Temporal Dynamics in Categorization: Typecasting and Entry-Driven Legitimation[1]

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Abstract

This paper proposes a unifying framework to integrate two of economic sociology's theory fragments on categorization: typecasting and entry-driven legitimation. Typecasting is a producer-level argument that considers the consequences for producers of earlier affiliation with one category on the chances of success in another. Entry-driven legitimation considers how the attributes of producers entering a category shape its likelihood of gaining legitimacy among relevant audiences. Both theory fragments treat the processes by which audiences assign category memberships to producers and emphasize the importance of temporal sequences of these assignments. In this paper, we develop this common foundation and develop a theory that explains the central empirical findings of the two approaches. We formalize these arguments using modal expressions to represent key categorization processes.

Introduction

Categorization in market contexts has attracted considerable interest in recent years. This development has been spurred by Zuckerman's (1999) seminal work in capital markets as well as growing recognition of the limits of traditional approaches to treating category and form. As we discuss below, a surge of work has pursued diverse questions about the emergence of categories and forms. Several theory fragments have developed to explain certain contexts. This paper tries to unify some of these arguments. It proposes a new theory that integrates two important fragments—on typecasting and legitimation—and has the potential to unify others as well.

Typecasting theory considers the implications for individual producers of earlier categorical assignments on later success in other categories (Zuckerman, Kim, Ukanwa, and von Rittman 2003). When audience members recognize a producer as a member of one category, they judge it as less suitable as candidate for another related category.

The theory of form emergence in the multiple-category context considers how the attributes of the producers associated with an emerging category shape its likelihood of gaining legitimacy among relevant audiences (McKendrick and Carroll 2001; McKendrick, Jaffee, Carroll, and Khessina 2003). Work in this area finds that a category is more likely to become a (taken for granted) form when new entrants do not have any prior categorical affiliations, in contrast with *dealio* entrants that come from other categories.

These specialized theories, which we call theory fragments, focus on causal factors and outcomes at different analytical levels—individual producer versus category—as well as on categories at different stages of development. Typecasting theory focuses on highly legitimated categories (forms) and considers how the existing identity of a producer shapes its future opportunities vis-à-vis market categories. Theories of form emergence focus on earlier stages of the categorization process and consider the factors that shape the likelihood of a category attaining the status of a (highly legitimated) form.

Despite these differences, the two arguments share an important focus. Both feature the implications of the time sequence of assignments of categorical memberships, and they assume that beliefs based on prior memberships affect the likelihood of granting memberships in other categories. The purpose of this paper is to advance a general theory about the stickiness of beliefs that can organize the two lines of argument as special cases. By identifying and integrating principles common to these very different but related fragments, we aim to establish a stronger foundation for future theorization and empirical work on market categorization.

To structure our theory integration, we use the formal theory-building tools and framework developed by Hannan, Pólos, and Carroll (2007) and extended by Pólos, Hannan, and Hsu (2009). The key constructions are multi-modal models that allow for subtle formalization of key sociological concepts such as legitimation, identity, and social form as consequences of the beliefs held by relevant audiences. By adopting a formal approach, we aim to minimize ambiguity and carefully reconstruct arguments central to both typecasting and form emergence in a way that highlights the specific and common underlying processes at work as well as the assumptions that might be necessary for each theory to hold. To be sure, there is a price to be paid. Formalization requires reliance on explicit simplifying assumptions, which might not fit real situations. Overall, however, we believe this approach to theory building has value for producing coherent, integrative sociological theories.

We begin with a brief overview of key lines of research on market categorization. We then highlight important concepts from recent theoretical work on the emergence of categories and forms. Then, in the main body of our paper, we extend this theory to yield theorems that capture the central insights of theories of typecasting and form emergence. While we rely on formalization to structure our theory integration, we have placed most of the technical details, including the formulas expressing the definitions, postulates, and theorems as well as the proofs, in the Appendix in the interest of making the arguments accessible.

Categorization in Markets

One source of the upsurge in interest in categories in research in economic and organizational sociology is dissatisfaction with conventional thinking about categories and forms. In the case of organizations, scholars generally agree that form refers to "those characteristics of an organization that identify it as a distinct entity and, at the same time, classify it as a member of a group of similar organizations" (Romanelli 1991: 81–82). Yet, there has been considerable disagreement about how to identify the presence and boundaries of a form (Hannan and Freeman 1986; Romanelli 1991; Pólos, Hannan, and Carroll 2002). A significant body of research identifies forms by looking for common patterns of features, suggesting that forms can be assessed in purely objective terms (see Carroll and Hannan 2000 for a review). Other research looks to boundary-creating processes such as social network ties and personnel flows to understand form distinctions (Hannan and Freeman 1986; DiMaggio 1986).

Nonetheless, a growing consensus holds that such approaches lose sight of the importance of the social meanings and interpretations of contemporaneous

audiences in the specification of forms for organizations and other kinds of producers in market. How can researchers ensure that the forms they study actually represent instances of meaningful social units? An audience-based approach to categories (an antecedent to forms) seeks to provide a resolution to such concerns.

This approach emphasizes the desirability of modeling what social agents perceive when they "see" a producer and what they expect of the bearers of the identity (Pólos et al. 2002; Hannan et al. 2007). Categories are viewed as a type of collective identity; they involve a typification of commonality where audience members recognize similarities among different producers and come to regard them as members of a common set. In some cases, categories become forms—that is, they become collective highly legitimated (taken-for-granted) by audience members.

This formulation addresses explicitly the sometimes-messy nature of socially constructed categories. Emphasizing what audience members see relies on the use of conceptual tools for representing the degree to which producers are perceived as fitting a category. Such a conceptualization allows modeling of *partiality* in category memberships and the impact of partiality on category dynamics (Hannan 2008).

A broad range of recent empirical work has incorporated important elements of this new approach to conceptualizing categories and forms (without necessarily employing a model of partial memberships). One active line of research asks how the perceptions and actions of external audiences shape the evolution of categories (Rosa, Porac, Runser-Spanjol, and Saxon 1999; Lounsbury and Rao 2004; Phillips and Owens 2004; Boone, Declerck, Rao, and Van Den Buys 2008; Koçak 2008; Schneiberg, King, and Thomas 2008; Kennedy 2008; Koçak, Hannan, and Hsu 2009). For example, Rao, Monin, and Durand's (2003) study of the nouvelle cuisine movement in French gastronomy finds that greater sociopolitical legitimacy of movement activities and theorization about nouvelle cuisine by culinary journalists and critics influenced the propensity of French chefs to "defect" from classical to nouvelle cuisine.

Research has also investigated how external audiences' categorical perceptions shape critical and commercial success and failure for individual producers (Zuckerman and Kim 2003; Hsu, Hannan, and Koçak 2009). In his research on financial markets, Zuckerman (1999) finds that firms that fail to establish themselves clearly as members of one of the categories used by financial analysts (by diversifying across their categories) are less likely to receive analyst coverage. This reduces their attractiveness to investors and impairs their stock market returns accordingly. And, in a study of Hollywood film projects, Hsu (2006) finds that audiences have trouble making sense of films that span established genres.

Genre-spanners fit poorly with audience tastes and have low appeal. This line of research suggests audience members exert strong constraints on individual producers to conform to the expectations inherent in the identities of the category with which they are associated.

The strength of category-related expectations (and thus the penalties associated with violating them) evolves over time with changes in the composition of a category. For example, Rao et al. (2005) find that penalties imposed on chefs who borrow elements from both classical and nouvelle cuisine weaken as the number of chefs who similarly straddle these category boundaries rises. This suggests that, as chefs increasingly engage in category-spanning activities, audience members' categorical understandings shift as well. Pervasive category spanning appears to cloud audience members' beliefs about what it means to a member of a category. Negro, Hannan, and Rao (2008) find this kind of pattern in their study of critical reactions to elite Italian wines: as category spanning becomes widespread, the rewards for membership in the category decline and the penalties for category spanning weaken.

The repercussions of category spanning vary as the identities of the individual producers change. For example, Zuckerman and collaborators (2003) show that although conforming to the expectations of a single category increases the likelihood that a new producer will gain attention from relevant audiences, such a simple and clear identity restricts future opportunities in other categories. In contrast, an identity that spans multiple categories may allow a wider range of activities to be acceptable to relevant audiences and thus prove more beneficial for experienced producers. These findings complement existing work on the relative costs and benefits of category spanning at the individual level (Faulkner 1983; O'Mahony and Bechky 2006; Leahey 2007).

