a test to select between alternative possible mindsets that could all explain a given initial choice. In the previous example, we could have also inferred the mindset $\{\{x,y\},\{y,z\}\}$ using the the mood $\{y,z\} <_A \{x,y\}$ for all A. But with this mindset the mood *is* important: the mood $\{x,y\} <_A \{y,z\}$ for all A would have generated the choice $c(\{x,z\}) = x$ instead of $c(\{x,z\}) = z$. If we observed such a change in choice, we would know that the mindset cannot be nested.

3.2 The observable behavioural implications of menu-induced moody choice

Even when behaviour is moody, it needs not be completely unstructured: by using a 'revealed preference' type of property, we can reject the hypothesis that the decision maker is acting on the basis of mood by observing certain patterns of choice:

Example 7 *Let $X = \{w,x,y,z\}$ and $\Sigma = \{\{x,y,z\},\{w,x,y\}\}$. Suppose*

$$\begin{aligned} c(\{x,y,z\}) &= \{x,y,z\} \\ c(\{w,x,y\}) &= \{x\} \end{aligned}$$

The choice from $\{w,x,y\}$ implies that, if there existed a variable checklist, then its mindset would contain a property P which 'separates' x and y, i.e. $x \in P$ and $y \notin P$. But then, whatever the mood at X, such a property would sooner or later also separate x and y in $\{x,y,z\}$, contradicting $x,y \in c(\{x,y,z\})$.

The reasoning in the above example suggests a necessary property:

Togetherness: If an alternative x is rejected from a set from which another alternative y is chosen, then x cannot be chosen when y is chosen. Formally, for all $A, B \in \Sigma$: $[x \in A \backslash c(A), y \in c(A), y \in c(B)] \Rightarrow x \notin c(B)$.

This property is equivalent to saying that if x and y are both chosen from a set, then from any other set x and y are either both chosen or both rejected, hence the name Togetherness. It is intermediate in strength between two classical revealed preference properties: the Weak Axiom of Revealed Preference (WARP) and Sen's property β. These are defined as follows:

WARP: If an alternative x is rejected from a set from which another alternative y is chosen, then x cannot be chosen when y is available. Formally: For all $A, B \in \Sigma$: $[x \in A \backslash c(A), y \in c(A), y \in B] \Rightarrow x \notin c(B)$.

Property β: If an alternative x is rejected from a set from which another alternative y is chosen, then x cannot be chosen in smaller set from which y is chosen. Formally, for all $A, B \in \Sigma$: $[B \subset A, x \in A \backslash c(A), y \in c(A), y \in c(B)] \Rightarrow x \notin c(B)$.

Observe that these axioms share the same conclusion as Togetherness, but Togetherness reaches it from a weaker (resp. stronger) premise than Property β (resp. WARP). It turns out that the property is also sufficient to characterise the model.

Proposition 2 *A choice function c has a variable checklist if and only if it satisfies Togetherness.*

This result clarifies the sense in which our model yields testable conditions that apply even to moody behaviour: an agent, no matter how moody, will never be observed to accept two alternatives from one set while rejecting only one of the two from another set.

The relation $\approx$ introduced in the proof of proposition 2 is simply one of 'behavioural indifference': $x \approx y$ requires x and y to be never separated by choice. A moody agent satisfies the transitivity of the behavioural indifference $\approx$. So in particular he is willing to carry out in one step a trade, such as between x and y, when he has implicitly (via $\approx$) revealed his willingness to carry out a sequence of pairwise trades leading from x to y. Moreover he will be willing to carry out explicitly the implicit sequence of trades in any order. This is because the implicit trades which are acceptable to a moody agent are all and only the trades between alternatives that have exactly the same properties, and 'having the same properties' is a symmetric and transitive relation.[13] Of course, alternatives can share the same properties whilst being different: for example, walking, cycling and taking a bus can all belong to a 'cheap leisurely means of transport' behavioural indifference class for an agent.

These observations are relevant for welfare analysis. Like in the standard case, a planner, faced with the task of choosing between implementing x or y, may let himself be guided by the sequences of behavioural indifferences of a possibly moody agent without fear of hurting the agent's welfare (namely, without strictly contradicting the pairwise choice the agent himself would make between x and y). The difference with standard welfare analysis is that the planner can no longer always use the behavioural strict preferences in the usual way to welfare judgements as a guide if he suspects that the agent is moody. Nevertheless, a case for strict welfare judgements can still be made, as we explain below.

We first observe that there is a different way to express Togetherness which sheds further light on the behavioural restrictions it implies:

All or Nothing: For all $A, B \in \Sigma$: If $c(A) \cap c(B) \neq \varnothing$, then $c(A) \cap c(B) = c(A) \cap B$.

All or Nothing demands that when moving from a choice set A to another choice set B, either the agent's choice changes completely (no alternative is chosen from both sets) or it is inertial, in the sense that whatever was originally chosen in A and is still available in B, it remains chosen, and no new alternatives are added to the choice.

Proposition 3 *A choice function satisfies Togetherness if and only if it satisfies All or Nothing.*

Contrast again the restriction imposed by All or Nothing with that imposed by WARP, which can be written as $A \cap c(B) \neq \varnothing \Rightarrow c(A) \cap c(B) = c(A) \cap B$ (the same conclusion of All or Nothing from a weaker premise). Suppose I express a willingness to go to the theatre or to the cinema when the only other alternatives are to work or to keep the appointment with the dentist, but choose to keep the appointment with the dentist when the other alternatives are cinema, theatre, work, and a visit to a friend in the hospital. In this example we have a violation of WARP but not of All or Nothing: the switch from the choice of cinema or theatre to the choice of seeing the dentist can be imputed to a shift in mood. It could be, for instance, that the presence of a friend in the hospital, while not

[13] In this connection, see Mandler [33] for how indifference can be distinguished from incompleteness by observing the trades an agent is willing to carry out.

providing me with a sufficiently strong reason to visit her, puts me in a pensive mood, focussing my mind away from entertainment choices.

