Theoretical Economics 12 (2017), 477–492 1555-7561/20170477

Choosing on influence

Tugce Cuhadaroglu
School of Economics and Finance, University of St. Andrews

Interaction, the act of mutual influence, is an essential part of daily life and economic decisions. This paper presents an individual decision procedure for interacting individuals. According to our model, individuals seek influence from each other for those issues that they cannot solve on their own. Following a choice-theoretic approach, we provide simple properties that aid us to detect interacting individuals. Revealed preference analysis not only grants underlying preferences, but also the influence acquired.

Keywords. Interaction, social influence, boundedly rational decision making, two-stage maximization, incomplete preferences.

JEL classification. D01, D03, D11.

Individuals who share the same environment, such as members of the same household, friends from school, or colleagues from the workplace, influence each others' behavior through different means of interaction such as advice, inspiration, and imitation. There is an immense economics literature documenting and analyzing the effect of social interactions on individual decisions.[1] However, not enough attention has been paid to the particular decision procedures individuals administer to interact, leaving the microfoundations of social interactions rather unexplored.[2] Addressing this gap, the current paper presents and studies a particular individual decision procedure for interacting agents.

Choice on mutual influence (CMI) works as follows: Consider two individuals who are endowed with transitive but not necessarily complete preferences. Facing a decision

Tugce Cuhadaroglu: tc48@st-andrews.ac.uk
I am grateful to Miguel Angel Ballester for his insightful comments since the very early versions of this work. I would also like to thank Jose Apesteguia, Salvador Barbera, Faruk Gul, Carmen Herrero, Sean Horan, Efe Ok, Kemal Ozbek, Paola Manzini, Marco Mariotti, Pedro Rey-Biel, Ariel Rubinstein, and Levent Ulku for their very helpful comments and suggestions. Financial support by the Spanish Ministry of Science and Innovation through Grant ECO2008-04756 (Grupo Consolidado-C), FEDER and also the Scottish Institute of Research in Economics (SIRE) is acknowledged.

[1]In particular, in labor markets (Mas and Moretti 2009), in education (Zimmerman 2003, Calvo-Armengol et al. 2009), among teenagers (Evans et al. 1992, Bramoullé et al. 2009), and in crime (Glaeser et al. 1996), to name a few.

[2]The extensive survey of Blume et al. (2010) on social interactions concludes: "A final area that warrants far more research is the micro-foundations of social interactions. In the econometrics literature, contextual and endogenous social interactions are defined in terms of types of variables rather than via particular mechanisms. This can delimit the utility of the models we have, for example, if the particular mechanisms have different policy implications."

DOI: 10.3982/TE2170

problem, each individual first maximizes his/her own preferences. If this yields a single alternative, that alternative is chosen. If not, individuals appeal to each other's preferences in a second stage to be able to further refine their choices. Let us introduce an example to demonstrate the process.

Example 1. Let $X = \{x, y, z\}$, and consider two individuals 1 and 2 with the preferences $x \succ_1 y$ and $z \succ_2 x$, respectively.[3] Assume that both 1 and 2 are asked to choose from X. Individual 1 likes x better than y. Maximization of $\succ_1$ leads to the elimination of y, leaving two individually uncomparable options, x and z. To choose between x and z, 1 seeks the influence of 2. Since $z \succ_2 x$, upon 2's advice, 1 ends up choosing z. Individual 2's decision process, alternatively, involves elimination of x in the first stage since $z \succ_2 x$. Since neither of them is able to rank y and z, 2 cannot refine her choice further. Thus, 1 ends up choosing z from X, whereas 2 ends up with y and z. ◊

CMI is a natural process of decision making for individuals with incomplete preferences. Notice that unless an individual has complete preferences for all those alternatives that the other individual cannot compare, the choice outcome will not be unique, as exemplified above. For this reason we do not restrict our attention to single-valued choice; we allow for set-valued choice outcomes.[4]

Our main result is the characterization of CMI. Three falsifiable properties of the choice behavior of two individuals characterize this type of interaction. The first property, *expansion,* is a well known individual rationality property. The remaining two properties are novel to our model. *Nullipotency* states that all the influence that could be created among these individuals is already inherent in their behavior; no further interaction could cause further refinement of their final choices. The key property of our model, *consistency of influence*, ensures that any violation of consistency in an individual's choice data indicates the influence acquired. This allows us to link individuals to each other by tracing inconsistencies in their choices. For two individuals to be interacting according to CMI, they have to account for each other's inconsistencies.

Our contributions to the literature are twofold. First, we provide a first attempt for a new approach to a problem that is mostly analyzed from an econometrical perspective. Influence via social interactions has mostly been handled in an applied framework. Given a group of socially related individuals, many advanced econometrical techniques are developed and applied with the purpose of identifying the influence individuals create on each other.[5] To the best of our knowledge, this is the first paper to deploy tools of choice theory to study interaction. A choice-theoretic approach to interaction is appealing for several reasons: First, the falsifiable properties allow us to detect interacting individuals from their observable choice behavior. Second, the revealed preference

[3] Conventionally, $x \succ_1 y$ reads as individual 1 strictly prefers alternative x to y.

[4] Following Sen (1993), we interpret the choice outcomes as "the set of 'choosable' elements." Hence choosing both x and y from a set means that x and y are both deemed choosable from that set. At times, the individual might finalize the choice by picking up any of the choosable alternatives.

[5] In addition to the papers mentioned at the beginning of the introduction, see Blume et al. (2010), Manski (1993, 2000).

argument yields the underlying preferences of these individuals, which are generally nonobservable. Last, the representation theorem also grants us the revealed influence among these individuals. We should be clear that, at this point, our model does not incorporate strategic intentions. Unlike persuasion or compliance models (Cialdini 2007), in CMI, influence is not payoff relevant for the influencing individual; it only helps the influenced individual further refine his/her choices.[6]

Second, presenting a simple and natural model of decision making, we contribute to the boundedly rational choice literature of recent decades that aims to explain nontextbook behavior of individuals.[7] In particular, as a two-stage maximization process, CMI is clearly related to the other two-stage maximization processes studied in this literature.[8] The baseline model of two-stage maximization would be rational shortlist methods (RSM) proposed by Manzini and Mariotti (2007). RSM essentially refers to a single-valued choice mechanism where a two-stage maximization process yields the chosen alternative uniquely. Two rationality properties—expansion and weak weak axiom of revealed preferences (WWARP)—are shown to characterize RSM. Rubinstein and Salant (2008) provide an alternative axiomatization of RSM with an exclusion consistency property. An interesting subclass of RSM—RSM with transitive rationales—is axiomatized by Au and Kawai (2011), Yildiz (2017), and Horan (2016) independently. While the former two works make use of properties that impose acyclicity to a revealed relation, Horan (2016) focuses on choice inconsistencies similar to the approach in this paper. He shows that RSM with transitive rationales cannot exhibit certain choice inconsistencies simultaneously. Our model is inherently different from the existing two-stage maximization procedures: we consider multiple individuals. The second criterion that the individual uses is not simply another criterion in his/her mind, but another individual that is also equipped with a choice structure. Hence the behavioral properties we search for should reveal the mutual relationship between these two individuals, and identify the specific choice problems where influence is acquired. Moreover, since we work with set-valued choice behavior, the technical challenges we face are different than those of the cited papers. The only exception to single-valued RSM is presented in Garcia-Sanz and R. Alcantud (2015), where they characterize a subset of set-valued RSMs that satisfy a consistency property. For that particular class of set-valued RSMs, weak WARP and expansion for correspondences remain sufficient for the characterization of choice behavior, which certainly is not the case in general.