Finally, much of this work concentrates on the legitimation or taken-for-grantedness of categories (Meyer and Rowan 1977). One key line of research uses ideas about identity to enhance understanding of form emergence (Carroll and Swaminathan 2000; Greve, Pozner, and Rao 2007; Bogaert, Boone, and Carroll 2006; Pontikes 2008). For example, Ruef (2000) demonstrates, for the healthcare domain, that the distribution of existing organizations in identity space affects the likelihood new categories will emerge. A key implication is that the fit of a new category within audience members' preexisting understandings shapes the likelihood of its acceptance and legitimation. McKendrick, Carroll, and colleagues study a complementary issue: how the identities of the producers associated with a category shape the likelihood it will achieve high legitimation (McKendrick and Carroll 2001; McKendrick et al. 2003). This research shows that a category is more likely to become taken for granted when its members specialize in the activities of that category, as compared to situations in which

members are active in multiple categories.

These various lines of research share a common conceptualization of categories as collective identities constructed over time through the actions of interested social agents. Yet, the diversity in approaches has produced a somewhat perplexing picture. Learning how these pieces fit together—or what changes must be made to make them fit—is vital to the continued development of this area of research. Such theoretical integration allows for checks on the consistency of different lines of reasoning as well as the identification of core ideas transferrable across diverse areas of theorization. As noted earlier, we aim to demonstrate this by integrating two very different lines of research on audience-based categorization—typecasting and entry-driven legitimation.

Before stating the new theory, we must sketch some of the elements of the foundation on which we build: category-emergence theory (Hannan et al. 2007). An important element involves the character of memberships in types and categories.

Partial Memberships in Types and Categories

Category-emergence theory considers a dual role structure: producer (the agents who make offerings in the domain) and audience member (the agents who evaluate offerings and potentially reward producers of offerings that they find appealing), and a language that spells out the meanings attached to the roles.

The basic linguistic objects are labels that audience members apply to producers. Applying labels (such as "university," "pharmacy," or "comedian") facilitates cognitive processing and eases communication about producers and their products (Whorf 1956; Zerubavel 1997; Hsu and Hannan 2005). Labeling thus appears to be an important step in the social construction of categories. Our formal story starts with a labeling function (a mapping of triplets of audience members, producers, and time points to the powerset of the set of available labels). A value of the label function gives the set of labels that an audience member applies to a producer at the time point.

Audience members often pair labels with schemas—patterns of characteristics that articulate whether and to what extent a label should be applied to a producer. Schemas provide abstract representations of the characteristics that an audience member regards as consistent with a given label. In other words, a schema establishes the label means.

In formal terms, schemas for labels are sets of formulas that pick out sets of relevant characteristics (or relations). They distinguish the values that are consistent with membership in a label from those that are not. An audience mem-

ber's schema for a label points to the subsets of the values of the relevant features or relations that contain the schema-conforming ones. For example, the label "microbrewer" is generally paired with a schema including feature values such as a small-scale operation, traditional handcrafted methods of production, and use of traditional ingredients.

We refer to a paired label and schema as a *type*.[1] Following several major lines of work in cognitive psychology and cognitive science, we assume that assessments of producers' membership in a type can be *partial,* a matter of degree (Hannan 2008). These assessments arguably depend on fits to schemas for labels. An audience member can regard some producers as full-fledged members of a type, others as having a moderate or low standing as a member, and still others as completely outside the type boundary. The key representation of the degree to which the producer's characteristics fit a schema is a *grade of membership* (GoM) function.

Types can have positive, neutral, or negative valuation. For issues related to typecasting, the interesting case concerns positive valuation. A type is said to be positively valued when the expected intrinsic appeal to an audience member of a producer's offering increases with its grade of membership in the audience member's meaning of the label.

Niches in Category Space

Before elaborating on our rendition of typecasting, we need to clarify connections of category theory and niche theory, because both have implications of multiple-category memberships. Indeed, it has proven useful to embed the issue of multiple-category memberships with niche theory (as Hsu et al. (2009) did in their extension of Hannan et al.'s (2007) fuzzy niche theory). Following McPherson (1983), Hannan and collaborators (2007) conceptualize the resource space as a sociodemographic space (with dimensions such as age, education, and income); and they assume that the tastes of audience members vary with social position. They define a producer's (fuzzy) niche with a grade-of-membership function that tells the degree to which each position in the space belongs in the producer's niche. This grade of membership is the expected appeal of the producer's offering to the typical taste at a position. They argue that gaining actual appeal to a local audience (at a social position) requires both *in-*

[1] From the definition of a schema as a function, it follows that at most one schema can be paired with a label. Therefore, types for labels are unique.

trinsic appeal to that audience and *engagement* of that audience. Intrinsic appeal concerns aesthetics; it arises from judgments about what does and does not fit a category. The intensity of a producer's engagement with the audience affects its ability to convert intrinsic appeal to actual appeal among those audience members.

Fuzzy niche theory posits so-called allocation principles for both expected intrinsic appeal and expected engagement. These state that the total intrinsic appeal and total engagement over positions are fixed at the same level for the producers being compared. Thus specialists have niches with high grades of membership in one or a few positions (where there expected appeal is high) and generalists' niches have lower (but positive) grades of membership in more positions.

In the case of positively valued types or categories, appeal to audiences depends on grades of membership (as we noted above). Hence this construction allows a clear representation of the jack-of-all-trades phenomenon and its impact on competition: broadening of a niche on either dimension (membership or engagement) comes at the expense of lower appeal.

In Hsu and collaborator's (2009) generalization, the resource space consists of a set of schematized *labels* (that is, resources are associated with labeled sets of activities). Employing the distinction between processes driven by audience attributions and by producer actions, they conceptualize a producer's niche in two ways. The first concentrates on the audience member;'s view: a producer's *membership niche* is its profile of GoMs in the (meanings) of the labels. A producer is a membership generalist to an observer who regards it as fitting partially to a set of labels, as a partial member of multiple categories. The second takes the producer-side view: a producer's *engagement niche* is the distribution of engagement over the labels.

Allocation principles arguably apply to both engagement and membership niches. Engaging the activities associated with multiple labels limits a producer's ability to devote attention, time, and other resources to learning about the preferences of the audience for each label and tailoring offerings accordingly. In terms of membership, producers that adopt characteristics that lead audience members to assign them to multiple labels naturally exhibit atypical values of schema-relevant features in some or all of the them. The better a producer fits a agent's schema for one label, the less likely are its feature values to be viewed as fitting the schema for another. Importantly, this second constraint centers on audience perceptions and beliefs rather than producer's attributes or actions.

The theory that we advance here concentrates on the *time ordering* of membership assignments. It considers the implications of audience members' *beliefs* about fit to applicable schemas for labels in a multi-category context where the

beliefs come from prior label assignments. This reasoning points to a process distinct from the one that builds on the principle of allocation in membership (which concerns the consequences of generalizing versus specializing at a single point in time).

This is not to say that engagement does not matter; it is just not the focus of this theory. Nonetheless, engagement can enter the picture in our theory if audience members believe that possession of schema-conforming values for certain labels limits the possibilities for engagement in a focal label and that such limited engagement would cause a deficit in attributes or skills that matter. The point is that these effects work through audience member beliefs rather than through real differences in attributes, skills, or quality. We turn now to models for such beliefs.

Modal Models for Legitimation

An audience member's experience with the degree of partiality of type members shapes the strength of reliance on his or her schema for the label. In some cases, audience members might judge that most type members have a high GoM in the label—they generally display feature values that fit well the relevant schema. Such generic fit and low frequency of observed misfit causes audience members to come to take for granted that the behavior and structures of any bearers of the label will be consistent with their schema for it. Beliefs about schema conformity can thereby become default assumptions of everyday life. This means that the defaults get used to fill in the many gaps in perceptions that come about from incomplete information, unobservability, and ambiguity.

We use three modal operators—for perception, default, and belief—to analyze these issues (see Pólos et al. 2009). In logic, the term modality was used originally to refer to qualities of the truth of a proposition, especially its possibility and necessity. The technical apparatus for analyzing logics with operators for possibility and necessity has been generalized to treat statements about an agent's "attitude" toward an object or relation; and the term modality is now generally extended to include expressions of perceptions, beliefs, and valuations. We use this extended sense of modality.

We refer to an agent's information state about a factual situation as a set of beliefs. Perceptions contribute to beliefs in an immediate way. What agents directly perceive updates their beliefs. (This does not mean that beliefs get corrected in a factual sense; perception is often inaccurate and can indeed be strongly influenced by beliefs.) Therefore the temporal order of perceptions matters: more recent perceptions replace older ones in case they conflict. But agents'

perceptions are generally partial, making some propositions true and others false, while leaving open the truth/falsity of others. Because partiality generates uncertainty, it is natural that mechanisms emerge that eliminate some of the gaps.[2]

We propose that agents rely on schematic defaults to "fill in" missing facts when a relevant direct perception is lacking *and* an applicable default is available. That is, defaults shape beliefs only in the absence of a current perception of the facts in question. Although beliefs based on taken-for-granted assumptions shape information states (and thus behavior), defaults are exposed to revision due to direct perceptions that conflict with the assumed facts.