With a view to welfare analysis, choices as in the example above provide us with some information about 'preferences': they tell us that, under both observed moods, work is never chosen, whereas all other three alternatives which are available in different moods (and we know that the mood must have changed across sets since WARP has been violated) are chosen under at least one mood. We deduce that, whatever the hierarchy of importance among the properties sought in the alternatives, work never offers a crucial property that some other alternative does not offer, and there are crucial properties that other alternatives offer but work does not. Work appears thus a good candidate to be declared welfare inferior to the other three alternatives available in both moods. We cannot make the same inference regarding visiting a friend in the hospital, since such a choice was not available in the first mood. This type of reasoning offers a concrete model that applies Bernheim and Rangel's [6] approach to 'behavioural welfare economics': their proposed welfare criterion would lead to same conclusion regarding the choice of work.[14]

3.3 Comparison with multiself models

Our procedure posits that the decision maker is able in principle to go down the complete list of properties in the variable checklist, which can be very long. However, note that in the checklists constructed in the proof, he stops at the first property. The multiplicity of properties in the proof serves only to activate, in the mind of the agent, different properties in different choice sets, and not to successively refine the selection within a given choice set. This is reminiscent of the model by Kalai, Rubinstein and Spiegler [22] (KRS), who assume that the decision maker maximises a preference relation (a weak order) which depends on the choice set. Indeed it may appear at first sight that the two models are equivalent: using a variable checklist means using a checklist that varies with A and therefore, in view of theorem 1, maximising a weak order that depends on A.

But a moment's reflection shows that the two models are in fact distinct: after all, while our model is characterised by Togetherness, the KRS model can explain any choice

[14] As we've argued more extensively elsewhere (Manzini and Mariotti [37]), the test for the validity of Bernheim and Rangel's [6] proposed association between choices and welfare rankings should be constituted by the most plausible psychological model(s) that generates the observed choices. Beside our own ([37]), other works suggest plausible models in which there is sometimes a discrepancy between Bernheim and Rangel's prescription and 'true welfare': see e.g. Masatlioglu, Nakajima and Ozbay [38] and Rubinstein and Salant [50]. This line of argument presupposes that the 'most plausible model(s)' can be identified, which is exactly what Bernheim and Rangel dispute.

observation.[15] Since for any choice set A we can simply pick a preference with the choice from that set in the highest indifference class in A (KRS work with finite sets), it may happen that x is strictly preferred to y in set A, but it is indifferent to y in set B when two different preferences are applied to the two sets A and B. Therefore it may happen that x is chosen while y is rejected from set A, while both x and y are chosen in set B, thus violating Togetherness. This highlights the centrality in our model of the *fixed nature of the mindset*. The fact that departures from 'rationality' in choice can only be attributed to the mood, and not to the mindset, imposes, unlike the KRS model, some discipline on behaviour. In the KRS model behaviour is determined by variable preferences, and there is no restriction on the variability of preferences.

Similar observations hold for the recent works by Green and Hojman [17] and Ambrus and Rozen [2]. Green and Hojman model an agent as a probability distribution over all possible ordinal preference orderings. Such preferences are then aggregated via a voting rule. If the voting rule satisfies a certain monotonicity property, this model can also explain any choice behavior. Ambrus and Rozen study a very general model of a decision maker as a collection of utility functions ('selves'), which encompasses many other models in this vein. Each choice set may activate a different aggregation procedure of the various selves. This aggregation procedure is constrained to satisfy some natural axioms, which however force the aggregation rule to incorporate some cardinal information: this contrasts with our and the other models mentioned in this section, which are purely ordinal.

The central result by Ambrus and Rozen is that with a sufficient number of selves any choice observation can be explained, in spite of the restrictions imposed on the aggregation procedure. This work leads to the conclusion that multiselves models need, in order to exhibit observable restrictions, limit the number of allowable selves. Replacing 'selves' with 'moods', this intuition could also be made to apply to our framework. Restricting the set of allowable moods would produce tighter implications for observable choice behaviour. Because our analysis specifies the components of a mood, one obvious way to restrict a mood is to restrict the number of properties that constitute it (some environments may specify natural restrictions). We also have noted above how the restriction of nestedness of the mood makes our model equivalent to utility maximisation.

[15] To be precise, KRS deal with choice functions. We are referring to the obvious extension of their ideas to choice correspondences.

4 The mood is determined by the environment

We now consider a different model. The mood does not depend on the feasible set, but instead we allow several observations of choice from an A, each time in a different (unidentifiable) mood.[16]

A mindset is defined exactly as before, as a set of properties Γ, and a mood is simply a well-order $<_m$ of Γ. We allow for the possibility that each observation is itself multivalued.

Specifically, let M be the set of moods, in which any set A is considered. A pair $\left(\Gamma, \{<_m\}_{m \in M}\right)$ is called an **environmental variable checklist**. Let $\gamma(A, <_m)$ denote the choice from A in mood $<_m \in M$. Analogously to before, $\gamma(A, <_m)$ is determined by a sequence of successive eliminations. Denote by P_0^m the first property in mood $<_m$.The survivor sets are defined by

$$S_A(P_0^m, <_m) = A$$

and

$$\text{For all } P \in \Gamma \backslash P_0^m\text{: } S_A(P, <_m) = \begin{cases} \bigcap\limits_{Q <_m P} S_A(Q, <_m) \cap P & \text{if } \bigcap\limits_{Q <_A P} S_A(Q, <_m) \cap P \neq \varnothing \\ \bigcap\limits_{Q <_m P} S_A(Q, <_m) & \text{otherwise} \end{cases}$$