The outline of this paper is as follows. The first section introduces CMI. We describe the model, and present the characterizing axioms and the theorem. We also tackle the

[6]Having said that, Yildiz (2017) suggests an example of a choice by Stackelberg game of which the equilibrium behavior is observationally equivalent to the outcome of a particular two-stage maximization process. A similar example, involving two Stackelberg games, can also be built for CMI. Thanks to an anonymous referee for pointing out the example.

[7]To name a few boundedly rational choice procedures, see Masatlioglu et al. (2012) for limited attention; Masatlioglu and Ok (2005), Apesteguia and Ballester (2013) for status quo bias; Salant and Rubinstein (2008) for framing effects; Rubinstein and Salant (2008) for the need for nonstandard models in general.

[8]In addition to the papers cited, see Bajraj and Ülkü (2015), Manzini and Mariotti (2012), Matsuki and Tadenuma (2013), Tyson (2012). For a comprehensive account of two-stage mechanisms, see Horan (2016). For a detailed analysis of identification in RSMs, see Dutta and Horan (2015).

identification problem in this section. The second section extends the model to multi-individual settings. The third section is devoted to further comments. The final section concludes.

1. Choice on mutual influence

1.1 *The model*

Let X be a nonempty finite set of alternatives and let Ω_X be the set of all nonempty subsets of X. Let 1 and 2 denote two individuals. For any $i \in \{1, 2\}$, we define the decision outcomes of i on Ω_X as a choice correspondence $C_i : \Omega_X \rightrightarrows X$ with $\varnothing \neq C_i(S) \subseteq S$ for all $S \in \Omega_X$.[9]

For $i \in \{1, 2\}$, let $\succ_i$ be the strict preference relation of i over X, i.e., an asymmetric and transitive but not necessarily complete binary relation over X.[10] The set of maximal elements of S according to $\succ_i$ will be $\text{Max}(S, \succ_i) = \{x \in S : \nexists y \in S \text{ with } yx \in \succ_i\}$. If individual preferences are complete enough to single out a most preferred alternative, i.e., if $\text{Max}(S, \succ_i)$ is a singleton, there will be no room for influence. If not, then i would be seeking influence of j over those choosable alternatives, leading to $\text{Max}(\text{Max}(S, \succ_i), \succ_j)$.

Definition 1. We say that a pair of choice correspondences (C_1, C_2) is a CMI mechanism if there exists a pair of asymmetric and transitive binary relations $(\succ_1, \succ_2)$ such that

$$C_1(S) = \text{Max}\big(\text{Max}(S, \succ_1), \succ_2\big),$$
$$C_2(S) = \text{Max}\big(\text{Max}(S, \succ_2), \succ_1\big) \quad \text{for all } S \in \Omega_X.$$

1.2 *Characterization*

Now suppose we observe (C_1, C_2). Three simple properties are sufficient to test whether this pair of behaviors is consistent with CMI. The first property, a well known individual rationality property, expansion (also known as Sen's γ), states that if an alternative is chosen from two different sets, it also is chosen from the union.

Expansion (EXP). For any $x \in X$, $S, T \in \Omega_X$, and $i \in \{1, 2\}$, if $x \in C_i(S) \cap C_i(T)$, then $x \in C_i(S \cup T)$.

Unlike EXP, the following two properties are not individual rationality properties, but are used to reveal the mutual relation between 1 and 2. The first of them, Nullipotency is required to link C_1 and C_2 to each other for those problems where they do not yield a single choice. It states that all the influence that could have come from j is already

[9]For the sake of brevity, we abuse notation and drop set delimiters and commas whenever we refer to menus or choices from menus. For instance, we use $xy = C_1(xyz)$ to denote 1's choice of x and y from the menu $\{x, y, z\}$. Similarly, an ordered pair $(x, y) \in X \times X$ is simply denoted as xy.

[10]We stick to strict preferences for simplicity purposes. Our results trivially generalize to the case where indifferences are allowed. Notice that also in this case, ties will be broken whenever the other individual has a strictly preferred alternative.

inherent in i's behavior; the decision outcomes of j cannot be used to further refine i's choices:

Nullipotency (NULL). For any $S \in \Omega_X$ and $i, j \in \{1, 2\}$ with $i \neq j$, we have $C_j(C_i(S)) = C_i(S)$.

The last property is the key property of CMI in that it allows identification of the influence of the individuals on each other. Consider two alternatives x, y and a choice problem S with $x, y \in S$ such that $x = C_i(xy)$ and $C_i(S) \neq C_i(S \setminus y)$. Following Horan (2016), let us call this a *weak* $\langle x, y\rangle$ *reversal* on S.[11] In our setting a weak $\langle x, y\rangle$ reversal is considered to be the evidence for influence. To see why, first notice that $x = C_i(xy)$ might be the result of j's influence on i as well as i's sincere preference for x over y. Indeed the existence of a weak $\langle x, y\rangle$ reversal signals the influence: If x is better than y according to the underlying transitive preferences, for any choice problem involving x and y, the existence of y would never alter the final choice.[12] Hence $x = C_i(xy)$ is the result of the influence of j, implying that x is preferred to y by j, not i. But then, since j's preferences are also transitive, j would never commit a weak $\langle x, y\rangle$ reversal him/herself.

Consistency of influence stems from the observation that any choice inconsistency, which happens to be in the form of $\langle x, y\rangle$ reversals in this setting, is the result of the influence taken. Thus, the influential individual has to behave consistently. Let us represent the lack of $\langle x, y\rangle$ reversals with an auxiliary relation: We say that x *shadows* y for i ($x \succ_i^s y$) if $C_i(S) = C_i(S \setminus y)$ for all $S \in \Omega_X$ with $x \in S$.

Consistency of Influence (CoI). For any $x, y \in X$ and $i \in \{1, 2\}$, if $x = C_i(xy)$, then x shadows y at least for one of the individuals.

Our first theorem shows that these properties are necessary and sufficient for choice on mutual influence.