Pólos et al. (2009) defined a model for the language containing these operators and provided their formal semantics. Their model was designed to satisfy the following constraints:

1. perception is partial at all time points (and possibly inaccurate);
2. beliefs must be grounded in either perception or taken-for-granted assumptions;
3. as seeing is believing, perception (at least temporarily) overrides earlier beliefs;
4. defaults shape beliefs (unless there is perceptual evidence to the contrary);
5. lasting beliefs develop if lasting taken-for granted assumptions are not contradicted by perceptual evidence.

Defaults and Induction

Audience members' perceptions of a producer's fit to their schemas for a label are often partial. In some cases, an audience member sees (or treats as a default) only that a producer claims a label or that some other audience members (perhaps critics or other kinds of gatekeepers) apply the label to the producer. Such situations offer the analytic leverage needed to define legitimation. Hannan et al. (2007) formulated this issue in terms of the proportion of schema-relevant features an audience member needs to check and find conforming before she assumes conformity with the schema for the unchecked features.

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[2] DiMaggio (1997) discusses the sociological implications of research in cognitive science on key related mechanism: automatic cognition, the implicit, automatic reliance on default assumptions about features embedded in schemas.

This idea can be represented in terms of a *test code for a label,* a partial segment of a schema for a label that an audience member uses to make inferences about fit to the rest of the schema on which she has no beliefs (perceptions or defaults). Induction from a test means that if the audience member believes that a producer "passes" the test, then she treats as a default that the unperceived/non-default values of schema-relevant features also fit the schema.[3] For example, an agent's test code for the type "classical French restaurant" might consist of specific ingredients used in dishes and the naming and presentation of dishes (Rao et al. 2003). If a restaurant displays feature values consistent with the agent's test, then she will induce that other schema-relevant features, such as the role of the chef in the restaurant's power structure and the organization of the kitchen, are consistent as well.

Definition (Induction from a test for a label)**.** *An induction from a test is a situation in which an audience member's belief that (1) a producer bears a type label and (2) its feature values satisfy a test is enough to trigger the application of the default that the values of unchecked features (for which there is no prior belief to the contrary) also satisfy his/her schema for the label.*

Induction does not mean that the agent assigns a GoM of one, because defaults do not override perceptions. If the agent perceived that the test code is passed and also perceives some lack of fit on one or more features that lie outside the minimal test code, then the schema-conforming defaults are not applied to those features.

If an audience member must check every relevant feature before assuming as a default that the rest of a producer's features match the relevant schema, then nothing is taken for granted. If only a small fraction of the relevant features must be checked (perhaps only the claim to the label), then defaults get used in a powerful way. These comparisons make the most sense when we consider the *minimal* test for an audience member-schema pair, the test that involves the smallest number of features.

The relative size of the minimal test for induction for fit to a schema relates directly to the degree of taken-for-grantedness of the label for the audience

[3] We modify the definition of induction offered by Hannan et al. (2007, Def. 4.1), which holds that induction "fills in" all non-perceived feature values when a test is *perceived* to be satisfied. This overlooks the role of existing defaults. Recall that defaults are beliefs when there is no contrary perception. There does not appear to be any reason to think that audience members will override existing defaults based only the passing of a test on other features. So we refine the earlier conception in line with this intuition. That is, we propose that induction works on features about which the audience member has no belief (based either on perception or default).

member. By size we mean the number of features that belong to the schema or test.

Definition (Taken for grantedness)**.** *The degree to which an audience member takes for granted that the untested feature values of a labeled producer conform to a schema for the label at a time point is the ratio of the size of the untested portion of the schema to size of the whole schema:* $(I - J)/I$*, where* I *denotes the number of features in the agent' schema for the label and* J *denotes the number of features in the agent's minimal test code.*

This definition sets taken for grantedness to zero if the audience member does not apply the label to the object or needs to see every (nonlabel) feature before making an induction (which is no induction at all); nothing is taken as satisfied by default. It sets this function to one if applying the label by itself shifts the audience member to defaults about schema-conformity on all other relevant features. In this case, the test on feature values is empty, $J = 0$; and the test is passed automatically whenever the label is applied.

We refer to a highly taken-for-granted type as an audience member's *concept.* That is, an audience member's type is a concept if she treats conformity to her schemata for the type label as taken-for-granted for (nearly) all those producers/products to which she assigns the label.

Incomplete Beliefs and Defaults in Typecasting

Reliance on defaults about concept membership shapes how audience members regard the producers to whom they apply a label. We claim that defaults also play a key role in creating the typecasting dynamic that Zuckerman et al. (2003) highlight in their study of the careers of Hollywood film actors. As noted earlier, this research shows that actors who are strongly identified with a single type (genre) of work often have difficulty obtaining future work in other types. Presumably, audience members assume that each type of work requires a distinct set of skills, so clear identification with one type of work implies that an actor has the skills for that genre and therefore lacks the skills necessary for others. (The skill sets in this example are an instance of a configuration of schema-conforming feature values.)

Our understanding of typecasting is that it depends on partiality of available information. Sometimes audience members have full information about the properties of a producer and can tell whether it fits one or another schema. In such situations, there is no reliance on typecasting—the agent relies on direct perception. But, when perception is incomplete, knowledge that a producer fits

one type generally gets treated as evidence that it likely does not fit other types (with clashing schemas)as we explain below. More generally, the typecasting argument has two important implications. The belief that a producer is an instance of one type will (1) increase the producer's appeal in exchanges of that type and (2) prevent acceptance of its membership in others.

To build to that multiple-type case, we first need to consider how taken for grantedness affects the assignment of GoMs when an audience member's test code is satisfied but the audience member lacks a belief about some relevant features. This leads us to contrast the power of concepts and mere types (those without a high level of taken for grantedness).

To simplify our formalization, we construct our arguments at the audience-member level. These results can be aggregated member by member to derive implications for an audience. In the interest of brevity, we do not develop these aggregate implications formally.

We treat simple situations in which fit to a schema can be assessed by simply counting (beliefs about) matches and mismatches of values of relevant features to the schema. In more complex cases, there might be weights assigned to features such that mismatches reduce fit more when they occur on certain features or elements of schemas might be conditional, meaning that the value of one feature affects what is schema-conforming on another. We implement this restriction with the notion of a flat schema.

Definition (Flat schema)**.** *An audience member's schema for a label is flat if he or she normally assigns higher grades of membership to objects with more matches to the schema and fewer mismatches.*

How can we represent the idea that audience members often lack complete beliefs about schema satisfaction? Because we want to make the argument general and we do not have any prior expectations about patterns, we develop a simple baseline probability model that allows us to compare situations that are alike on average. We state the elements of the probability model as auxiliary postulates, which means that we regard them as analytical conveniences not as claims about the world.

Recall that induction leads audience members to form beliefs in the absence of contrary perceptions when a minimal test code is passed. This makes it extremely cumbersome to develop the baseline probability model on assumptions that the audience members are equally likely to form beliefs about the producers being compared. Instead we structure the analytic situation to situations for which all beliefs that do not result from induction come instead from perceptions.

In the first step, we impose a homogeneity constraint on the availability of perceptions on schema-relevant features. We assume that each feature is as likely as any other to be perceived and that the probability of a perceptions does not vary over producers. Another way of putting this is to say that the audience member perceives the values of a simple random sample of schema-relevant features of each producer being compared.

Auxiliary assumption 1 (Perceptions available for random samples of features)**.** *Perceptions about fit to a schema for a label are available at random for producers in the sense that the probability that the audience member perceives the value of a feature is the same for all schema-relevant features.*

The key intuition behind typecasting relies on a counterfactual: had the audience member had full information about two producers (who differ in their histories of prior labels and memberships), she would have no reason to prefer one to the other. According to the counterfactual, the audience member would generally regard the producers as having equal grades of membership in her schema for the label. To represent this counterfactual, we assume as the second element in the baseline probability model that the two producers being compared are equally likely to satisfy the audience member's schema if the audience member perceived all of the relevant features. We do so by assuming that the probability that a perception of each feature is the same for the two producers being compared. In other words, the producers are equivalent in expected-value terms.

Auxiliary assumption 2 (Common probability of schema-conforming perceptions)**.** *The probability that an audience member perceives that a producer's feature values satisfy her schema for a label (conditional on having a belief about these values) is the same for all producers.*

This probability model, when applied to flat schemas, implies a pattern that agrees with the core intuition about the constraints imposed by typecasting. We develop this implication for a simplified situation that makes the analysis tractable. The simplification considers situations in which the audience member has flat schemas for two labels, l and l', of the same length ($I = I'$),[4] has minimal test codes for each schema, and the probabilities that the audience member perceives l-schema-relevant feature value are equal for the two triplets of producers, audience members, and time points.