Then, for all $A \in \Sigma$, $\gamma(A, <_m)$ is defined as follows:

$$\begin{aligned} \gamma(A, \quad < \quad {}_m) &= S_A(P, <_m), \text{ where } P \in \Gamma \text{ is such that} \\ S_A(P, \quad < \quad {}_m) &= S_A(Q, <_m) \text{ for all } Q \in \Gamma \text{ with } P <_m Q \end{aligned} \tag{2}$$

We begin by noting that the functions $\gamma(., <_m)$, which describe the observations conditional on one mood, satisfy (Arrow's) IIA:

IIA: All the alternatives chosen from a large menu must still be chosen when available in a smaller menu. Formally, for all $A, B \in \Sigma$: $[A \subset B,\ c(B) \cap A \neq \varnothing] \Rightarrow c(A) = c(B) \cap A$.

Then:

Proposition 4 *For all $<_m \in M$, $\gamma(., <_m)$ satisfies IIA.*

Unfortunately, proposition 4 is often not of practical use: although each $\gamma(., <_m)$ satisfies IIA, the specific mood under which choice was made is most likely unobservable:

[16] As in the previous section, our setup is static. Laibson [28] studies a dynamic model of what we would call an 'environmental mood' triggered by binary cues.

it often seems plausible to expect an external observer to have only choice data, not mood data, at his disposal. In the next section we explore the testable conditions that observed choice produced under the influence of environmental mood do and do not meet.

4.1 Environmental mood causes behaviour inconsistency

The object $c(A)$ is now interpreted as the collection of all the choices the agent makes from A in all possible moods.

Definition 3 *A choice function c on Σ* ***has an environmental variable checklist*** *if there exists an environmental variable checklist $\left(\Gamma, \{<_m\}_{m\in M}\right)$ such that for all $A \in \Sigma$*

$$c(A) = \bigcup_{<_m \in M} \gamma(A, <_m) \text{ for all } A \in \Sigma$$

This is related to the methodology of Salant and Rubinstein's [51] 'choice with frames', where a choice correspondence is interpreted as including, for each A, all the single-valued choices made from A in some frame. The definition here is similar (replacing 'frame' with 'mood'), but we allow the starting choice $\gamma(A, <_m)$ to be multi-valued.[17]

We search for standard 'consistency' properties that c may satisfy. First of all, it is easy to show that c *does not inherit* IIA from the $\gamma(., <_m)$. Alternatives which are not chosen, in any mood, from a large set, may be chosen, in some mood, from a smaller set in which they are available.

We illustrate this with an example which shows, more in particular, that c fails to satisfy two classical basic consistency properties. One is Property β already defined, and the other[18] is:

Expansion: An alternative chosen from two feasible sets must still be chosen when the two sets are merged. Formally, for all $A, B \in \Sigma$ with $A \cup B \in \Sigma$: $c(A) \cap c(B) \subset c(A \cup B)$.

Suppose there are three properties you look at when selecting from a restaurant menu: recommended by a friend, cheapness, and perceived appeal. In a 'trusting mood' you sift through the properties in this order: a friend's recommendation is the most important aspect. In a 'confident mood' you switch the order of the first and last property: you prefer to rely on your own judgement and the last thing you look at is friends' recommendations.

[17] Below we explore the relationship with Salant and Rubinstein's [51] in more detail. Bernheim and Rangel [6] similar framework of 'choice with ancillary conditions' also allows choice to depend on information beyond the feasible set, although they do not focus explicitly on the properties of c.

[18] This property is also known as property γ (see Sen [52]).

So in a trusting mood the fish dish, which has been recommended by a friend, is selected over the pizza, which has not been recommended. And the fish is also selected, in a confident mood, over the pasta, because the latter is less appealing.

However both pizza and pasta are cheaper than fish. When all three dishes are on the menu, you are never observed to select fish (in violation of Expansion and Property β). The reason is that when you are confident, fish and pasta, which have both been recommended, survive the first elimination round and then pasta is selected on the grounds of cheapness. And when you are trusting, fish and pizza, which are both appealing, are shortlisted, to finally select pizza on the ground of cheapness. Formally:

Remark 1 *c does not satisfy Expansion, nor Property β, nor IIA. Let $\Gamma = \{P, Q, R\}$, $M = \{<_m, <_n\}$, $P <_m Q <_m R$ and $R <_n Q <_n P$. Suppose $P = \{x, z\}$, $Q = \{y, z\}$ and $R = \{x, y\}$. Then*

$$\begin{aligned} \gamma\left(\{x,y\}, <_m\right) &= \{x\} \\ \gamma\left(\{x,z\}, <_m\right) &= \{z\} \end{aligned}$$

$$\begin{aligned} \gamma\left(\{x,y\}, <_n\right) &= \{y\} \\ \gamma\left(\{x,z\}, <_n\right) &= \{x\} \end{aligned}$$

and therefore

$$\begin{aligned} c\left(\{x,y\}\right) &= \{x,y\} \\ c\left(\{x,z\}\right) &= \{x,z\} \end{aligned}$$

But

$$\begin{aligned} \gamma\left(\{x,y,z\}, <_m\right) &= \{z\} \\ \gamma\left(\{x,y,z\}, <_n\right) &= \{y\} \end{aligned}$$

so that

$$c\left(\{x,y,z\}\right) = \{y,z\}$$

We conclude that c violates both Expansion and Property β.

Obviously, since Togetherness is weaker than Property β, the example also shows that, unlike in the model of menu-induced mood, c fails Togetherness.