Theorem 1. *Let (C_1, C_2) be a pair of choice correspondences. The pair (C_1, C_2) satisfies EXP, NULL, and CoI if and only if (C_1, C_2) is a CMI mechanism.*

Proof. Necessity is fairly straightforward; thus it is omitted. We prove the sufficiency part. For $i \in \{1, 2\}$, choose $\succ_i = \succ_i^s$. Formally,

$$xy \in \succ_i \quad \text{iff} \quad C_i(S) = C_i(S \setminus y) \quad \text{for all } S \text{ with } x, y \in S.$$

Notice that $\succ_i$ is asymmetric by definition since $xy, yx \in \succ_i$ implies that $\varnothing = C_i(xy)$. To see the transitivity of $\succ_i$, take any $x, y, z \in X$ with $xy, yz \in \succ_i$. Take any $S \in \Omega_X$ with $x, z \in S$. If $y \in S$, then by $yz \in \succ_i$, $C_i(S) = C_i(S \setminus z)$. Let $y \notin S$ and consider $S \cup y$. By $xy \in \succ_i$, $C_i(S \cup y) = C_i(S)$. By $yz \in \succ_i$, $C_i(S \cup y) = C_i(S \cup y \setminus z)$. By $xy \in \succ_i$, $C_i(S \setminus z \cup y) = C_i(S \setminus z)$. But then $C_i(S) = C_i(S \setminus z)$.

[11] Horan (2016) shows that for choice functions, committing a weak $\langle x, y\rangle$ reversal is equivalent to violating independence of irrelevant alternatives. For choice correspondences these two properties are independent.

[12] Transitivity implies that when x is strictly better than y, anything worse than y is also worse than x. Hence all alternatives that are eliminated by y in maximization are already eliminated by x, yielding $\mathrm{Max}(S, \succ_i) = \mathrm{Max}(S \setminus y, \succ_i)$.

Take any $S \in \Omega_X$. We now show that $\mathrm{Max}(\mathrm{Max}(S, \succ_i), \succ_j) \subseteq C_i(S)$. Take any $x \in \mathrm{Max}(\mathrm{Max}(S, \succ_i), \succ_j)$. Obviously $x \in \mathrm{Max}(S, \succ_i)$. We claim that for any $z \in \mathrm{Max}(S, \succ_i)$, $x \in C_i(xz)$. To see that, take any $z \in \mathrm{Max}(S, \succ_i)$ and assume, to the contrary, that $z = C_i(xz)$. Since $x \in \mathrm{Max}(S, \succ_i)$, there exists $T \in \Omega_X$ with $x, z \in T$ such that $C_i(T) \neq C_i(T \setminus x)$. But then CoI and the definition of $\succ_j$ imply that $zx \in \succ_j$. This is a contradiction with $x \in \mathrm{Max}(\mathrm{Max}(S, \succ_i), \succ_j)$, which proves the claim that $x \in C_i(xz)$ for all $z \in \mathrm{Max}(S, \succ_i)$. But then EXP implies that $x \in C_i(\mathrm{Max}(S, \succ_i))$.

We conclude this part of the proof by showing that $C_i(\mathrm{Max}(S, \succ_i)) = C_i(S)$ so that $x \in C_i(\mathrm{Max}(S, \succ_i))$ also implies $x \in C_i(S)$. First notice that for any $y \in S \setminus \mathrm{Max}(S, \succ_i)$, there exists $y' \in \mathrm{Max}(S, \succ_i)$ such that $y'y \in \succ_i$ since $\succ_i$ is transitive. But then by definition of $\succ_i$, $C_i(\mathrm{Max}(S, \succ_i)) = C_i(\mathrm{Max}(S, \succ_i) \cup y)$. Iterative application of the same argument yields that $C_i(\mathrm{Max}(S, \succ_i)) = C_i(S)$, establishing that $x \in C_i(S)$.

The last part of the proof is to show that $C_i(S) \subseteq \mathrm{Max}(\mathrm{Max}(S, \succ_i), \succ_j)$. Take any $x \in C_i(S)$. By definition of $\succ_i$, $x \in \mathrm{Max}(S, \succ_i)$. Assume, to the contrary, that $x \notin \mathrm{Max}(\mathrm{Max}(S, \succ_i), \succ_j)$. Then by transitivity of $\succ_j$, there exists $z \in \mathrm{Max}(\mathrm{Max}(S, \succ_i), \succ_j)$ such that $zx \in \succ_j$. As we have shown in the previous step, $z \in \mathrm{Max}(\mathrm{Max}(S, \succ_i), \succ_j)$ implies that $z \in C_i(S)$. By definition of $\succ_j$, $zx \in \succ_j$ implies that $x \notin C_j(T)$ for any $T \in \Omega_X$ with $x, z \in T$. But then, by NULL, $C_j(C_i(S)) = C_i(S)$, which creates the desired contradiction since both $x, z \in C_i(S)$. $\square$

The independence of the properties is easily demonstrated by specific examples. Consider $X = \{x, y, z\}$, $x = C_1(xy)$, $y = C_1(yz)$, $x = C_1(xz)$, and $x = C_1(xyz)$. If $x = C_2(xy)$, $y = C_2(yz)$, $x = C_2(xz)$, and $y = C_2(xyz)$, CoI and NULL are satisfied but EXP is not. If instead, $y = C_2(xy)$, $z = C_2(yz)$, $x = C_2(xz)$, and $x = C_2(xyz)$, CoI is not satisfied but the others are. Finally, if $xy = C_2(xy)$, $z = C_2(yz)$, $z = C_2(xz)$, and $z = C_2(xyz)$, NULL is the only one that is not satisfied.

The key point of our characterization exercise lies in the following observation: *i*'s choice behavior not only reveals information about *i*'s underlying preferences but also *j*'s underlying preferences. Individuals have to account for each other's inconsistencies. An interesting implication arises for identical choice behaviors. For $C_1 = C_2 = C$, it is immediate to see that (C, C) has a CMI representation if and only if C is quasi-rational, i.e., is consistent with the maximization of a transitive asymmetric binary relation[13] and, hence, does not display any choice inconsistencies. Moreover if C is single-valued, then the same statement holds if and only if C is a rational choice function.

It is worth noting that when choice is restricted to a unique alternative, the characterization of CMI can be obtained similarly by EXP and CoI properties as NULL becomes redundant.[14]

1.3 *Identification*

The characterization theorem ensures that given a particular pair of choice behaviors (C_1, C_2) satisfying EXP, NULL, and CoI, we can recover a pair of revealed preferences

[13] See Plott (1973) for characterization of transitive asymmetric relations.

[14] Indeed this is a direct implication of the first part of the characterization proof, which shows that $x \in \mathrm{Max}(\mathrm{Max}(S, \succ_i), \succ_j)$ yields $x \in C_i(S)$, without referring to NULL.

$(\succ_1, \succ_2)$ that would represent (C_1, C_2) according to CMI. But in some situations one can actually find other pairs of revealed preferences that would explain the same choice behavior.[15] But then the following question arises immediately: How accurately can we actually identify the underlying preferences (and hence the influence)? To answer this question, we investigate the common part of all pairs of preferences that explain a given (C_1, C_2).