[4] If we allow I, I', J, and J' to vary freely subject only to the constraint that $(I-J)/I > (I'-J')/I'$ (the relevant condition for judging the degree of taken for grantedness), then the implications appear to be indeterminate.

Let $\Phi[t, t']$ indicate that the following conditions hold over the time interval beginning at t and ending at t':

1. l is the label of a concept for the audience member over the interval $[t, t']$ and the schemas for it do not change over the interval:
2. l' is a type label for the audience member at (at least) the end point of the interval;
3. the audience member's schemas for l and l' are flat over the interval and have the same length $I = I'$;
4. on average, perceptions about the l-relevant and l'-relevant feature values of all the producers in the domain are incomplete to the same degree for the audience member over the time interval and all producers fit the audience member's schemas for l to the same degree within that interval.

Lemma 1 (Taken for grantedness and expected grades of membership)**.** *With random availability of perceptions of feature values for flat schemas and with a common probability of perceiving schema-conformity for a feature, audience members presumably assign higher grades of memberships (to producers) in the meaning of a label when the conformity with label is more taken for granted (under the conditions stated in* Φ*).*

[The proof of this lemma, along with those of other lemmas and theorems, can be found in the Appendix.]

According to Lemma 1, an audience member presumably assigns a higher grade of membership to a producer when her minimal test for induction is smaller. Hence conformity with the schema is more taken for granted. This result has an immediate implication about the importance of concepts in situations of partial beliefs.

Theorem 1 (Concepts versus types and grades of membership)**.** *When an audience member has partial observations on some type-relevant producer characteristics, he or she presumably assigns higher grades of membership in the type to objects when the type is a concept, that is, highly taken for granted (under the conditions stated in* Φ*).*

Because we focus on positively valued types, the argument behind Theorem 1 also implies a parallel difference in the intrinsic appeal of offerings.

Corollary 1 (Concepts versus types and appeal)**.** *When an audience member has partial observations on some type-relevant producer characteristics, the offerings of members of the type presumably have more appeal when the type is a concept (under the conditions stated in* Φ*).*

Typecasting

The argument made to this point, together with the behavior of the modalities, yields what we regard as a somewhat surprising implication. Consider the case in which an audience member first decides that a producer passes the minimal test code for a concept and does not display any observable violations of the schema for that concept. She then later perceives that the same producer also passes the minimal test code for a clashing concept and does not display any observable violations of the schemata for that concept. What happens?

As we thought about these issues, we first reasoned that a schema clash might block an audience member from applying defaults and would yield lowered GoMs in both concepts. But we recognized that this is not how defaults work (as we have modeled them). Once defaults are set, they have the status of facts *unless and until* they are overridden by new perceptions. So, in the scenarios we are considering, the audience member treats all of the schema-relevant features as satisfying the schema and also treats the defaults as facts when considering membership in the clashing concept. The result is that the audience member decides that the producer does not fit well the focal (clashing) concept, and she does not alter her judgment of the producer's typicality in the original concept. This conclusion fits our interpretation of the typecasting imagery.

We first define clashes between schemas.[5] To simplify what follows, we consider pairs of labels whose schemas clash (for an audience member) but only outside of their minimal test codes.

Definition (Code clash)**.** *Schemas for a pair of labels clash outside an agent's minimal test codes for them if (1) the pair of minimal test codes can be jointly satisfied and (2) the pair of codes cannot be jointly satisfied.*

Now this argument can be built on the argument behind Theorem 1. The key step in linking it to typecasting is constructing meaningful simplifying assumptions that allow us to capture the key insights.

Let $\Psi[t, t']$ indicate that the following conditions hold over the time interval beginning at t and ending at t':

1. code clash: the audience member's schemas for l and l' clash outside their minimal test codes and schema clashes outnumber non-clashes;

[5] Hannan et al. (2007) define schema clash indirectly with a meaning postulate (MP5.1) that presumes part of what we want to derive: "Normally, the higher a producer's grade of membership in a type whose schema clashes with that of a focal category, the lower the producer's grade of membership in the focal type."

2. the audience member applies the label l to the producer x and believes that the producer x passes her minimal test code for l over the relevant time interval;

3. the audience member applies the label l' to both producers at the later time point t';

4. the audience member either does not apply the label l to the producer x' over the relevant time interval: or does not believe that the x' passes her minimal test code for l over the interval.

Theorem 2 (Typecasting)**.** *If two concepts' schemas clash outside an audience members' minimal tests for them, membership in one at an earlier point in time (1) yields a higher fit to the schema for that label at subsequent times but (2) reduces the fit to the schema for the other label at a later point in time when the audience member does not generally have beliefs about a producer's conformity to schema on all relevant features (under the conditions stated in* Ψ*).*

Adding considerations of time sequencing in assignments and paying attention to (taken-for-granted) concepts, changes the multiple-category membership story in an important way. Recall that the assumption of a principle of allocation in memberships implies that audience members will generally assign *lower* grades of memberships in all of the relevant categories when she decides that the producer "belongs" to several labels, as contrasted with the case in which the producer belongs to only one. Seeing (or believing) the producers' features and noting that they partially fit several relevant schemas leads to diminished membership in each. In our rendition of typecasting, something different happens: the assigned grade of membership in the prior concept does *not* diminish but the grade of membership assigned in the newly relevant concept is lower than it would be absent typecasting.

In the case of positively valued types, the pattern identified by Zuckerman and collaborators immediately follows from the argument just discussed.

Corollary 2 (Zuckerman et al. 2003)**.** *In the case of two concepts with schemas that clash only outside an audience member's tests for them, membership in one at an earlier point in time presumably (1) enhances the intrinsic appeal of the producer's offering in the first but (2) reduces the appeal of its offering in the other at a later point in time when the audience member does not generally have beliefs about a producer's conformity to schema on all relevant features (under the conditions stated in* Ψ*).*

Theorem 2 and Corollary 2 highlight both the benefits and the drawbacks of being typecast, of passing the minimal test code of a taken-for-granted type. On

the one hand, reliance on defaults means that audience members will assign a high grade of membership to the producer and find its offerings to be appealing. But this restricts the producer's ability to demonstrate fit with a clashing type in the future. Audience members will rely on prior defaults in the case of partial perception and immediately assume a poor fit with the schema and their tastes for offerings of the clashing type.

Contrast and Taken for Grantedness

Our rendering of the typecasting argument has potentially broad implications. Exploring them requires attention to related processes underlying taken for grantedness (legitimation).

The original theory of density-dependent legitimation held that growth in the number of producers associated with a category increases its taken for grantedness (Hannan and Freeman 1989). This formulation did not address the idea that different producers might contribute differentially to the taken for grantedness of a category. To incorporate this possibility and generalize the theory, Hannan et al. (2007) shifted attention from density to population contrast.

Contrast refers to the average grade of membership among those with positive GoM (for an audience member). In other words, a high contrast condition approximates a binary membership relation (full membership versus nonmembership). Categories with high contrast stand out sharply against the background, increasing the likelihood that audience members see the cluster of producers in similar ways. Such similarity of perceptions eases the gaining of consensus among audience members about the meaning of the category (intensional consensus). Hannan and collaborators (2007) posit that the level of legitimation of a label in the audience as a whole increases monotonically with the level of intensional consensus about the label. Then it follows that legitimation (the average level of taken for grantedness over all pairs of producers and audience members) increases with average contrast.

Here we focus on another path, one that links legitimation to contrast at the agent level. The contrast of a type for an audience member is defined as the average of the nonzero grades of membership that the audience member assigns to the objects to which he assigns the type label. For an audience member, high type-contrast means that the producers to whom he or she assigns the type label generally fit the concept schema well (because high contrast means that the audience member assigns either high or very low GoM in the meaning of the label to the objects in the domain). Cases of poor fit to schemas will generally be viewed as exceptions to the general rule when contrast is high. Such generic

fit causes the audience member to come to take for granted that any producers to which she applies the type label will have schema-consistent features. The probability that beliefs about schema conformity will become defaults therefore increases with contrast.

Postulate 1. *A type's expected degree of taken-for-grantedness normally increases (with some delay) monotonically with its contrast to the audience member.*

With these notions in hand, we return to our main substantive focus, the effects of temporal sequencing in category assignments.

De-Novo and De-Alio Entrants

The intuition underlying our rendition of the typecasting theorem—that the assumption that a producer's prior membership in one concept constrains beliefs about later fit with others—can be usefully extended to shed light on other aspects of the dynamics of types and concepts. In this section, we show that this process of induction and typecasting can explain key findings on form emergence.

