ODD+D for a NetLogo version of Abelson's and Bernstein's community referendum simulation model

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This document describes one of the first models which can nowadays be qualified as agent-based and published first as [Abelson and Bernstein, 1963] and programmed in the now obsolete FAP language (FORTRAN Assembly Program, [Ferguson and Moore, 1961]) as well as a replication programmed in NetLogo [Wilensky, 1999] for a book chapter *Formal design methods and the relation between simulation models and theory: A philosophy of science point of view* to appear in [Rudás and Péli, 2020].

Table 1 An ODD Protocol for Abelson's and Bernstein's early work

Outline	Guiding questions	Description
I. Overview		
I.i Purpose	I.i.a What is the purpose of the study?	"to describe the specific features of this particular simulation model, bringing several levels of theory and both experimental and field phenomena to bear upon the total conception; to illustrate the properties of the model by giving some results of a preliminary trial upon artificial, albeit realistic, data; to discuss some of the broad problems that are likely to be encountered in this type of approach; and finally, thus, to elucidate the general character of simulation technique, which seems to offer eventual promise of uniting theories of individual behavior with theories of group behavior." [Abelson and Bernstein, 1963, p. 93]
	I.i.b For whom is the model designed?	Scientists, students/teachers
I.ii Entities, state variables and scales	I.ii.a What kinds of entities are in the model?	Citizen agents, news channels, sources, places (where citizens meet and exchange information) are the active entities, i.e. agents, of the model. Beside these, there are assertions (as passive objects, for short called memos in Table 2 and in the NetLogo model) (pp. 94–95). These are implemented as a list of the following structure: `[from` S `via` X `at` t `opinion` o `aspect` a `state` s `forgettability` f`]` where the S denotes the source or citizen which generated the memo, X is the channel or place between sender and receiver, t is the time of generation, o denotes whether the memo is pro or con, a is the aspect of the issue which the memo refers to, whereas s shows whether the memo was accepted or rejected (or not yet decided upon) and f is an auxiliary item which carries on whether the memo can be forgotten later within the current period. Hence a complete assertion or memo might represent a sentence spoken by a natural person S_1 at place X and understood by another person S_2 with the following content: "S_1 told me (S_2) about her current opinion at t = five minutes ago was o = pro with respect to aspect a = harmfulness, and — $s = 1$, i.e. I agree with her and I am unlikely ($f = 0.2$) to forget about her opinion." More details can be found in Figure 1 which gives all information about the entities, their instance variables and their methods, in terms, however, of the NetLogo replication, as the original code is lost (and would obviously not have lent itself to an UML description, as it was very machine-near code).
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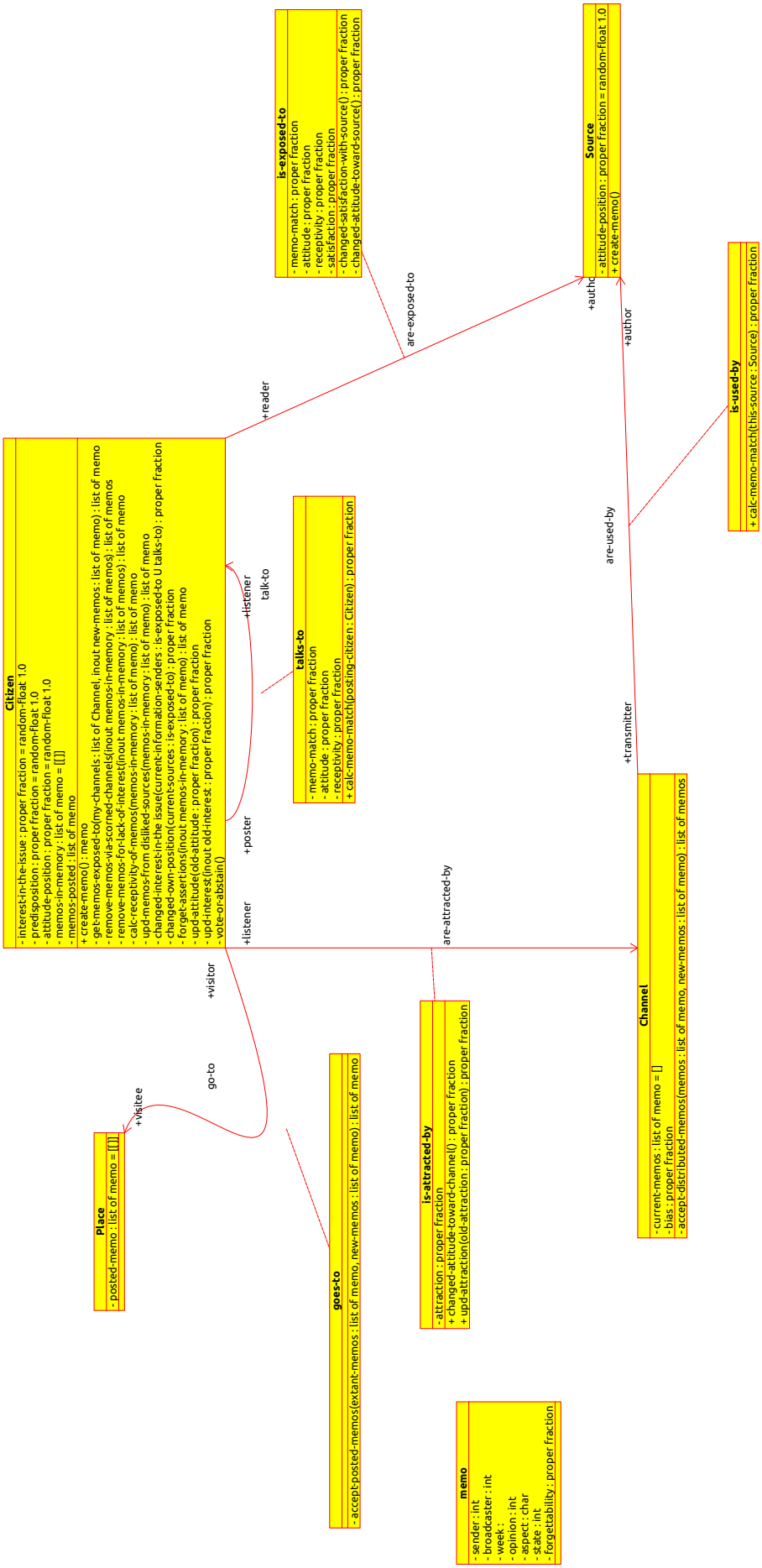