Unlike the standard revealed preference argument, in our setting, choices from binary menus do not necessarily reveal the underlying preferences; they also reflect the influence acquired. Consider the mutually exclusive sets of binary comparisons: Disagreements, influences acquired, influences formed, and agreements, where the following definitions apply.

- Disagreements of i from j: $D_i = \{xy \in X \times X : x = C_i(xy) \neq C_j(xy)\}$.
- Influence of i over j: $I_i = \{xy \in X \times X : x = C_i(xy) = C_j(xy)$ and there exists $S \in \Omega_X$ with $x \in S$ such that $C_j(S) \neq C_j(S \setminus y)\}$.
- Agreements: $A = \{xy \in X \times X : x = C_i(xy) = C_j(xy)$ and $C_i(S) = C_i(S \setminus y)$ and $C_j(S) = C_j(S \setminus y)$ for all $S \in \Omega_X$ with $x \in S\}$.

Notice that $(D_i \cup I_i \cup A) = \{xy \in X \times X : C_i(S) = C_i(S \setminus y)$ for all $S \in \Omega_X$ with $x \in S\}$ coincides with the *shadows* relation for i: $\succ_i^s$. In the proof of Theorem 1, we show that the pair $(\succ_1^s, \succ_2^s)$ explains a given pair of choice behaviors (C_1, C_2) consistent with CMI. Indeed the pair $(\succ_1^s, \succ_2^s)$ is the largest pair of binary relations (in terms of set inclusion) that would explain (C_1, C_2); it is not possible to add another binary comparison to either of the relations and yet explain the same data. However, one can find subsets of these relations that would explain the same choices.

A first observation is that any pair of preferences explaining a given (C_1, C_2) has to possess the binary pairs that two individuals disagree on, D_1 and D_2. These refer to the pairs of alternatives about which the individuals have reverse tastes. Moreover, thanks to CoI, we are able to detect the pairs of alternatives where an influence is acquired for sure, I_1 and I_2. Finally, since preferences are defined to be transitive, the ordered pairs that are not necessarily in D_i or I_i, but implied by transitivity of $\succ_i$, will be common to any pair of preferences for the given (C_1, C_2). Let us denote the transitive closure of $D_i \cup I_i$ as $\mathrm{tr}(D_i \cup I_i)$.[16] Thus, the intersection of all pairs of preferences that explain given choice data will be $(\mathrm{tr}(D_1 \cup I_1), \mathrm{tr}(D_2 \cup I_2))$. This refers to the part of the preferences that is uniquely identified. The following theorem shows that any transitive completion of the pair $(\mathrm{tr}(D_1 \cup I_1), \mathrm{tr}(D_2 \cup I_2))$ with the binary comparisons in A explains the given choice behavior.

Let us define an *A-completion* of $(\mathrm{tr}(D_1 \cup I_1), \mathrm{tr}(D_2 \cup I_2))$ as $(\mathrm{tr}(D_1 \cup I_1 \cup A_1), \mathrm{tr}(D_2 \cup I_2 \cup A_2))$ for $A_1 \subseteq A$ and $A_2 \subseteq A$ such that $A_1 \cup A_2 = A$. Notice that when $A_1 = A_2 = A$, the A-completion coincides with the pair of shadow relations, i.e., $(\mathrm{tr}(D_1 \cup I_1 \cup$

[15]We say that $(\succ_1, \succ_2)$ explains (rationalizes) (C_1, C_2) if $C_1(S) = \mathrm{Max}(\mathrm{Max}(S, \succ_1), \succ_2)$ and $C_2(S) = \mathrm{Max}(\mathrm{Max}(S, \succ_2), \succ_1)$.

[16]The transitive closure of a binary relation is the smallest transitive relation that contains it.

$A_1), \mathrm{tr}(D_2 \cup I_2 \cup A_2)) = (\succ_1^s, \succ_2^s)$. Also notice that for $A_1 = \varnothing$, we have $A_2 = A$ and, hence, $(\mathrm{tr}(D_1 \cup I_1), \succ_2^s)$ is also an A-completion.

Theorem 2. *Let (C_1, C_2) be a CMI mechanism. Then any preference pair $(\succ_1, \succ_2)$ that explains (C_1, C_2) is identified uniquely up to A-completions of the pair $(\mathrm{tr}(D_1 \cup I_1), \mathrm{tr}(D_2 \cup I_2))$.*

Proof. Let (C_1, C_2) be a CMI mechanism.

Necessity. Consider any $(\succ_1, \succ_2)$ explaining (C_1, C_2). Fix $i, j \in \{1, 2\}$ with $i \neq j$, without loss of generality. We first show that $\mathrm{tr}(D_i \cup I_i) \subset \succ_i$. Take any $xy \in D_i$. Since $y = C_j(xy)$, by definition of CMI, we have $xy \notin \succ_j$. But then $x = C_i(xy)$ implies that $xy \in \succ_i$. Now take any $xy \in I_i$. As there exists $S \in \Omega_X$ with $x \in S$ and $C_j(S) \neq C_j(S \setminus y)$, we have $xy \notin \succ_j$. But then $x = C_i(xy)$ implies that $xy \in \succ_i$. Thus for any $xy \in (D_i \cup I_i)$, we also have $xy \in \succ_i$. Transitivity of $\succ_i$ proves that $\mathrm{tr}(D_i \cup I_i) \subset \succ_i$. Now we only need to show that for any $xy \in (\succ_i \setminus \mathrm{tr}(D_i \cup I_i))$ we have $xy \in A$. Take such xy and notice that by definition of CMI, $xy \in \succ_i$ implies that $x = C_i(xy)$ and $C_i(S) = C_i(S \setminus y)$ for all $S \in \Omega_X$ with $x \in S$. The noninclusion $xy \notin D_i$ implies that $x = C_j(xy)$ and $xy \notin I_i$ implies that $C_j(S) = C_j(S \setminus y)$ for all $S \in \Omega_X$ with $x \in S$. But then, by definition of A, we have $xy \in A$.

Sufficiency. We now show that any A-completion of $(\mathrm{tr}(D_1 \cup I_1), \mathrm{tr}(D_2 \cup I_2))$ explains (C_1, C_2). Take any A-completion, $(\mathrm{tr}(D_1 \cup I_1 \cup A_1), \mathrm{tr}(D_2 \cup I_2 \cup A_2))$, and for ease of notation let us denote it by $(\succ_1^*, \succ_2^*)$. In the proof of Theorem 1 we have shown that $(\succ_1^s, \succ_2^s)$ explains (C_1, C_2). Below we show that $\mathrm{Max}(\mathrm{Max}(S, \succ_i^*), \succ_j^*) = \mathrm{Max}(\mathrm{Max}(S, \succ_i^s), \succ_j^s)$ for any $S \in \Omega_X$ and for $i, j \in \{1, 2\}$ with $i \neq j$, thus any A-completion also explains (C_1, C_2).