In their seminal study of the disk-array producers, McKendrick and Carroll (2001) found that a label for an emerging category gains more legitimation from *de-novo* entrants (those with no prior existence in the view of an audience member) than from *de-alio* entrants (already existing producers whom the audience member regards as diversifying from some other categories). They reasoned that (1) audience members perceive de-novo entrants as more focused on the activities associated with the label than their diversified counterparts, and (2) focused members contribute more to audience members' understandings of what it means to be a type member. The conclusion is that de-novo entrants contribute more to legitimation than de-alio entrants. This argument had a serious impact on the thinking of organizational theorists. However, so far it has not been integrated into the formal theoretical framework of categories.

To capture McKendrick and Carroll's insight, we focus on the case of de-alio entrants with clashing memberships. A producer has de-novo status in a label to an audience member if she applies the label at the time point and has not previously applied any label to it. A producer has de-alio-clashing membership in a label if the audience member applies the label at the time point and also continues to apply a label assigned earlier in a clashing concept and believes that the producer passes the minimal test for the clashing concept.

When an audience member assesses the fit to a focal type of a de-alio entrant from a clashing concept, the process of induction building on a time sequence

of memberships (which drives the typecasting dynamic as stated in Theorem 2) is also at work. Prior membership in the clashing concept reduces the subsequent fit of the de-alio entrant in the focal type. This puts the de-alio entrant at a disadvantage as compared with a comparable de-novo entrant (when there is random availability of beliefs and a common probability of forming a schema-conforming belief for each producer).

Theorem 3 (De-novo entrants have higher expected grade of membership)**.** *De-novo entrants presumably have higher expected grades of membership in an audience member's types than do de-alio entrants with memberships in clashing concepts (under the conditions stated in* Ψ*).*

This grade of membership disadvantage for de-alio entrants also results in a disadvantage in terms of the appeal of their offerings to audience members.

Corollary 3 (De-novo entrants have higher expected appeal)**.** *The offerings of de-novo entrants presumably have higher intrinsic appeal than do those of de-alio entrants with memberships in clashing concepts (under the conditions stated in* Ψ*).*

McKendrick and Carroll (2001) suggest that the extent to which audience members perceive a set of entrants as having a type focus contributes to the taken for grantedness of the type. This idea of perceptual focus can be analyzed in terms of contrast, as defined in the previous section. Because de-novo entrants have a higher expected grade of membership in an audience member's concept, they naturally contribute more to type contrast.

Lemma 2 (De-novo entrants contribute more to expected contrast)**.** *De-novo entrants presumably contribute more (with some delay) to the contrast of an audience member's type than de-alio entrants from clashing concepts (under the conditions stated in* Ψ*).*

The core insight of the de-novo/de-alio story is an implication of the preceding argument. The implication follows from Lemma 2 and Postulate 1. Because Lemma 2 yields a difference in the expected contrasts at the end of the period $[t, t']$ and Postulate 1 states a delayed effect of contrast on expected taken for grantedness, we express the desired theorem as holding for expected taken for grantedness at some time at or after t' (reflecting the possible delay in the effect of contrast on taken for grantedness).

Theorem 4 (McKendrick and Carroll 2001)**.** *The expected (delayed) contribution of a set of entrants to the taken for grantedness of a type presumably is higher for de-novo than de-alio entrants (under the conditions stated in* Ψ*).*

Discussion

This paper sought to determine whether processes underlying typecasting and form emergence could be usefully integrated to explain dynamics central to both theory fragments. We attempted this integration by extending a model of how audience members apply labels and assess fits of producers to schema to apply to multiple concepts.

Our theory building suggests that induction of fit to schemas in a context in which assignments of concepts (or categories) come in a sequence might be at the core of the issues considered by these two theories. Audience members often rely on defaults about schema-relevant features to define the concept memberships of producers in the face of partial information. Following Hannan et al. (2007), we proposed that taken for grantedness is linked to induction: what defines the taken-for-grantedness of a type is the degree to which audience members automatically fill in defaults for producers who exhibit some minimal criteria for membership for that type. One implication is that audience members presumably assign a higher grade of membership to a producer for a concept versus mere type. As a result, they also presumably find the producer more appealing in the former case.

Generalizing this story to the case of multiple memberships sets the foundation for modeling the typecasting dynamic. When audience members associate a producer with one concept at an earlier point in time, the (believed) fit of that producer in that concept will be enhanced, but its fit in other types will be reduced. A similar process of induction can explain McKendrick and Carroll's (2001) finding about form emergence. De-alio entrants are generally believed to have worse fit with a concept schema because they already belong to a clashing concept. Hence de-alio entrants presumably get assigned lower GoMs in a concept than their de-novo counterparts, and they contribute less to the taken for grantedness of a type.

The intuition underlying both theories relies on a counterfactual: with complete information about the producers under comparison, audience members would assign equal grades of membership in the relevant types. Both theories suggest that, by relying on defaults to cope with incomplete information, audience members become biased in systematic ways in their perceptions. Capturing this intuition formally required the introduction of auxiliary assumptions. In particular, we stipulated random availability of perceptions and a common probability of perceiving a schema-conforming value on each feature (on which they have a perception) for each of the producers under comparison.

Our formalization also shows the importance of relationships among categories. Without some clash between the codes of the relevant categories, there

would be no reason to expect such systematic bias in beliefs unless there were systematic differences in engagement. Zuckerman et al. (2003) argue that lay theories of skill provide the foundation for typecasting processes to emerge. For classification structures such as types and concepts to be restrictive, audience members must believe that the features or skills necessary to be a member of one type differ from those required of others. They must also believe that significant type-specific investments are necessary to acquire the necessary features of each—meaning that there is a so-called principle of allocation tradeoff . These tendencies are what lead audience members to presume that a producer who has demonstrated fit with one category must lack the features necessary for others.

Clearly a formal translation of this insight would require attention to the membership schemas for different categories. But to capture the core intuition, we needed to formalize this in a way that audience member's beliefs or assumptions (rather than their direct perceptions) would drive the main dynamic. More specifically, we needed audience members to assume incompatibility of membership for producers who might actually possess features consistent with the types in question. Thus, clash in codes between concepts should matter when some features are unobserved. Our treatment of induction provides a sensible way to model this by allowing us to focus on code clash outside of an audience member's minimal test criteria.

This thought process also led us to think about the role of code clashes in McKendrick and Carroll's argument about form emergence. Their informal argument did not explicitly consider the relationship between the categories de-alio producers span. Yet, our framework suggests that clashes between spanned categories must also be present for bias against de-alio producers to emerge.

We developed our model at the level of the audience member by considering the audience member's application of labels and assessment of fit to his/her own schema for the label. As we noted above, these results have implications at the level of the audience as a whole. When the members of an audience come to substantial agreement about the meaning of a set of labels, they will generally make similar assessments of fit of producers to schemata and engage in induction based on similar observations. Hence, the line of argument we presented in this paper applies *mutatis mutandis* to a comparison of categories and forms, the audience-level parallels of types and concepts.

A core tool used to develop our theory is use of multi-modal models in representing perception, default, and belief. We think that the use of these modalities allows a more precise specification of legitimation processes. Following Hannan et al. (2007), we proposed that the default operator holds when audience members encounter producers who pass their minimal tests for a type. In the case

of highly taken-for-granted types, minimal test codes are very small and processes of induction are common. However, for less taken-for-granted types, a large minimal test means the audience member will not assume much in terms of conformity with the concept schema. In such cases, the perception operator largely applies, and only partial membership will be assigned when an audience member lacks a belief about some schema-relevant features. Together, these modalities capture in a very specific way what seems distinctive about both membership in highly legitimated types and membership in multiple market types and concepts (categories and forms).

More broadly, this integration project pushed us to identify, articulate, and check the consistency of principles that might probe useful for other identity-based theories of market categorization. Theories about market categorization often concern counterfactuals—the way an agent's position in the market's role structure is decoupled from its actual features and exerts independent constraints on its opportunities (Zuckerman et al. 2003). Our model building highlights how different theories conceptualize this issue in similar ways with regards to the constraints of classificatory memberships. In particular, we demonstrate the utility of the model of induction for representing such counterfactual dynamics. In doing so, we provide a path for articulating similar processes in theories of social structuration more generally. For example, similar inductive processes likely play a role in theories of status (Podolny 1993; 1994), reputation (Fombrun and Shanley 1990; Rao 1994), and role structures more generally (White 1981; Leifer 1988). Attention to this fundamental social process might provide a way for researchers in these diverse areas of research to better integrate their findings.

Our framework might also be used to develop new theoretical insights. To give one example, our version of the typecasting process could be extended to consider what happens when audience members gain greater familiarity with a domain and develop stronger beliefs about distinctions between types. At the audience level, this reflects increasing institutionalization of the domain. Our framework suggests that audience members should increasingly rely on defaults to induce memberships, resulting in more extreme assessments of grades of membership. As a result, the overall contrast of categories within a domain would increase.