Finally, the example also constitutes a violation of a more recent property introduced by Eliaz and Ok [13], the Weak Axiom of Revealed Non-Inferiority:

WARNI: If in a set A there is an alternative x that is chosen, possibly from some other sets, in the presence of each alternative in A, then x should be chosen from A. Formally, for all $A, B \in \Sigma$: $[\forall y \in A \; \exists B \in \Sigma$ such that $x \in c(B), \, y \in B] \Rightarrow x \in c(A)$.

Eliaz and Ok interpret the fact that $x \in c(B)$ and $y \in B$ as revealing the non-inferiority of x compared to y (though not necessarily its superiority). This suits a situation in which an agent may be undecided, rather than indifferent, between two alternatives (in which case he cannot rank them). WARNI expresses a type of consistency that an undecided agent must satisfy: an alternative which is revealed non-inferior to any other alternative in a set should be chosen in that set. Therefore we have the interesting conclusion that some changes of mood are incompatible with consistent indecisiveness.

4.2 Consistency of moody behaviour

We now show that environmental moody behaviour is nonetheless subject to strong restrictions. Of course if the mindset comprises only nested properties, we would have a result analogous to proposition 1.

Proposition 5 *Let c be a choice function that has an environmental variable checklist with a nested mindset. Then c maximises a weak order $\succsim$ on X.*

Let us turn to another classical property of choice:[19]

Property α: If an alternative is chosen (in some mood) from a large set, then it is chosen (in some mood) from a smaller set in which it is available. Formally, for all $A, B \in \Sigma$: $[A \subset B, \, x \in c(B) \cap A] \Rightarrow x \in c(A)$.

As we shall see, if c is generated by environmental moods, it must satisfy Property α. Intuitively, if in some mood you pick steamed salmon from a menu, it means that in that mood steamed salmon fulfills some crucial property which the other alternatives do not fulfill, and this will continue to be the case even in subsets of that menu.

Property α is however not sufficient to characterize c, as the following example illustrates.

[19] See Sen [52].

Example 8 *Suppose* $c(\{x,y,z\}) = \{x\}$ *and* $c(\{x,y,w\}) = \{x,y\}$. *Although these two choices do not violate Property* α, *it is not possible to find a mindset* Γ, *a set of moods* M *and a choice function* γ *such that*

$$c(A) = \bigcup_{<_m \in M} \gamma(A, <_m)$$

To see this, suppose to the contrary that $y \in \gamma(\{x,y,w\}, <_m)$ *for some* $m \in M$. *Since* $y \notin c(\{x,y,z\})$, *it must be that there is an alternative* $i \in \{x,y,z\}$ *such that* $i \in P_i$, $y \notin P_i$ *and* $y \in P_j \Rightarrow i \in P_j$ *for all* P_j *such that* $P_j <_m P_i$. *If* $i = x$, *then it could not be that* $y \in \gamma(\{x,y,w\}, <_m)$; *while if* $i = z$, *then either* $x \notin \gamma(\{x,y,w\}, <_m)$, *or it must be that* $z \in c(\{x,y,z\})$. *In either case we have a contradiction.*

4.2.1 Moody WARP

The above example leads us to a significantly stronger condition that must be fulfilled by a c generated by environmental moods:

Moody WARP: If an alternative x is rejected from a set A, then x is rejected from any other set that contains *all* the alternatives chosen in A. Formally, for all $A, B \in \Sigma$: $[x \in A \backslash c(A), c(A) \subset B] \Rightarrow x \notin c(B)$.

For example, if you were observed to choose sometimes steamed seabass and sometimes the vegetarian option, but never steamed salmon, from a menu, then you will not choose steamed salmon from any new menu that includes both steamed seabass and the vegetarian option. If your behaviour is determined by mood, it is easy to understand why this must be the case. Whatever mood you are in, your choices from the old menu reveal that the first property that discerns between steamed salmon and steamed seabass (resp., the vegetarian option) is such that steamed seabass (resp., the vegetarian option) has it while steamed salmon lacks it.

Observe how WARP strengthens Moody WARP simply by replacing the entire choice set $c(A)$ with *any* alternative contained in it. For a fully rational agent any chosen element is representative of the class of chosen elements, but not so for a moody agent.

Example 9 *Let* $X = \{w,x,y,z\}$, $A = \{w,x,y\}$, $B = \{x,y,z\}$, $\Sigma = \{A,B\}$ *with the observed choice function as follows:*
$c(A) = \{w,x\}$
$c(B) = \{y,z\}$.
This pattern violates WARP since e.g. y *is rejected in* A *in the presence of* x, *but is*

then chosen in B in the presence of x. However Moody WARP holds, and indeed we have the following variable checklist: $P_1 = \{w, z\}$, $P_2 = \{x, z\}$, $P_3 = \{w, y\}$ and moods $<_1$ and $<_2$ with $\{x, z\} <_1 \{w, y\} <_1 \{w, z\}$ (so that $\gamma(A, <_1) = x$ and $\gamma(B, <_1) = z$) and $\{w, y\} <_2 \{x, z\} <_2 \{w, z\}$ (so that $\gamma(A, <_2) = w$ and $\gamma(B, <_2) = y$.

Observe also that Moody WARP implies Property α.[20]

Proposition 6 *If c has an environmental variable checklist then it satisfies Moody WARP.*

Mood swings thus allow observed choice to exhibit a significant degree of consistency, in the form of the Moody WARP property. A violation of Moody WARP informs us that the agent's choices cannot be explained by 'preference maximisation plus mood'. This result is very general in that it holds on any arbitrary domain of choice. While we have been unable to obtain a result of similar absolute generality in the other direction, we can nevertheless show that Moody WARP does fully characterise moody choice in a leading case.

Proposition 7 *Suppose that the domain Σ of c consists of all the nonempty subsets of a finite set X.Then c has an environmental variable checklist if and only if it satisfies Moody WARP.*

So, on the full finite domain, Moody WARP exhausts the testable implications of environmentally induced mood swings.