Fig. 1 Class diagram for base sets, their attributes and their functions in the Abelson Bernstein model and its NetLogo replication

ODD Protocol continued		
Outline	Guiding questions	Description
	I.ii.b By what attributes (i.e. state variables and parameters are these entities characterised?	Of citizens: "demographic characteristics; predisposing experiences and attitudes toward the referendum campaign arguments; frequency of exposure to the several news channels; attitudes toward well-known persons and institutions in the community (who might subsequently prove pivotal in the campaign); knowledge, if any, and acceptance of various standard assertions, pro or con, on the referendum issue; frequency of conversation about local politics, and the demographic characteristics of conversational partners, if any; initial interest in the referendum issue, initial position on the issue, and voting history in local elections." [Abelson and Bernstein, 1963, p. 95] Of sources: these have "attitude positions" (cf. rule A18) which control the assertions which they distribute over channels. Of channels: these have a "bias" (cf. rule B27): "Some of the channels, usually the specialized ones, will be clearly biased toward one or the other side of the issue. (This information will be in the input to the computer.)" [Abelson and Bernstein, 1963, p. 105] More details can be found in Figure 1.
	I.ii.c What are the exogenous drivers of the model?	"The standard local communication channels are represented in the computer, and can be loaded each simulated week with appropriate assertions from sources" [Abelson and Bernstein, 1963, p. 95].
	I.ii.d If applicable, how is space included in the model?	"Each individual specifies on the initial survey the places where he is likely to hold conversations on community issues." [Abelson and Bernstein, 1963, p. 113]
	I.ii.e What are the temporal and spatial resolutions and extents of the model?	"Following the conversational cycle, a new 'week' is in effect, and the individuals are exposed anew to the channels . . . " [Abelson and Bernstein, 1963, p. 112]. In the first 'half week' citizens are only exposed to sources via channels, in the second 'half week' they communicate with each other; the rules controlling the two 'half weeks' are fairly similar.
I.iii Process overview and scheduling	I.iii.a What entity does what, and in what order?	". . . the individuals are exposed anew to the channels . . . " [Abelson and Bernstein, 1963, p. 112]; "Each individual in turn is confronted with each of his potential conversational partners in turn." [Abelson and Bernstein, 1963, p. 108] Nothing is said about the order in which citizens are exposed to source and channels in the first 'half-week' and to each other in the second 'half week'.
	II. Design Concepts	
II.i Theoretical and Empirical Background	II.i.a Which general concepts, theories or hypotheses are underlying the model's design at the system level or at the level(s) of the submodel(s) . . .	Abelson and Bernstein specify several theoretical approaches underlying their model, , for instance • Thurstone's theory according to which "attitudes are measurable" [Thurstone, 1928] mentioned in [Abelson, 1964, p. 142], • theoretical and empirical findings reported in [Tannenbaum, 1956] about "initial attitude toward source and concept as factors in attitude change through communication" which are used to support the "assumptions ... made about receptivity" — see the method `calc-receptivity-of memos` in the class diagram Fig. 1 and the sequence diagram Fig. 2 as well as the function c_r in the functions list on Table 2, but most of the the sources on which Abelson and Bernstein rely are not listed in this ODD description, but nearly all of their assumptions are supported by the cited literature.
	II.i.b On what assumptions are the agents' decision models based?	See II.i.a.
	II.i.c Why are certain decision models chosen?	See II.i.a.
	II.i.d If the model . . . is based on empirical data, where does the data come from?	"On the basis of actual survey data gathered in the community by a probability sample ten or more weeks prior to the scheduled referendum, a large number of actual people (e.g. 500) are anonymously represented in the computer." [p. 94]