Our study also draws attention to the need to consider relationships between codes for different market types in arguments about partiality in memberships. An important direction for future research in this area is to develop better understanding of how inter-category relationships shape market dynamics. Currently, theories of multiple memberships either do not explicitly consider relationships between categories (Zuckerman 1999; Hsu 2006) or focus exclusively on opposi-

tional categories (Carroll and Swaminathan 2000; Zuckerman and Kim 2003). Yet a richer set of inter-category relationships characterizes real-life markets. For example, some categories appear to overlap in expected features and seem complementary, while others do not directly clash but contain features that are largely unrelated. Our framework provides a concrete way to conceptualize relationships between category codes and provides an avenue for future research development on multiple-category memberships.

Appendix: Formal Details

The theory on which we build states (some) definitions, postulates, auxiliary assumptions, lemmas, and theorems in a nonmonotonic logic (Pólos and Hannan 2002, 2004). In formal terms, models of arguments are represented as sequences of intensions of open formulas. The formal language to represent causal stories defines a new kind of quantifier, denoted by $\mathfrak{N}$. Formulas quantified by $\mathfrak{N}$ state what is expected to be the case "normally' according to a causal story. The normal case is what we assume to be the case if we lack more specific information that overrules the default.

The implications of a set of rules with exceptions, called provisional theorems, are the logical consequences of a stage of a theory. Provisional theorems have a haphazard existence: what can be derived at one stage, might not be derivable in a later stage. So the status of a provisional theorem differs from that of a causal story. The syntax of the language codes this difference. It introduces a "presumably' quantifier, denoted by $\mathfrak{P}$. Sentences (formulas) quantified by $\mathfrak{P}$ are provisional theorems at a stage of a theory (if they follow from the premises at that stage).

Our analysis relies on the use of auxiliary assumptions, which make certain analyses tractable. Because auxiliary assumptions have a different status than causal claims (which are believed to be true in the world), we mark them with a different quantifier, $\mathfrak{A}$ (for "assumedly'). Their role in inference is the same as for formula quantified with $\mathfrak{N}$.

We assume here that the reader is familiar with the distinction of free and bound variables, and we use this distinction to establish the following conventions.

1. The outer-most quantifier of the formula, that is the quantifier whose scope is the whole formula, binds all the free variables of the formula. This allows us to omit the (sometimes long) lists of variables following these quantifiers.

2. If the quantifier whose scope is the whole formula is *universal*, then we omit the quantifier as well, but we still indicate its scope with square brackets.

Definitions

Only some of the definitions needed for the formal analysis are set off as explicit definitions in the body of the paper. Here we include other needed definitions as well.

Schema. Let $\mathbf{f}_i = \{f_1, f_2, \ldots f_i\}$ be the indexed set of i features that are relevant for a schema. Each feature in the set has a range of possible values. We denote the set of possible values of feature f_j by $\mathbf{r}_j$ and a value for an object at a time point as $f_{j,x,t}$.

$$\sigma_l : \mathbf{a} \times \mathbf{t} \longrightarrow \mathscr{P}(\mathbf{r_1}) \times \cdots \times \mathscr{P}(\mathbf{r_I}); \quad \sigma_l(y,t) = \langle \mathbf{s}_1, \ldots, \mathbf{s}_I \rangle \equiv \mathbf{S}_I$$

where $\mathscr{P}(\cdot)$ denotes the powerset (set of all subsets of a set), $\mathbf{s}_i$ is the set of all the schema conforming values of the ith feature, and I is the total number of schema-relevant features. The schema $\sigma(l,y,t)$ is defined provided that $l \in \mathbf{l}(k,y,t)$.

Type.

$$\mathbf{ty} : \mathbf{a} \times \mathbf{t} \longrightarrow \mathscr{P}(\mathbf{l} \times \mathbf{S}), \text{ such that } (\langle l, \mathbf{S}_I \rangle \in \mathbf{ty}(y,t)) \leftrightarrow (\sigma(l,y,t) = \mathbf{S}_I).$$

Positively valued type.

$$\begin{aligned} \text{PVT}(l,y,t) \leftrightarrow \exists \mathbf{S}_I [\langle l, \mathbf{S}_I \rangle \in \mathbf{ty}(y,t)] \wedge \mathfrak{N}\, x, x', y [(\mu_i(x,y,t) > \mu_i(x',y,t)) \\ \rightarrow \mathrm{E}\{\widetilde{\alpha}(l,x,y,t)\} > \mathrm{E}\{\widetilde{\alpha}(l,x',y,t)\}], \end{aligned}$$

where $\widetilde{\alpha}(l,x,y,t)$ is a function that tells the intrinsic appeal of the offering of producer x in type l to audience member y at time point t.

Induction from a test. Let $\mathbf{S}_I$ denote an indexed set of values of I features and $\mathbf{F}_J$ denote an indexed set of values of some subset of the relevant features: $0 \leq J < I$. We use the expression $f_{i,x,t} \in \mathbf{s}_i$ to represent the fact that the ith feature of the object x has a value that complies with the schema $\sigma(l,x,t)$ at the time point t; and let $\sigma(l,y,t) = \mathbf{S}_I$.

$$\begin{aligned} [\text{INDUC}(\sigma(l,y,t), \mathbf{t}_J) \leftrightarrow \forall i,j,x [(l \in \mathbf{l}(x,y,t)) \wedge (j \in J) \wedge (i \in I \setminus J) \\ \wedge (\boxed{\text{B}}_y (f_{j,x,t} \in \mathbf{t}_j)) \rightarrow (\neg \boxed{\text{B}}_y (f_{i,x,t} \notin \mathbf{s}_i)) \leftrightarrow \overrightarrow{\boxed{\text{D}}}_y (f_{i,x,t} \in \mathbf{s}_i)]], \end{aligned}$$

where $\overrightarrow{\boxed{\text{D}}}_y \varphi(x,t)$ is a shorthand for the formula

$$\exists t' \forall t'' [(t < t'' \leq t') \rightarrow \boxed{\text{B}}_y \varphi(x,t'')].$$

In case induction holds, we refer to $\mathbf{t}_J = \{\mathbf{t}_j \mid j \in J\}$ as y's test for judging conformity to the schema $\sigma(l,y,t)$, in notation, $\text{TST}(\sigma(l,y,t), \mathbf{t}_J)$, and we say that the test has J items.

Minimal test for induction. The set of values of the J features, $\mathbf{t}_J$, is y's minimal test for induction for the schema for l at time t, in notation $\text{MT}(\sigma(l,y,t),\mathbf{t}_J)$, iff (1) it is one of y's tests for conformity with the schema; (2) it no more test features for the schema than any other of y's tests; and (3) y induces satisfaction of the schema $\sigma(l,y,t)$ on the untested features from this test. For simplicity we assume that minimal tests are unique.

Taken for grantedness.

$$[g(l,x,y,t) \equiv \begin{cases} (I-J)/I & \text{if } (\langle l,\sigma(l,y,t)=\mathbf{S}_I\rangle \in \text{TY}(y,t)) \wedge \text{MT}(\sigma(l,y,t),\mathbf{t}_J) \\ & \wedge (l \in \mathbf{l}(x,y,t)); \\ 0 & \text{otherwise}]; \end{cases}$$

$$[G(l,y,t) \equiv \textstyle\sum_{x|l\in\mathbf{l}(x,y,t)} \dfrac{g(l,x,y,t)}{|\{x \mid l \in \mathbf{l}(x,y,t)\}|}].$$

Concept.

$$[\text{CONCEPT}(l,y,t) \leftrightarrow (\langle l,\sigma(l,y,t)\rangle \in \mathbf{ty}(y,t)) \wedge (G(l,y,t) > \mathfrak{g} \approx 1)].$$

Flat schema. Let $\sigma(l,y,t)=\mathbf{S}_I$ and let $p^+(l,x,y,t)$ denote the proportion of features values of x on which y's beliefs at t are schema conforming, i.e.,

$$[p^+(l,x,y,t) = \frac{|\{f \mid \boxed{\text{B}}_y f_{i,x,t} \in \mathbf{s}_i\}|}{|\{f \mid \boxed{\text{B}}_y f_{i,x,t} \in \mathbf{s}_i\}| + |\{f \mid \boxed{\text{B}}_y f_{i,x,t} \notin \mathbf{s}_i\}|}].$$

$$\text{FLAT}(l,y,t) \leftrightarrow \mathfrak{N}\, x,x'\,[(p^+(l,x,y,t) > p^+(l,x',y,t)) \rightarrow \text{E}\{\mu_{i(l)}(x,y,t)\} > \text{E}\{\mu_{i(l)}(x',y,t)\}.$$