(I) First notice that since $\succ_i^s = D_i \cup I_i \cup A$, we have $\succ_i^* \subseteq \succ_i^s$ and, hence, $\mathrm{Max}(S, \succ_i^s) \subseteq \mathrm{Max}(S, \succ_i^*)$ for any S and $i \in \{1, 2\}$ [1]. (II) Next notice that by definition of A-completion, $xy \in (\succ_i^s \setminus \succ_i^*)$ implies that $xy \in \succ_j^*$ for $i, j \in \{1, 2\}$ with $i \neq j$. We will refer to the arguments (I) and (II) in the rest of the proof.

Take any $S \in \Omega_X$. We claim that $\mathrm{Max}(\mathrm{Max}(S, \succ_i^*), \succ_j^*) \subseteq \mathrm{Max}(\mathrm{Max}(S, \succ_i^s), \succ_j^s)$ to start with. To prove this, take any $x \in \mathrm{Max}(\mathrm{Max}(S, \succ_i^*), \succ_j^*)$ and assume, to the contrary, that $x \notin \mathrm{Max}(\mathrm{Max}(S, \succ_i^s), \succ_j^s)$. There are two possible cases, both of which result in the desired contradiction as we show below.

Case 1: Choice x is eliminated in the first stage. Then, by transitivity of $\succ_i^s$, there exists $y \in \mathrm{Max}(S, \succ_i^s)$ with $yx \in \succ_i^s$. Since $x \in \mathrm{Max}(S, \succ_i^*)$ and by (I), $y \in \mathrm{Max}(S, \succ_i^*)$, we have $yx \notin \succ_i^*$. But then (II) implies that $yx \in \succ_j^*$. Since, $y \in \mathrm{Max}(S, \succ_i^*)$, we contradict $x \in \mathrm{Max}(\mathrm{Max}(S, \succ_i^*), \succ_j^*)$, as desired.

Case 2: Choice x is eliminated in the second stage. Then, by transitivity of $\succ_j^s$, there exists $y \in \mathrm{Max}(\mathrm{Max}(S, \succ_i^s), \succ_j^s)$ with $yx \in \succ_j^s$. Since $y \in \mathrm{Max}(S, \succ_i^s)$, (I) implies that $y \in \mathrm{Max}(S, \succ_i^*)$. Since $x \in \mathrm{Max}(\mathrm{Max}(S, \succ_i^*), \succ_j^*)$, we have $yx \notin \succ_j^*$. Thus, we have $yx \in (\succ_j^s \setminus \succ_j^*)$. But then (II) implies that $yx \in \succ_i^*$, creating a contradiction to $x \in \mathrm{Max}(S, \succ_i^*)$, as desired.

We finally claim that $\mathrm{Max}(\mathrm{Max}(S, \succ_i^s), \succ_j^s) \subseteq \mathrm{Max}(\mathrm{Max}(S, \succ_i^*), \succ_j^*)$. Take any $x \in \mathrm{Max}(\mathrm{Max}(S, \succ_i^s), \succ_j^s)$ and assume, to the contrary, that $x \notin \mathrm{Max}(\mathrm{Max}(S, \succ_i^*), \succ_j^*)$. Similarly, we have the following cases, which end in contradictions as desired:

Case 1: Choice x is eliminated in the first stage. Since $x \in \text{Max}(S, \succ_i^s)$, (I) creates the desired contradiction.

Case 2: Choice x is eliminated in the second stage. Then, by transitivity of $\succ_j^*$, there exists $y \in \text{Max}(\text{Max}(S, \succ_i^*), \succ_j^*)$ with $yx \in \succ_j^*$. Since $\succ_j^* \subseteq \succ_j^s$, $yx \in \succ_j^s$. But then $x \in \text{Max}(\text{Max}(S, \succ_i^s), \succ_j^s)$ implies that $y \notin \text{Max}(S, \succ_i^s)$. Then, by transitivity of $\succ_i^s$, there exists $z \in \text{Max}(S, \succ_i^s)$ with $zy \in \succ_i^s$. Since $y \in \text{Max}(S, \succ_i^*)$, we have $zy \notin \succ_i^*$. Thus we have $zy \in (\succ_i^s \setminus \succ_i^*)$. But then, (II) implies that $zy \in \succ_j^*$. Since by (I), $z \in \text{Max}(S, \succ_i^*)$, $zy \in \succ_j^*$ creates a contradiction to $y \in \text{Max}(\text{Max}(S, \succ_i^*))$, proving the claim and, hence, establishing the result. □

Theorem 2 ensures that we can recover a major part of underlying preferences and, hence, the influence. The overidentification problem relates to those ordered pairs in A.[17] Consider the extreme case where two individuals show exactly the same choice behavior overall. Then since $D_i = I_i = \varnothing$, we cannot conclude whether two individuals actually have the same preferences or one of them has null preferences and is getting fully influenced by the other. In the other extreme, if we observe a pair of choice behaviors with a null A, we can completely identify the underlying preferences and the influence. In general, if we observe that $\text{tr}(D_i \cup I_i) = (D_i \cup I_i \cup A)$ for both $i \in \{1, 2\}$, then it is immediate to see by Theorem 2 that a unique pair of preferences explains this choice behavior.

2. Extension to multi-individual settings

CMI is a simple decision mechanism for interacting individuals. Despite its simplicity, it is powerful enough to easily extend to multi-individual settings and explain more complicated forms of social interactions, as we try to exemplify in this section. Consider a group N consisting of n individuals. Each individual $i \in N$ is equipped with a transitive and asymmetric $\succ_i$ over X. Given a choice problem, i first maximizes $\succ_i$. As long as this first stage does not yield a unique choice, a second stage involving *some kind of interaction* with other group members takes place so as to refine the choice outcomes. Here are several examples as to what might happen in that second stage interaction.

Example 2 (Unanimous Influence). The second stage of the decision process of each i involves a consideration of the opinions of all other group members. If all others agree on the same ranking of alternatives, then i behaves accordingly. Otherwise no influence is acquired. ◊

[17] Let us note that further information about the underlying preferences might also help. The identification issue arises due to the fact that although i is actually indecisive between some x and y, he/she does not commit a weak $\langle x, y\rangle$ reversal. But this only happens if x and y are too "similar" in terms of their relative comparison to the other alternatives for both of the agents: whatever is better than x for i is also not worse than y and whatever is worse than y for i is also not better than x at least for one of the agents. Moreover, no alternative that is better than x is better than any alternative that is worse than y, again at least for one of the agents. This observation translates as a richness condition on the pair of preferences. When underlying preferences are assumed to be "rich enough" as well as being transitive and asymmetric, they are uniquely identified. Certainly whether richness is a reasonable assumption is open to discussion. This result is available upon request.