4.2.2 Environmental moods produce behaviour that looks like rational behaviour with errors

We now proceed to illustrate another interesting feature of moody behaviour. As it turns out, to an observer of choices and not of moods, moody behaviour can always appear as the outcome of occasional departures, attributable to mistakes, from ordinary preference maximisation.

An *error function* is a correspondence $e : \Sigma \to 2^X$, with $e(A) \subset A$ for all $A \in \Sigma$. An error function is *monotonic* if $B \subset A$ implies $e(A) \cap B \subset e(B)$. With a monotonic error function, the alternatives that can be chosen by mistake in a large set can also be chosen by mistake in a small set. Popular models of choice error have this feature. For example, in the Random Utility Model (culminated in McFadden's ([39], [40]) conditional logit or multinomial logit discrete choice model)[21] suppose that the agent maximises a

[20] To see this, let Moody WARP hold, and suppose that there are sets A and B such that $A \subset B$ but that in contradiction to Property α there is some $x \in C(B) \cap A$ such that $x \notin C(A)$. Since $A \subset B$ it also follows that $C(A) \subset B$, which together with $x \in A \backslash C(A)$ and Moody WARP implies $x \notin c(B)$, contradiction.

[21] See also McFadden [41] for a historical perspective.

utility function u but that the utility is subject to an alternative-dependent random shock, so that the utility of x is a random variable $u(x) + \varepsilon(x)$. Interpret $x \in e(A)$ as x not maximizing u over A, but $u(x) + \varepsilon(x) \geq u(y) + \varepsilon(y)$ for all $y \in A$ for some realizations $\varepsilon(x)$ and $\varepsilon(y)$ of the errors associated with x and y, respectively. Then clearly the same realizations yield $u(x) + \varepsilon(x) \geq u(y) + \varepsilon(y)$ for all $y \in B \subset A$, so that $x \in e(B)$.

The inequality condition in the statement below ensures that the error cannot trivially explain the entire choice: the set of preference maximisers must be nonempty for each choice set.

Proposition 8 *(Maximisation-plus-error interpretation). Let c have an environmental variable checklist. Then there exist a preference $\succsim$ and a monotonic error function e such that for all $A \in \Sigma$*

$$\begin{aligned} c(A) &= \{x : x \succsim y \text{ for all } y \in A\} \cup e(A) \\ \text{and } c(A) &\neq e(A) \end{aligned}$$

The proof of this result consists of fixing an arbitrary mood and then collecting any observation not explained by that mood in the error function. An interpretation of the arbitrary mood in the proof can be that of a 'baseline' or 'cool' mood: any departure from this cool mood, which generates a rational preference, can be considered as an error by an external observer (and perhaps also by the agent). With a view to welfare analysis, the cool mood choices should be considered welfare revealing. It is clear, however, that choice data alone cannot be sufficient to identify the cool mood. Auxiliary assumptions and observations would be necessary.[22]

4.3 Relationship with choice with frames

We can now make the relationship between this framework and Salant and Rubinstein [51] choice with frame more precise. As we observed in section 4.1, the choice function $\gamma(., <_m)$ can be seen as a special type of choice with frame, where each mood $<_m$ plays the role of a particular frame. Of course, in our framework a mood is a well order of the *properties*, rather than of single alternatives. Nevertheless, in view of theorem 1, to each $<_m$ we can associate a weak order on the set of alternatives. When the weak order is a strict linear order, such a substitution generates a choice function that Salant and Rubinstein term 'choice by salient consideration' (a single-valued choice function that

[22] This conclusion is in line with Koszegi and Rabin's [25] penetrating general discussion of the extent to which choice data are welfare revealing.

maximises some frame dependent strict linear order on the alternatives). In the proof of theorem 7 however we implicitly prove that a c with a variable checklist can always be seen (on the domain of statement) as the union of single-valued choice functions. In short, then, we can establish an equivalence between the choice correspondence induced by a choice by salient consideration as frames vary, and the choice correspondence c induced by $\gamma(., <_m)$ as moods vary. The upshot is that, as a by-product, theorem 7 also provides a characterization of choice correspondences generated by salient consideration choice functions.

5 Relationship between the two models and extensions

The models we have considered are logically independent. We illustrate this with a simple example.[23] Let $A = \{h_1, h_2, u_1\}$ and $B = A \cup \{u_2\}$, where h_i and u_i stand for healthy and unhealthy food items, with the index 1 denoting a smaller portion than index 2. Suppose that you observe the following choice functions $c_1(A) = c_2(A) = \{h_1, h_2\}$, $c_1(B) = \{u_1, u_2\}$ and $c_2(B) = \{h_2, u_2\}$. Then it is easy to verify - using our characterisations - that c_1 can be explained solely by menu-driven moods (Togetherness holds and Moody WARP fails), while c_2 can be explained solely by environment-driven moods (Moody WARP holds and Togetherness fails).

The moods for c_1 could be e.g. $\{h_1, h_2\} <_A \{u_1, u_2\}$ and $\{u_1, u_2\} <_B \{h_1, h_2\}$, according to the explanation that the decision maker can stick to healthy food when they are the majority, but adding an extra unhealthy food item switches the mood to 'gluttony'. And for c_2 we could have $\{h_1\} <_c \{h_2, u_2\}$ when the decision maker is in a cool mood, and sticks to his diet; while in a depressed mood he seeks satisfaction in large portion sizes, e.g. $\{h_2, u_2\} <_d \{h_1\}$.