Code clash outside the minimal test codes. Let the set of features on which the schemas l and l' clash for the audience member and time point be denoted by $\mathbf{cl}^+(l,l',y,t)$, that is,

$$[\mathbf{cl}^+(l,l',y,t) = \{f_i \mid \forall\, t,x[(f_i \in \mathbf{S}_I \cap \mathbf{S}_{I'}) \rightarrow \neg((f_{i,x,t} \in \mathbf{s}_i) \leftrightarrow (f_{i,x,t} \in \mathbf{s}_{i'}))]\}];$$

and let the set of features on which they do not clash be denoted by $\mathbf{cl}^-(l,l',y,t)$, that is,

$$[\mathbf{cl}^-(l,l',y,t) = \{f_i \mid \forall\, t,x[(f_i \in \mathbf{S}_I \cap \mathbf{S}_{I'}) \rightarrow (f_{i,x,t} \in \mathbf{s}_i) \leftrightarrow (f_{i,x,t} \in \mathbf{s}_{i'})]\}].$$

Finally, let

$$[(\langle l,\mathbf{S}_I\rangle \in \mathbf{ty}(y,t)) \wedge (\langle l',\mathbf{S}_{I'} \in \mathbf{ty}(y,t)) \wedge \text{MT}(\sigma(l,y,t),\mathbf{t}_J) \wedge \text{MT}(\sigma(l',y,t),\mathbf{t}_{J'})].$$

$$[\text{CLASH}(l,l',y,t) \leftrightarrow \forall j[(j \in J \cap J') \rightarrow (j \notin \mathbf{cl}^{+}(l,l',y,t))] \wedge (\mathbf{cl}^{+}(l,l',y,t) \neq \emptyset)].$$

Type contrast.

$$[c(l,y,t) \equiv \frac{\text{card}\{\mu_{i(l)}(y,t)\}}{|\text{supp}\{\mu_{i(l)}(y,t)\}|}].$$

De-novo and de-alio entrants.

$$[\text{DE-NOVO}(l,x,y,t) \leftrightarrow (l \in \mathbf{l}(x,y,t)) \wedge \forall t'[(t' < t) \rightarrow (\mathbf{l}(x,y,t) = \emptyset)]];$$

$$e_n(l,y,t,t') = |\{x \mid (t \leq u < t') \wedge \text{DE-NOVO}(l,x,y,u)\}|.$$

$$\begin{aligned}[\text{DE-ALIO}(l,x,y,t) \leftrightarrow (l \in \mathbf{l}(x,y,t)) \wedge \forall s[(s < t) \rightarrow (l \notin \mathbf{l}(x,y,s))] \\ \wedge \exists l', t'\,[\text{CLASH}(l,S_I,l',S_{I'},y,t) \wedge \text{CONCEPT}(l',y,t) \wedge (I = I') \wedge \text{MTST}(\sigma(l',y,t),\mathbf{t}_{J'}) \\ \wedge \forall s[(t' \leq s < t) \rightarrow (l' \in \mathbf{l}(x,y,s)) \wedge \forall j[(j \in J') \rightarrow \boxed{\text{B}}_y(f_{j,x,t} \in \mathbf{t}_{j'})]]]];\end{aligned}$$

$$e_a(l,y,t,t') = |\{x \mid (t \leq s \leq t') \wedge \text{DE-ALIO}(l,x,y,s)\}|.$$

Postulates

Auxiliary assumption 1. Perceptions of feature values available for random samples of features.

Let $\sigma(l,y,t) = \mathbf{S}_I$.

$$\mathfrak{A}\,[\exists \pi \forall i,x[(i \in I) \rightarrow \Pr\{\neg \exists\, v\,[\boxed{\text{P}}_y(f_{i,x,t} = v)]\} = \pi]]].$$

Auxiliary assumption 2. Common probability of perceptions of schema-conformity.

Let $\sigma(l,y,t) = \mathbf{S}_I$.

$$\mathfrak{A}\,[\exists \rho \forall i,x[(i \in I) \rightarrow \Pr\{\boxed{\text{P}}_y(f_{i,x,t} \in \mathbf{s}_i) \mid \exists v[\boxed{\text{P}}_y(f_{i,x,t} = v)\}] = \rho]].$$

Postulate 1. A type's expected taken-for-grantedness normally increases (with some delay) monotonically with its contrast.

$$\begin{aligned}\mathfrak{N}\,[\exists u \forall s[(0 < s < u) \wedge (c_{i(l)}(y,t+s) > c_{i(l')}(y,t'+s)) \wedge (G(l,t,t+s) = G(l',y,t'+s)) \\ \rightarrow \text{E}\{G(l,t,t+u) > \text{E}\{G(l',y,t'+u)\}]].\end{aligned}$$

Nearest-Possible-World Conditions

$\Phi[t, t'] \leftrightarrow$

1. $[(t \leq s \leq s' \leq t') \rightarrow \exists \mathbf{S}_I[(\langle l, \mathbf{S}_I \rangle \in \mathbf{ty}(y, s)) \wedge (\langle l, \mathbf{S}_I \rangle \in \mathbf{ty}(y, s'))$;
2. $[\exists \mathbf{S}_{I'}[\langle l', \mathbf{S}_{I'} \rangle \in \mathbf{ty}(y, t')]]$;
3. $[(t \leq s \leq t') \rightarrow \text{FLAT}(l, y, s) \wedge \text{FLAT}(l', y, s)]$;
4. within the period $[t, t']$ neither π nor ρ depends on the label, the time, or the producer.

$\Psi[t, t'] \leftrightarrow$

1. $[\text{CLASH}(l, l', y, t') \wedge (0 < |\mathbf{cl}^+(l, l', y, t')| > |\mathbf{cl}^-(l, l', y, t')|)]$;
2. $[(t \leq s \leq t') \rightarrow (l \in \mathbf{l}(x, y, s)) \wedge \exists \mathbf{s}_j \forall j[\text{MTST}(l, y, s, \mathbf{t}_J) \wedge (j \in J) \rightarrow \boxed{\text{B}}_y (f_{j,x,s} \in \mathbf{s}_j)]]$;
3. $[(t \leq s \leq t') \rightarrow (l \notin \mathbf{l}(x', y, s)) \vee (\exists j[(j \in J) \rightarrow \boxed{\text{B}}_y (f_{j,x',s} \notin \mathbf{s}_j)])]$;
4. $l' \in \mathbf{l}(x, y, t') \cap \mathbf{l}(x', y, t')$.

Lemmas and Theorems

Testing what follows from the premises in a stage of a theory in the nonmonotonic logic operates on representations of arguments as "rule chains" (Pólos and Hannan 2002). The links in these chains are strict rules, definitions, auxiliary assumptions, and causal stories. The chains start with the subject of the argument and terminate with the purported conclusion of the argument (the consequence to be derived). In nonmonotonic inference, different rule chains—each representing an argument embodied in the state of the theory—might lead to opposing conclusions. The testing procedure determines whether any inference can be drawn at all and, if so, which one. Such testing requires standards for assessing whether a pair of relevant rule chains is comparable in specificity and determining specificity differences for comparable chains. In the case of this paper, the available premises and definitions all point in the same direction; we do not see any rule chains that point to opposing conclusions. Thus all that is required for proofs is that we establish a rule chain that connects the antecedent and consequent in a claimed theorem.

Throughout we assume that $\sigma(l, x, t) = \mathbf{S}_I$ and $\sigma(l', x', t') = \mathbf{S}_{I'}$.

Lemma 1. Taken for grantedness and grades of membership.

$$\mathfrak{P}\,[\Phi[t,t'] \wedge (I(l,y) = I(l',y)) \wedge (g(l,x,y,t) > g(l,x',y,t')) \\ \rightarrow \mathrm{E}\{\mu_{i(l)}(x,y,t)\} > \mathrm{E}\{\mu_{i(l)}(x',y,t')\}].$$

Proof. Under the simplification stated in $\Phi[t,t']$ and the baseline probability model and the absence of induction, the expected ratio of perceptions that feature values fit the schemas for the two labels to positive perceptions about the relevant feature values are the same for the two situations being compared for any I and I' the expected ratio equals ρ. Given the restriction to a flat schemas, this implies that $\mathrm{E}\{\mu_{i(l)}(x,y,t)\} = \mathrm{E}\{\mu_{i(l')}(x',y,t')\}$ in the absence of induction. So the only systematic difference between these cases must be due to induction. In particular, if the expected number of inductions of schema satisfaction is greater for one situation than the other, then the expected grade of membership is higher for that situation.