Example 3 (Directed Influence). For each i, there is one other j to whose preferences i refers in the second stage. Notice that influence is not necessarily mutual here; instead it forms a directed network of interacting individuals. ◊

Example 4 (Expert Influence). The group includes various experts: individuals who know better than the others about certain alternatives. In the second stage, individuals seek expert influence: Whenever i is unable to choose from several alternatives that happen to be in j's expertise, he/she refers to j's opinion. Since individuals have distinct sets of expertise, i gets influenced by different experts on different issues. ◊

These are a few natural extensions of CMI to multi-individual environments. The interesting question for the outside observer becomes how to figure out their distinctive features. What kind of properties of the observed choice behaviors, $(C_1, C_2, \ldots, C_n)$ allow us to differentiate these scenarios from each other?

Depending on what we have learned from CMI, we know that following choice inconsistencies is the key to answering this question. Variations of CoI would allow us to detect the influence acquired as well as the influential individual(s). Variations of NULL, alternatively, would ensure, given that j influences i, that any influence that j could potentially have on i is indeed acquired.

In this text we only provide the characterization of the last example, which happens to be a nontrivial extension.[18] Choice on expert influence (CEI) is an intuitive individual decision model for groups with an inherent division of expertise. For instance, within a group of friends, it is quite natural for everyone to refer to a specific person for trip advice and to another person for advice on which car to buy. Similarly, in an economics department, it is quite natural for a microeconomist to refer to an econometrician's view to resolve a dispute about the contribution of an econometrics paper as well as to refer to a macroeconomist for a macroeconomics paper.

Let $E_i \subset X$ denote the expertise of individual i. For simplicity purposes, we assume that areas of expertise are disjoint; $E_i \cap E_j = \varnothing$ for $i \neq j$. If an individual j does not possess any expertise, then $E_j = \varnothing$. Let $(\succ_j |E_j)$ denote the part of the preference of j over the alternatives in his/her expertise, i.e., $(\succ_j |E_j) = \{xy \in \succ_j : x, y \in E_j\}$. Then the expert rationale of this society will be $\succ^E = \bigcup_{j \in N} (\succ_j |E_j)$.

Definition 2. We say that $(C_1, C_2, \ldots, C_n)$ is a CEI mechanism, if there exists n asymmetric and transitive binary relations $(\succ_1, \succ_2, \ldots, \succ_n)$ and n areas of expertise $E_1, E_2, \ldots, E_n$ such that $C_i(S) = \text{Max}(\text{Max}(S, \succ_i), \succ^E)$ for all $S \in \Omega_X$ and for all $i \in N$.

[18] The characterization of the others can also be obtained by adjusting the two properties accordingly: In choice on unanimous influence, the second stage relation of i is simply $\bigcap_{j \in N \setminus \{i\}} \succ_j$. Hence NULL becomes, for all i and S, $\bigcup_{j \in N \setminus \{i\}} C_j(C_i(S)) = C_i(S)$. Similarly, CoI states that whenever $x = C_i(xy)$, then x shadows y for i or for all $j \in N \setminus \{i\}$. Characterization of choice on directed influence very closely follows that of CMI when choice outcomes are restricted to unique alternatives. Then, in addition to EXP, the property that for each i, there exists a j such that CoI holds is sufficient to characterize the model. When set-valued outcomes are allowed, characterization becomes trickier since $xy = C_i(xy)$ no longer implies that $xy = C_j(xy)$ simply because j influencing i can him/herself be influenced by another individual k. Still we can characterize this model by straightforward adjustments of CoI and NULL under an additional assumption on preferences. That result is available upon request.

Let I denote the set of binary pairs associated with at least one inconsistency: $I = \{xy \in X \times X$: An $\langle x, y\rangle$ reversal has been committed by some $i \in N\}$. These are the binary pairs for which an influence has been acquired. The following consistency property brings some structure to this set.

Consistency of Expert Influence (CoEI). For any $xy \in I$, there exists $j \in N$ such that x shadows y for j. Moreover, for any $z \in X$ with $yz \in I$, y shadows z for j.

CoEI ensures that for any influence acquired, there is an expert j behind it. Moreover, if j is the expert on a pair of issues, any related influence has to come from j. Notice that this is the case since areas of expertise are disjoint. We now introduce the NULL counterpart of this setting, a property that accounts for the set-valued outcomes. Binding influence states that if there is an expert on a certain set of issues, it is not possible not to be influenced by him/her.

Binding Influence (BI). For any binary chain $x_1x_2, x_2x_3, \dots, x_{t-1}x_t \in I$, we have $x_lx_k \neq C_i(x_lx_k)$ for any $l, k \in \{1, 2, \dots, t\}$, for all $i \in N$.

The existence of a binary chain in I indicates the existence of an expert for the alternatives that constitute a part of this chain. BI ensures that the expert is actually influential. CoEI and BI are the properties that build the interaction links between individuals. Apart from these, we need two individual rationality properties: EXP and a weakening of weak WARP for correspondences.

Weak WARP (WWARP*).* For any $x, y \in X$ and $i \in N$, if $x = C_i(xy)$ and $x \in C_i(S)$ for some $S \in \Omega_X$ with $x, y \in S$, then $y \notin C_i(S)$.

WWARP* prohibits the choice of an alternative y from a set where another alternative x, which is uniquely chosen over y from the binary problem, has been chosen.[19]

Theorem 3. *Let $(C_1, C_2, \dots, C_n)$ be an n-tuple of choice correspondences. The n-tuple $(C_1, C_2, \dots, C_n)$ satisfies EXP, WWARP*, CoEI, and BI if and only if $(C_1, C_2, \dots, C_n)$ is a CEI mechanism.*

Proof. We only prove sufficiency. For $i \in N$, once again choose $\succ_i \subseteq X \times X$ as $\succ_i = \succ_i^s$. As shown in the proof of Theorem 1, $\succ_i$ is asymmetric, is transitive, and $C_i(S) = C_i(\text{Max}(S, \succ_i))$ for any $S \in \Omega_X$. Now, for $j \in N$, define E_j as

$$x, y \in E_j \quad \text{if and only if} \quad xy \in \text{tr}\big(\succ_j |E'_j\big),$$

where $x, y \in E'_j$ if and only if $xy \in (I \cap \succ_j)$ and for all $yz, tx \in I$, we have $yz, tx \in \succ_j$.

Notice that by CoEI, for any $xy \in I$, there exists $j \in N$ such that $x, y \in E'_j \subseteq E_j$. If $E_j \cap E_k \neq \varnothing$ for some $j, k \in N$, then discard $E_j \cap E_k$ either from E_j or E_k, randomly. Notice that this does not break transitivity of $(\succ_j |E_j)$ or $(\succ_k |E_k)$ thanks to CoEI. Finally, let $\succ^E = \bigcup_{j \in N}(\succ_j |E_j)$. The term $\succ^E$ is asymmetric and transitive, since each $(\succ_j |E_j)$ is asymmetric and transitive and areas of expertise are disjoint.