So far we have considered checklists that by themselves produce rational behaviour. Mood (variability of the checklist) is the *only* factor that caused departures from preference maximization. But the method we have used can be generalized to incorporate aspects of bounded rationality distinct from the effects of mood. In particular, we can relax the 'precision' of a checklist. In a checklist the decision maker is always able to tell whether or not an alternative has or lacks a given property: but what if his power

[23] This example is loosely based upon Wansink [56], who studies the determinants of 'eating bouts'. An eating bout is a splurge on food that is some multiple (three times the usual amount in this study). Both external cues (i.e. menu composition) and internal states (i.e. moods) are invoked as alternative triggers for such eating bouts.

of discrimination is more opaque? In a checklist, for any given property, an alternative either has it or it does not, so that a property either couples or uncouples any two distinct alternatives: a lottery is either riskless or risky, a house is either affordable or not for a given budget, a candidate is either qualified for a job or he is not, and so on. Operationally, we can associate to each alternative an index function that takes value 1 for each property that the alternative possesses, and 0 otherwise. Nevertheless one can conceive of many instances where this manichaean distinction might be unreasonable, specifically those cases where an alternative may possess a given property *to a degree* - a food item might not just either bowl you over or disgust you, but just be passable; a painkiller might not be just either completely effective or completely ineffective, but also somewhat effective, and so on. In this cases a modeler would like to be able to distinguish whether a given alternative definitely possesses, or definitely does not possess, or possesses to some degree a given property. Operationally this can be done by coding each alternative with either 1, 0 or -1 for 'definitely has', 'somewhat as' and 'definitely does not have' the given property.[24] Formally, this makes of each property a semiorder.[25] A semiorder is simply a binary relation B that ranks any two alternatives only if they are 'definitely' apart; in particular, B can be represented by a function f and a parameter δ such that xBy if and only if $f(x) > f(y) + \delta$. In words, x is declared superior than y whenever the f-attribute value of x exceeds the f-attribute value of y by a difference which is at least δ - in all other cases the two alternatives are not sufficiently distant, in utility terms, to be told apart.

Going back to three valued properties, we can view each property as a function f assigning value 0, 1 or -1 to each alternative. Setting $\delta = 1$ we have that two alternatives x and y can be distinguished by a property P only if the property assigns value 1 to one alternative and -1 to the other. This is the approach we have followed in Manzini and Mariotti [36], where however, as in the original checklist model, the order of application of the properties is fixed. A natural extension would be to fix the mindset as the collection of (three valued) properties, and let the order in which they are considered depend on mood.

[24] This point can be generalised still further to consider properties that admit an arbitrary number of 'degrees', or discrimination. This is an alternative interpretation of Manzini and Mariotti [35]. See also Apesteguia and Ballester [3].

[25] More precisely, a semiorder is a binary relation P on X that is irreflexive (i.e. for all $x \in X$, $(x,x) \notin P$.) and which satisfies *(i)* $(x,y), (w,z) \in P$ imply $(x,z) \in P$ or $(w,y) \in P$; *(ii)* $(x,y) \in P$ and $(y,z) \in P$ imply $(x,w) \in P$ or $(w,z) \in P$. See Luce [31].

6 Concluding remarks

In this paper we have distinguished between the mindset of an agent, which expresses the stable component of his psychology and is identified by the characteristics he cares for in choice alternatives; and his mood, assuming that it manifests itself as the urgency the agent attaches to these characteristics. The mood may depend on the choice set, or it may vary exogenously, with choice from the same set observed under different moods.

Our framework shows that mood swings in the presence of a stable mindset give rise to regularities in choice behaviour, generating their testable implications on choice data. These implications are simple modifications of classical revealed preference conditions.

In practice, mood is not entirely unpredictable: psychological research may help to identify correlations between environmental and personal variables with mood, and mood with choice, so that additional elements of predictability in choice can be identified. Our contribution has been to identify what can be predicted *exclusively* in terms of an economic choice model.

While mood affects choice, it is also true that choice affects mood: as we saw, which movie you choose to watch after surgery is going to have an effect on how much painkillers you will ask for. In general, there is a subtle two-way interaction between psychological states and choices.[26] While at the moment it is not clear how this interaction can be modelled, some progress has been made by Dalton and Ghosal [11] who resolve the interaction through an elegant equilibrium analysis. Our paper is just a first step towards the formal modelling of moody choice behaviour.

7 Appendix: Proofs

Proof of proposition 1. We show the following: let c and d be two choice functions on Σ that have, respectively the variable checklists $\left(\Gamma, \{<_A\}_{A\in\Sigma}\right)$ and $\left(\Gamma, \{<'_A\}_{A\in\Sigma}\right)$; then $c = d$.

Suppose that $c(A) \neq d(A)$ for some $A \in \Sigma$ and in particular let (possibly relabeling the choice functions) $x \in c(A)$ and $x \notin d(A)$. The latter implies that there exist $y \in A$ and $P \in \Gamma$ such that $x \notin P$ and $y \in P$. For $x \in c(A)$ it must then be the case that there exists $Q <_A P$ and $z \in A$ such that $y \notin Q$ and $z \in Q$. If $P \subset Q$ this is incompatible with $y \in P$, and if $Q \subset P$ then $x \notin Q$. Therefore $x \notin S_A(Q, <_A)$ and $x \notin c(A)$, a contradiction.

[26] Coricelli and Rustichini [10] analyse how counterfactuals can generate envy and regret, and argue how envy is the social correspondent of (individual) regret and link these emotions to adaptive learning.

So any sequence of the properties in the mindset Γ generates the same behaviour and by theorem 1 the behaviour generated by any particular sequence maximises a weak order, as claimed. ∎

Proof of proposition 2. Suppose c satisfies Togetherness. Let $x \approx y$ if and only if there is no $A \in \Sigma$ such that $x \in c(A)$ and $y \in A \backslash c(A)$ or $y \in c(A)$ and $x \in A \backslash c(A)$. The relation $\approx$ is obviously reflexive and symmetric. To see that it is also transitive, suppose that $x \approx y \approx z$ and that $x \in c(A)$ and $z \in A$ for some $A \in \Sigma$. We show that $z \in c(A)$.