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ODD Protocol continued		
Outline	Guiding questions	Description
	II.i.e At which level of aggregation were the data available?	At the individual level
II.ii Individual Decision Making	II.ii.a What are the subjects and objects of decision making? On which level of aggregation is decision making modelled?	Subjects: citizen agents; objects: assertions to be endorsed or not, votes cast at time step ten of the simulation
	II.ii.b What is the basic rationality behind agents' decision making in the model? Do agents pursue an explicit objective or have other success criteria?	Agents follow a detailed set of rules, but do not have objectives or other success criteria.
	II.ii.c How do agents make their decisions?	They follow the detailed set of rules laid out on pp. 98–113 of the article.
	II.ii.d Do the agents adapt their behaviour to changing endogenous and exogenous state variables?	No, the set of rules remains constant, but the agents' attitudes change according to the rules and to the endorsed assertions which they receive from different sources. "Changes can be effected in two general ways: (1) by exposure to public "assertions" from "sources," these appearing in communication "channels" (broadly defined); (2) via conversations with others who have some stand on the issue and who may also make assertions." [p. 95]
	II.ii.e Do social norms or cultural values play a role in the decision making process?	No.
	II.ii.f Do spatial aspects play a role in the decision process?	Only in so far as agents meet each other in fixed places, which reduces the scope of agents with which they can communicate.
	II.ii.g Do temporal aspects play a role in the decision process?	"The first three [rules, B22–B24] deal with the probability that i will "forget" assertions previously accepted, that is, act in future interactions as though he had never encountered them." [p. 110]
	II.ii.h To which extent and how is uncertainty included in the agents' decision rules?	Several rules define probabilities of endorsing and forgetting (A1, A2, B1, B22, C2).
II.iii Learning	II.iii.a Is individual learning included in the decision process?	No.
	II.iii.b Is collective learning implemented in the model?	No.
II.iv Individual Sensing	II.iv.a What endogenous and exogenous state variables are individuals assume to sense and consider in their decisions? Is the sensing process erroneous?	Citizen agents sense assertions from peers and from channels, with a certain probability which depends on their interest, but without error.
	II.iv.b What state variables of which other individuals can an individual perceive? Is the sensing process erroneous?	None. Citizen agents communicate only via assertions, and these are either accepted as they are or rejected.
	II.iv.c What is the spatial scale of sensing?	Citizen agents perceive other citizens' assertions only when they meet at their usual meeting place; assertions from public channels have no spatial restriction.
	II.iv.d Are the mechanisms by which agents obtain information modelled explicitly, or are individuals simply assumed to know these variables?	The former.
	II.iv.e Are costs for cognition and costs for gathering information included in the model?	Not explicitly, the role of interest could be thought to be similar to the role of costs.