[19] It is also possible to characterize CMI with EXP, WWARP*, CoI, and a weakening of NULL to binary problems. Since weakening NULL comes with the cost of an additional WWARP* axiom, we prefer the previous characterization.

Now take $i \in N$ and $S \in \Omega_X$. First, take $x \in \text{Max}(\text{Max}(S, \succ_i), \succ^E)$. We show that $x \in C_i(\text{Max}(S, \succ_i))$ and, hence, $x \in C_i(S)$. For any $z \in \text{Max}(S, \succ_i)$, we have $x \in C_i(xz)$. This holds since $z = C_i(xz)$ and $x \in \text{Max}(S, \succ_i)$ imply that $zx \in I$. But then $zx \in \succ^E$, contradicting $x \in \text{Max}(\text{Max}(S, \succ_i), \succ^E)$. Hence, $x \in C_i(xz)$ for all $z \in \text{Max}(S, \succ_i)$. But then, by EXP, $x \in C_i(\text{Max}(S, \succ_i))$, as claimed, establishing that $x \in C_i(S)$.

Take $x \in C_i(S)$. We finally show that $x \in \text{Max}(\text{Max}(S, \succ_i), \succ^E)$. By definition of $\succ_i$, $x \in \text{Max}(S, \succ_i)$. Assume, to the contrary, that $x \notin \text{Max}(\text{Max}(S, \succ_i), \succ^E)$. But then, since $\succ^E$ is transitive, there exists $y \in \text{Max}(\text{Max}(S, \succ_i), \succ^E)$ such that $yx \in \succ^E$. By the previous part of this proof, we know that $y \in \text{Max}(\text{Max}(S, \succ_i), \succ^E)$ implies $y \in C_i(S)$. If $x = C_i(xy)$, since $x \in C_i(S)$, by WWARP*, we have $y \notin C_i(S)$, a contradiction. If $y = C_i(xy)$, since $y \in C_i(S)$, by WWARP*, we have $x \notin C_i(S)$, a contradiction. Finally, if $xy = C_i(xy)$, then by BI, there is no binary chain $yz_1, z_1z_2, \ldots, z_tx \in I$, which contradicts $yx \in \succ^E$, establishing the proof. □

3. Further comments

3.1 *Peer influence versus homophily*

A considerable amount of social interaction studies are devoted to the identification problem of homophily and influence. In this subsection, we want to discuss how our model can be applied to this specific identification problem.

Homophily refers to the tendency to create social ties with people who are similar to one's self.[20] Peer influence or social influence, alternatively, is defined as adopting similar behavioral patterns with people with whom one is socially connected.[21] Both homophily and social influence result in behavioral resemblances between connected people. However, it is not trivial for an outside observer to identify the underlying reason for particular behavioral resemblances: Do people who are socially connected to each other behave similarly because of homophily or peer influence? More importantly, how do we observationally distinguish one from the other? This phenomenon is known as the identification problem of homophily and social influence, and it is mainly challenged from an econometrical perspective. Many studies document that both phenomena prevail simultaneously and distinguishing one from the other requires strong parametrical assumptions.[22]

As claimed in the introduction, CMI brings a new approach to this issue. Consider two socially connected individuals. First of all, as long as our testable properties are satisfied, revealed preference analysis grants us the potential influence as well as the underlying preferences. Hence, what is left is to identify the level of homophily of this

[20] For an overview of research on homophily in general, see McPherson et al. (2001); on couples, see Blackwell and Lichter (2004); on economic netwo,rks see Currarini et al. (2009).

[21] For peer influence in teenage behavior, see Evans et al. (1992); in crime, see Glaeser et al. (1996); in education, see Zimmerman (2003); in labor markets, see Mas and Moretti (2009); over social networks, see Calvo-Armengol et al. (2009) and Bramoullé et al. (2009).

[22] See Aral et al. (2009), Bramoullé et al. (2009), Calvo-Armengol et al. (2009), Lewis et al. (2012), Manski (1993), Noel and Nyhan (2011).

pair. Although outside the scope of this text, a measure of homophily can easily be constructed in terms of the similarity of the individual preferences. The more similar individual tastes are, the more homophilic that pair is.[23]

3.2 *Challenges to inference*

It is worth acknowledging that our analysis intrinsically assumes that as long as their behaviors do not contradict the defining properties of our model, individuals are taken to be in interaction. Consider two members of a household, say 1 and 2, and assume that their individual grocery shopping behavior is consistent with CMI. So far, our approach takes this information, the fact that they are sharing the same environment and do not violate EXP, NULL, and CoI, for pure evidence of mutual influence between them. However, it is quite possible to come up with alternative explanations to their behavior. It might as well be the case that 1 and 2 are actually running short-list methods, where 1 first cares about the healthiness of the product, hence, first short-lists the most healthy products and then picks the cheapest ones out of this short list, whereas 2 first cares about affordability and then the healthiness, hence, runs the opposite shortlisting. Their behavior will *look like* they are mutually influencing each other, although the underlying story is entirely different.

It is no coincidence that empirical studies on social interactions also suffer from the same inference problem, as pointed out by Manski (2000), p. 117:

> The second and more fundamental problem is the inherent difficulty of drawing inferences from the data that economists commonly bring to bear to study social interactions. The prevailing practice has been to try to infer the presence of interactions from observations of the outcomes experienced in a population of interest. However, the observed outcomes of the population can usually be generated by many different interaction processes, or perhaps by processes acting on individuals in isolation. Hence the findings of empirical studies are often open to an uncomfortably wide range of interpretations.

What Manski suggests as a solution to this problem, from which we could also benefit, is "enrichment of data," "well designed experiments," and "careful elicitation of persons' subjective perceptions of the interactions in which they participate." In particular, for our setting, observations of choice behavior before and after a certain pair is formed might be helpful. Similarly, comparing the behavior of an individual in the vicinity of different individuals can be informative, though still requires cautious inference. In this regard, there is a lot to be learned from well designed controlled experiments, as Manski suggests, where it is much easier to change a certain parameter with the purpose of comparing the outcomes.

[23]An example of a similarity function between preferences would be Kendall's correlation coefficient τ, which measures the correlation between two preferences based on the distance between them. Kendall's τ for incomplete preferences can be found in Bogart (1973).

4. Concluding remarks

This study presents a first attempt to provide a choice-theoretic approach to interaction. We model interaction as a means to deal with an inherent individual necessity: inability to choose due to incomplete preferences. Our baseline model, CMI, despite its simplicity, is flexible enough to grasp at more convoluted forms of interactions. The characterization of CMI lays out two important properties of choice behavior consistent with the model: First, choice inconsistencies in one's behavior correspond to the influences acquired and, hence, are traced back to the preferences of the influential individual. Second, all the influence that can be acquired is already inherent in the choice behavior. These properties correspond to our CoI and NULL properties, respectively. A key observation, which we also explore in the second section of this paper, is that modifications of these two properties aid in characterizing various interaction environments.