Since $x \approx y$ we have $x \in c(\{x, y, z\})$ if and only if $y \in c(\{x, y, z\})$ ($\{x, y, z\}$ is in the domain by assumption), and similarly $y \approx z$ implies that $y \in c(\{x, y, z\})$ if and only if $z \in c(\{x, y, z\})$. Therefore if $x \in c(\{x, y, z\})$ then $c(\{x, y, z\}) = \{x, y, z\}$. Therefore by Togetherness $x \in c(A)$ and $z \in A$ imply $z \in A$. If instead $x \notin c(\{x, y, z\})$, then $c(\{x, y, z\}) = \varnothing$, a contradiction. $\approx$ is therefore an equivalence relation and it partitions the set of alternatives into equivalence classes, which we denote $[x] = \{y \in X : y \approx x\}$.

Given $A \in \Sigma$, take any $x \in c(A)$ and let $P_A = [x]$. Note that P_A is uniquely defined, and let the mindset be $\Gamma = \{P_A : A \in \Sigma\}$. Since $\approx$ is an equivalence, we have $P_A \cap P_B = \varnothing$ for all distinct menus $A, B \in \Sigma$. Let the mood $<_A$ be any well-order for which $P_A <_A P$ for all $P \in \Gamma \backslash P_A$. Then $A \cap P_A = c(A)$ (for any $y \notin c(A)$ and $x \in P_A$ it cannot be $y \approx x$ by the definitions of $\approx$ and P_A). And since for all $P \in \Gamma \backslash P_A$ we have $P_A \cap P = \varnothing$, it follows that, for all $P \in \Gamma$, $S_A(P, <_A) = c(A)$. Finally, note the finiteness of P_A.

Conversely, let $\left\{\Gamma, \{<_A\}_{A \in \Sigma}\right\}$ be a variable checklist for c. Suppose $x, y \in c(A)$ for some $A \in \Sigma$, and suppose by contradiction that, for some $B \in \Sigma$, $y \in c(B)$ and $x \in B \backslash c(B)$. Then there exists $P \in \Gamma$ such that $y \in P$ and $x \notin P$. By definition of having a checklist there exists $Q \in \Gamma$ such that $S_A(Q) = S_A(R)$ for all $R \in \Gamma$ with $Q <_A R$. This cannot be true if $Q <_A P$. On the other hand, if $P <_A Q$ it cannot be $x, y \in c(A)$, a contradiction. ∎

Proof of proposition 3. Suppose that Togetherness holds and that $c(A) \cap c(B) \neq \varnothing$. Obviously for any $x \in c(A) \cap c(B)$ we have $x \in c(A) \cap B$, that is $c(A) \cap c(B) \subseteq c(A) \cap B$. For the converse inclusion, for any $x \in c(A) \cap B$ either $c(A) \cap c(B) = \{x\}$ or there exists $y \neq x$ with $y \in c(A) \cap c(B)$ and so by Togetherness $x \in c(B)$ (otherwise, $x \in B \backslash c(B)$ would violate Togetherness). This shows that $c(A) \cap B \subseteq c(A) \cap c(B)$ and we conclude that $c(A) \cap c(B) = c(A) \cap B$.

Conversely, suppose that Togetherness is violated, that is there exist $A, B \in \Sigma$ and $x \in A \backslash c(A)$, $y \in c(A)$, $y \in c(B)$ but $x \in c(B)$. Then $c(A) \cap c(B) \neq \varnothing$. Moreover, $x \notin c(A) \cap c(B)$ while $x \in c(B) \cap A$, so that $c(A) \cap c(B) \neq c(B) \cap A$, violating All or Nothing. ∎

Proof of proposition 4: If $x \in \gamma(B, <_m)$ then x must be in any $S_B(P, <_m)$, and therefore in any $S_A(P, <_m)$, so that $x \in \gamma(A, <_m)$ whenever $x \in A$: so $\gamma(B, <_m) \cap A \subset \gamma(A, <_m)$. And if $x \notin \gamma(B, <_m)$ and $\gamma(B, <_m) \cap A \neq \varnothing$, then there exists $y \in \gamma(B, <_m) \cap A$ that has a property which x does not have. So there is P for which $x \notin S_A(P, <_m)$, and consequently $x \notin \gamma(A, <_m)$. This shows that $\gamma(A, <_m) \subset \gamma(B, <_m) \cap A$, and we conclude that $\gamma(A, <_m) = \gamma(B, <_m) \cap A$. ■

Proof of proposition 6. As a preliminary, we say that 'x $m-$tops y', written xT_my, if there is a mood $<_m$ and a property P_i such that $x \in P_i$, $y \notin P_i$ and $y \in P_j \Rightarrow x \in P_j$ for all P_j such that $P_j <_m P_i$. Observe that for all $D \in \Sigma$ and $<_m \in M$, $x \in \gamma(D, <_m)$ only if there is no $y \in D$ such that yT_mx.