Let the random variable that records the number of inductions be denoted by $in(l,x,y,t)$. By the law of total probability,

$$\mathrm{E}\{in(l,x,y,t)\} = \mathrm{E}\{in(l,x,y,t) \mid \text{min. test for } l \text{ passed}\} \cdot \Pr\{\text{min. test for } l \text{ passed}\},$$

because no induction takes place if the minimal test is not passed. Under the baseline probability model stated in Auxiliary Assumptions 1 and 2 and the assumption in Φ that the probabilities are common across producers, the probability that x passes y's minimal test for l equals $(\pi\rho)^J$.

Because inductions can only apply to features outside the minimal test code (of which there are $I-J$ for the label l) for which the audience member does perceive the value of the feature. The probability of not perceiving the value of a feature is $1-\pi$. So the expected number of inductions, conditional on passing the minimal test for l is $(I-J)(1-\pi)$. Thus $in(l,x,y,t)\} = (I-J)(1-\pi)\cdot(\pi\rho)^J$. Similar calculations yield $\mathrm{E}\{in(l',x',y,t')\} = (I'-J')(1-\pi)\cdot(\pi\rho)^{J'}$. The rule chain supporting the theorem requires that the expected number of inductions for l exceeds that for l', which requires that $(I-J)(1-\pi)\cdot(\pi\rho)^J > (I'-J')(1-\pi)\cdot(\pi\rho)^{J'}$. Dropping the common multiplier $(1-\pi)$ and setting $I = I'$, we check whether $(I-J)\kappa^J > (I-J')\kappa^{J'}$, where $\kappa = \pi\rho$. after rearranging terms, we must show that

$$\frac{I-J}{I-J'} > \kappa^{J'-J}.$$

By the definition of taken for grantedness, $g(l,x,y,t) > g(l',x',y,t')$ yields $(I-J)/I > (I'-J')/I'$ and the antecedent states that $I = I'$. Together these conditions imply that $J' > J$. This latter inequality in turn implies that $(I-J)/(I-J') > 1$ and

$\kappa^{J'-J} < 1$ (because $\kappa = \pi\rho$ and the antecedent in the formula stating the lemma states that both π and ρ lie between zero and one). So the expected number of inductions is higher for l the type for which the producer x higher taken for grantedness in y's view, which implies that x's expected fit to y's meaning of l is higher than is the case for the other comparison. □

Theorem 1. Concepts versus types and grades of membership.

$$\mathfrak{P}[\Phi[t,t'] \wedge (I(l,y) = I(l',y)) \wedge \text{CONCEPT}(l,y,t) \wedge \neg\text{CONCEPT}(l',y,t') \rightarrow \text{E}\{\mu_{i(l)}(x,y,t)\} > \text{E}\{\mu_{i(l')}(x',y,t')\}].$$

Proof. The definition of a concept as a pair of label and schema for which an audience member has a very high level of taken-for-grantedness tells that the relative size of the minimal test for l is smaller than that for l'. With this inequality granted, the rule chain behind Lemma 1 applies. □

Corollary 1. Concepts versus types and appeal.

Let $\text{PVT}(l,y,t) \wedge \text{PVT}(l',y,t')$.

$$\mathfrak{P}[\Phi[t,t'] \wedge (I(l,y) = I(l',y)) \wedge \text{CONCEPT}(l,y,t) \wedge \neg\text{CONCEPT}(l',y,t') \rightarrow \text{E}\{\tilde{\alpha}(l,x,y,t)\} > \text{E}\{\tilde{\alpha}(l',x',y,t')\}].$$

Proof. The rule chain linking the antecedent and consequent results from application of the chain rule to the (rule chain supporting) Theorem 1 and the definition of a positively valued type. □

Theorem 2. Typecasting and grades of membership.

$$\mathfrak{P}[\Phi[t,t'] \wedge \Psi[t,t'] \wedge (t' > t) \rightarrow \text{E}\{\mu_{i(l)}(x,y,t')\} > \text{E}\{\mu_{i(l)}(x',y,t')\} \wedge \text{E}\{\mu_{i(l')}(x,y,t')\} < \text{E}\{\mu_{i(l')}(x',y,t')\}].$$

Proof. In the absence of induction, the expected fit of both producers is the same for each label under the assumptions stated in the definition of $\Phi[t,t']$, because the audience member's schemas for the labels are flat and the probability that a schema-relevant feature will be perceived is the same as is the probability that the agent will perceive schema conformity for each label. Induction can produce both increased fit (when the feature value induced fits the schema) and reduced fit (when the induction goes the other way).

In the case of the first term in the consequent (fit to l), the result follows from the assumption that the audience member perceives that x passes the minimal

test at all points in the interval and no information is available about such a perception for the second producer, x'. It then follows that induction will normally increase the fit to l for one producer (x) but not the other (x'). Under the assumption that clashes outnumber non-clashes, the expected net effect of induction is to reduce the fit of x to the second label (l') relative to that of x'. □

Corollary 2. Zuckerman et al. 2003.

Let $\text{PVT}(l, y, t) \wedge \text{PVT}(l', y, t')$.

$$\mathfrak{P}[\Phi[t, t'] \wedge \Psi[t, t'] \wedge (t' > t) \wedge \text{PVT}(l, y, t) \wedge \text{PVT}(l', y, t') \\ \rightarrow \text{E}\{\tilde{\alpha}(l, x, y, t')\} > \text{E}\{\tilde{\alpha}(l, x', y, t')\} \wedge \text{E}\{\tilde{\alpha}(l', x, y, t')\} < \text{E}\{\tilde{\alpha}(l', x', y, t')\}].$$

Proof. The rule chain linking the antecedent and consequent results from application of the cut rule to the (rule chain supporting) Theorem 2 and the definition of a positively valued type (Definition 3). □

Theorem 3. De-novo entrants have higher grade of membership.

$$\mathfrak{P}[\Phi[t, t'] \wedge \Psi[t, t'] \wedge \text{DE-NOVO}(l, x, y, t) \wedge \text{DE-ALIO}(l, x', y, t') \\ \rightarrow \text{E}\{\mu_{i(l)}(x, y, t')\} > \text{E}\{\mu_{i(l)}(x', y, t')\}].$$

Proof. By definition a producer is a de-novo entrant in a label if the audience member applies the label at that time point and does not apply any label to the producer at any earlier time point. A producer is a de-alio-entrant (from a clashing concept) if the audience member applies the focal label to the producer and has earlier applied to it the label of a clashing concept. In such a comparison, the rule chain that supports Theorem 2 applies; and this rule chain yields the conclusion. □

Corollary 3. De-novo entrants have higher expected appeal.

Let $\text{PVT}(l, y, t) \wedge \text{PVT}(l', y, t')$.

$$\mathfrak{P}[\Phi[t, t'] \wedge \Psi[t, t'] \wedge \text{DE-NOVO}(l, x, y, t) \wedge \text{DE-ALIO}(l, x', y, t') \\ \rightarrow \text{E}\{\tilde{\alpha}(l, x, y, t')\} > \text{E}\{\tilde{\alpha}(l, x', y, t')\}].$$

Proof. The rule chain that supports this implication relies on the application of the cut rule to the (rule chain behind) Theorem 3 and the definition of a positively valued type. □

Lemma 2 De-novo entrants contribute more to expected contrast.

Let the number of entries in two labels be the same over the relevant period $e_n(l, y, t, t') + e_a(l, y, t, t') = e_n(l', y, t, t') + e_a(l', y, t, t')$.

$$\mathfrak{P}[\Phi[t, t'] \wedge \Psi[t, t'] \wedge (e_n(l, y, t, t') > e_n(l', y, t, t')) \wedge (c(l, y, t) \geq c(l', y, t)) \\ \rightarrow \mathrm{E}\{c(l, y, t')\} > \mathrm{E}\{c(l', y, t')\}].$$

Proof. This is an immediate implication of (the rule chain supporting) Theorem 3, which tells that each de-novo entrant has higher expected GoM in the audience member's type than does a de-alio entrant. The definitions of type contrast and of the two types of entrants tell that an entrant with higher GoM increases contrast more than does one with lower GoM, which implies that a de-novo entrant adds more to contrast. Addition over entries preserves this inequality, given the stipulation that the number of de-novo entries is at least as great as the number of de-alio entries. □

Theorem 4. McKendrick and Carroll 2001.

Let the condition stated in the preamble to Lemma 2 hold.

$$\mathfrak{P}[\Phi[t, t'] \wedge \Psi[t, t'] \wedge (e_n(l, y, t, t') > e_n(l', y, t, t')) \wedge (c(l, y, t) \geq c(l', y, t)) \\ \rightarrow \exists u[(u \geq t') \wedge (\mathrm{E}\{G(l, y, u)\} > \mathrm{E}\{G(l', y, u)\})]].$$

Proof. This theorem follows from a cut rule applied to (the rule chain supporting) Lemma 2 and Postulate 1. □

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