As the studies of the last decades have shown, expanding the realm of choice data has provided new explanations for the behaviors that were once classified as "irrational." The novelty of this paper lies in its focus on multiple choice behaviors instead of one. We believe there is still a lot to explore once we go beyond more than one individual's behavior.

References

Apesteguia, Jose and Miguel A. Ballester (2013), "Choice by sequential procedures." *Games and Economic Behavior*, 77, 90–99. [479]

Aral, Sinan, Lev Muchnik, and Arun Sundararajan (2009), "Distinguishing influence-based contagion from homophily-driven diffusion in dynamic networks." *Proceedings of the National Academy of Sciences*, 106, 21544–21549. [488]

Au, Pak Hung and Keiichi Kawai (2011), "Sequentially rationalizable choice with transitive rationales." *Games and Economic Behavior*, 73, 608–614. [479]

Bajraj, Gent and Levent Ülkü (2015), "Choosing two finalists and the winner." *Social Choice and Welfare*, 45, 729–744. [479]

Blackwell, Debra L. and Daniel T. Lichter (2004), "Homogamy among dating, cohabiting, and married couples." *Sociological Quarterly*, 45, 719–737. ISSN 1533-8525. doi:10.1111/j.1533-8525.2004.tb02311.x. [488]

Blume, Lawrence E., William A. Brock, Steven N. Durlauf, and Yannis M. Ioannides (2010), "Identification of social interactions." In *Handbook of Social Economics* (Jess Benhabib, Alberto Bisin, and Matthew O. Jackson, eds.), 853–964, North Holland, Amsterdam. [477, 478]

Bogart, Kenneth (1973), "Preference structures I: Distances between transitive preference relations." *Journal of Mathematical Sociology*, 3, 49–67. [489]

Bramoullé, Yann, Habiba Djebbari, and Bernard Fortin (2009), "Identification of peer effects through social networks." *Journal of Econometrics*, 150, 41–55. [477, 488]

Calvo-Armengol, Antoni, Eleonora Patacchini, and Yves Zenou (2009), "Peer effects and social networks in education." *Review of Economic Studies*, 76, 1239–1267. [477, 488]

Cialdini, Robert B. (2007), *Influence: The Psychology of Persuasion*. HarperCollins, New York. [479]

Currarini, Sergio, Matthew O. Jackson, and Paolo Pin (2009), "An economic model of friendship: Homophily, minorities, and segregation." *Econometrica*, 77, 1003–1045. [488]

Dutta, Rohan and Sean Horan (2015), "Inferring rationales from choice: Identification for rational shortlist methods." *American Economic Journal: Microeconomics*, 7, 179–201. [479]

Evans, William N., Wallace E. Oates, and Robert M. Schwab (1992), "Measuring peer group effects: A study of teenage behavior." *Journal of Political Economy*, 100, 966–991. [477, 488]

Garcia-Sanz, María D. and José Carlos R. Alcantud (2015), "Sequential rationalization of multivalued choice." *Mathematical Social Sciences*, 74, 29–33. [479]

Glaeser, Edward L., Bruce Sacerdote, and Jose A. Scheinkman (1996), "Crime and social interactions." *The Quarterly Journal of Economics*, 111, 507–548. [477, 488]

Horan, Sean (2016), "A simple model of two-stage choice." *Journal of Economic Theory*, 162, 372–406. ISSN 0022-0531. doi:http://dx.doi.org/10.1016/j.jet.2016.01.002. [479, 481]

Lewis, Kevin, Marco Gonzalez, and Jason Kaufman (2012), "Social selection and peer influence in an online social network." *Proceedings of the National Academy of Sciences*, 109, 68–72. ISSN 1091-6490. [488]

Manski, Charles F. (1993), "Identification of endogenous social effects: The reflection problem." *Review of Economic Studies*, 60, 531–542. [478, 488]

Manski, Charles F. (2000), "Economic analysis of social interactions." *Journal of Economic Perspectives*, 14, 115–136. [478, 489]

Manzini, Paola and Marco Mariotti (2007), "Sequentially rationalizable choice." *American Economic Review*, 97, 1824–1839. [479]

Manzini, Paola and Marco Mariotti (2012), "Categorize then choose: Boundedly rational choice and welfare." *Journal of the European Economic Association*, 10, 1141–1165. [479]

Mas, Alexandre and Enrico Moretti (2009), "Peers at work." *American Economic Review*, 99, 112–145. doi:10.1257/aer.99.1.112. [477, 488]

Masatlioglu, Yusufcan, Daisuke Nakajima, and Erkut Y. Ozbay (2012), "Revealed attention." *American Economic Review*, 102, 2183–2205. doi:10.1257/aer.102.5.2183. [479]

Masatlioglu, Yusufcan and Efe A. Ok (2005), "Rational choice with status quo bias." *Journal of Economic Theory*, 121, 1–29. ISSN 0022-0531. doi:http://dx.doi.org/10.1016/j.jet.2004.03.007. [479]

Matsuki, Jun and Koichi Tadenuma (2013), *Choice via Grouping Procedures*. Center for Research on Contemporary Economic Systems, Graduate School of Economics, Hitotsubashi University. [479]

McPherson, Miller, Lynn Smith-Lovin, and James M. Cook (2001), "Birds of a feather: Homophily in social networks." *Annual Review of Sociology*, 27, 415–444. doi:10.1146/annurev.soc.27.1.415. [488]

Noel, Hans and Brendan Nyhan (2011), "The "unfriending" problem: The consequences of homophily in friendship retention for causal estimates of social influence." *Social Networks*, 33, 211–218. ISSN 03788733. doi:10.1016/j.socnet.2011.05.003. [488]

Plott, Charles R. (1973), "Path independence, rationality, and social choice." Econometrica: Journal of the Econometric Society, 1075–1091. [482]

Rubinstein, Ariel and Yuval Salant (2008), "Some thoughts on the principle of revealed preference." In *Handbooks of Economic Methodologies* (A. Caplin and A. Schotter, eds.), 115–124, Oxford University Press, New York. [479]

Salant, Yuval and Ariel Rubinstein (2008), "(A, f): Choice with frames." *The Review of Economic Studies*, 75, 1287–1296. [479]

Sen, Amartya (1993), "Internal consistency of choice." *Econometrica*, 61, 495–521. [478]

Tyson, Christopher J. (2012), "Behavioral implications of shortlisting procedures." *Social Choice and Welfare*, 41, 941–963. ISSN 1432-217X. doi:10.1007/s00355-012-0704-0. [479]

Yildiz, Kemal (2017), "List rationalizable choice." *Theoretical Economics*, forthcoming. [479]

Zimmerman, David J. (2003), "Peer effects in academic outcomes: Evidence from a natural experiment." *The Review of Economics and Statistics*, 85, 9–23. [477, 488]

Co-editor Nicola Persico handled this manuscript.

Manuscript received 1 May, 2015; final version accepted 14 March, 2016; available online 24 March, 2016.