Let $A, B \in \Sigma$ be such that $c(A) \subset B$. The statement of the proposition is trivially true if $A \cap \gamma(B, <_m) = \varnothing$ for all $<_m \in M$ (in which case $A \cap c(B) = \varnothing$), so suppose that $A \cap \gamma(B, <_m) \neq \varnothing$ for some $<_m \in M$. Then

$$\begin{aligned} A \cap c(B) &= A \cap \bigcup_{<_m \in M} \gamma(B, <_m) \\ &= \bigcup_{<_m \in M} A \cap \gamma(B, <_m) \subset \bigcup_{<_m \in M} \gamma(A, <_m) \\ &= c(A) \end{aligned}$$

where the inclusion is proved with the following reasoning. Since $c(A) \subset B$, for all $<_m \in M$ we have $\gamma(A, <_m) \subset B$. So in particular there is no $y \in A \backslash B$ that $m-$tops any $x \in \gamma(A, <_m)$. Therefore for all $x \in \gamma(B, <_m) \cap A$ we also have $x \in \gamma(A, <_m)$ (if not, there would exist $y \in A \backslash B$ with yT_mx). We conclude that, for all $<_m \in M$, $\gamma(B, <_m) \cap A \subset \gamma(A, <_m)$, from which the desired inclusion follows. ■

In the formal parts that follow we will find it convenient to write Moody WARP in an equivalent way:[27]

Moody WARP (restated): $c(A) \subset B \Rightarrow c(B) \cap A \subset c(A)$.[28]

[27] To see this, let Moody WARP hold, and suppose that $C(A) \subset B$ but that in contradiction there exists some x such that $x \in (C(B) \cap A) \backslash C(A)$. Since $C(A) \subset B$ and $x \in A \backslash C(A)$, Moody WARP requires $x \notin C(B)$, contradiction. For the other direction, let Moody WARP (restated) hold, and suppose that $x \in A \backslash C(A)$, $C(A) \subset B$ but that in contradiction $x \in C(B)$. Then $x \in (C(B) \cap A) \backslash C(A)$, an immediate contradiction of Moody WARP (restated).

[28] A small choice theoretic observation: this formulation makes it clear that Moody WARP is a stronger version of the classic axiom by Aizerman (see Aizerman and Malishevski [1]), which adds to the premise in Moody WARP the requirement that the sets A and B are nested, i.e. $B \subset A$.

Proof of proposition 7: In view of proposition 6, we only need to prove one direction. Let Moody WARP hold. We construct a variable checklist explicitly, then show that it retrieves $c(A)$ for each set $A \in \Sigma$. Let $\Gamma = \left\{ \{x\}_{x \in X} \right\}$, and let $|X| = n$.

An $a-$path is a sequence $a = \{x_i\}_{i=1,...n}$ of distinct alternatives $x_1, x_2, ...x_n$ defined recursively as follows. $x_1 \in c(X)$ and, for all $i > 1$, $x_i \in c(X \setminus \{x_1, ..., x_{i-1}\})$. Denote by α the collection of $a-$paths, and note that each $a-$path covers all of the alternatives in X . Construct M by setting, for each $a \in \alpha$:

$$\{x_i\} <_a \{x_j\} \text{ if and only if } i < j \text{ and } x_i, x_j \in a$$

We now show that this construction retrieves choice.

Fix an arbitrary set $A \in \Sigma$, let $x \in c(A)$, and suppose by contradiction that for each $<_m \in M$, there is an alternative w such that $\{w\} <_m \{x\}$. For each $<_m$ let $\{y_m\}$ denote the $<_m$ $-$maximal property in A, that is $\{y_m\} <_m \{z\}$ for all $z \in A \setminus \{y_m\}$. By construction we have that $y_m \in \gamma(A_m, <_m)$ where $A_m = \{y_m\} \cup \{z \in X : \{y_m\} <_m \{z\}\}$. Observe that by assumption there is no $<_m$ such that $x \in \gamma(A_m, <_m)$ (otherwise $\{x\}$ would be maximal in A for some mood). Moreover, by construction it must also be that $A \subseteq A_m$, for otherwise it would not be true that $\{y_m\} <_m \{z\}$ for all $z \in A \setminus \{y_m\}$. If for any of the A_m it is the case that $c(A_m) \subset A$, then by Moody WARP it would follow that $c(A) \cap A_m \subset c(A_m)$, contradicting $x \notin \gamma(A_m, <_m)$. So suppose not, so that $c(A_m) \setminus A \neq \varnothing$, and consider $A_{m1} = A_m \setminus \{z_1\}$ where $z_1 \in c(A_m) \setminus A$. As before, either $c(A_{m1}) \subset A$, so that the contradiction $c(A) \cap A_{m1} \subset c(A_{m1})$ follows; or $c(A_{m1}) \setminus A \neq \varnothing$. More in general, proceed recursively setting $A_{mj} = A_{mj-1} \setminus \{z_j\}$ where $z_j \in c(A_{mj}) \setminus A$ whenever $c(A_{mj}) \setminus A \neq \varnothing$ and $j > 1$. At each step either $c(A_{mj}) \subset A$, implying $c(A) \cap A_{mj} \subset c(A_{mj})$; or $c(A_{mj}) \setminus A \neq \varnothing$. Since X is finite there exists a j^* such that $c(A_{mj^*}) \setminus A = \varnothing$, generating the desired contradiction.

Suppose now that $x \in A \setminus c(A)$, and that in contradiction there exists some mood $<_m \in M$ such that $x \in \gamma(A, <_m)$. By construction it must be that $x \in c(B)$ where $B = \{x\} \cup \{y \in X : \{x\} <_m \{y\}\}$, and that $A \subset B$. If $A = B$ we have an immediate contradiction. Otherwise, then $c(A) \subset B$, so that by Moody WARP $c(B) \cap A \subset c(A)$ also follows, implying $x \in c(A)$, a contradiction. ■

Proof of proposition 8: Fix any mood $<_m \in M$. By theorem 1 there exists a preference $\succsim$ such that, for all $A \in \Sigma$, $\gamma(A, <_m) = \{x : x \succsim y \text{ for all } y \in A\}$. Then define e by $e(A) = c(A) \setminus \gamma(A, <_m)$. Since $c(A) \setminus \gamma(A, <_m) = \bigcup_{<_n \in M \setminus \{<_m\}} \gamma(A, <_n)$, the same arguments used before to show that c satisfies Moody WARP, and therefore Property α, prove that e has the desired monotonicity property. ■

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