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ODD Protocol continued		
Outline	Guiding questions	Description
II.v Individual Prediction	There are no predictions.	
II.vi Interaction	II.vi.a Are interactions among agents and entities assumed as direct or indirect?	Indirect: Citizen receive assertions from sources via channels; whether the interaction is direct between two citizens is not entirely clear, it rather seems that this interaction is bound to places where they meet.
	II.vi.b On what do the interactions depend?	Channel attraction in the case of source assertions, interest in the issue in the case of assertions from peers.
	II.vi.c If the interactions involve communication, how are such communications represented?	Explicit messages (assertions).
	II.vi.d If a coordination network exists, how does it affect the agent behaviour? Is the structure of the network imposed or emergent?	Citizens receive assertions only via channels and at places where they meet peers. The structure of the network does not change over time.
II.vii Collectives	There are no collectives or other aggregations.	
II.viii Heterogeneity	Agents of each type are homogeneous as they have the same structure, processes are equal among them, but some state variables are randomly assigned during the initialisation and change over time.	
II.ix Stochasticity	Assertions are randomly generated according to the attitude state variable of sources and citizens, assertions are accepted, rejected and forgotten with a probability depending mainly on interest in the issue, nut also on the attractivity of a channel or on the assertion match between citizens or citizens and sources.	
II.x Observation	II.x.a What data are collected from the ABM for testing, understanding and analysing it, and how and when are they collected?	Abelson and Bernstein report only very little about their results. The NetLogo model offers a lot of test outputs and several plots and monitors showing how the model develops over time, including the attitudes of citizens and the instance variables of the relations between citizens and between citizens and channels/sources.
	II.x.b What key results, outputs or characteristics of the model are emerging from the individuals? (Emergence)	As there is no emerging structure beside the frequency distributions of attitudes and channel-citizen and source-citizen relations, nothing important can be observed in this respect.
III. Details		
III.i Implementation Details	III.i.1 How has the model been implemented?	On an IBM 7090, using FAP, The FORTRAN Assembly Program. The replication is implemented in NetLogo.
	III.i.2 Is the model accessible and if so where?	No, and if it were, it would not be useful after more than half a century. But see the reimplementation in Section **??**.
III.ii Initialisation	III.ii.a What is the initial state of the model world, i.e. at time $t = 0$ of a simulation run?	For the citizens' communication network this is specified as follows [Abelson and Bernstein, 1963, p. 113]: "Each individual specifies on the initial survey the places where he is likely to hold conversations on community issues. For each appropriate place the individual thinks of an actual conversational partner (if any), and tells the interviewer the key demographic characteristics of this actual partner. This information then serves as a template in locating pseudo-partners." For the sources and channels, their attitude positions [p. 106] and biases [p. 112] as well as the "assertion value for each source within each channel" [p. 100] are "input to the computer", i.e. derived from empirical data. For the connection of citizens to sources and channels, there is no precise specification. In the NetLogo model, citizens are distributed over the world, as are places, and citizens are assigned to their two nearest places where they meet their peers; the number of peers per citizen depends on the structure of the citizens-places network, but citizens never have more than six communication partners. For the connection between sources, channels and citizens, all channels are open to all channels, and all sources distribute over all channels.

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ODD Protocol continued		
Outline	Guiding questions	Description
	III.ii.b Is the initialisation always the same, or is it allowed to vary among simulations?	Presumptively the latter.
III.iii Input Data	III.iii.a Does the model use input from external sources such as data files or other models to represent processes that change over time?	Presumptively yes, at least for the assertions from the media channels. "The two columnists make opposing assertions for all ten weeks of the campaign. The mayor intervenes in the fourth week and is mildly pro-fluoridation. The data were manufactured from a combination of demographic information, intuition, and actual survey statistics on fluoridation gathered by Arnold Simmel and others." [p. 115]
III.iv Submodels	III.iv.a What, in detail, are the submodels that represent processes listed in 'Process overview and scheduling'?	There are no submodels; the scheduling of events in Abelson's and Bernstein's model seems to be a round-robin process; the NetLogo model uses the usual `ask` strategy.
	III.iv.b What are the model parameters, their dimension and reference values?	In the original model, parameters are not mentioned. In the NetLogo replication, a number of model parameters are hidden in the code, mainly those which parameterise the "direct functions" and the "inverse functions" mentioned in Section **??** with respect to rules A2, A3 and B22.
	III.iv.c How were submodels designed or chosen, and how were they parameterised and then tested?	Does not apply.

The abbreviation $\mathbf{M}_p$**(CR)** used in the following table refers to the non-statement view reconstruction of Abelson's and Bernstein's work.

Table 2 Synopsis between $\mathbf{M}_p$**(CR)** and the rules listed in Abelson's and Bernstein's article

$\mathbf{M}_p$**(CR)**	
base sets	explanation
$\mathcal{C}$	a non-empty finite set [of citizens]
$\mathcal{S}$	a non-empty finite set [of sources like TV or radio stations or newspaper journalists producing information]
$\mathcal{X}$	a non-empty finite set [of channels which transmit information from sources to citizens]
$\mathcal{P}$	a non-empty finite set [of places where citizens typically meet and exchange information]
$\mathcal{M}$	memos, short for Abelson's and Bernstein's assertions (see Section **??**, I.ii.a), as instance variables of citizens, sources, channels and places]

$\mathbf{M}_p$**(CR)**			
	functions		explanation
name	domain	range	
i_i	$\mathcal{C} \times \mathcal{T}$	(0, 1)	$i_i(\gamma, t)$ yields the current interest in the issue
p_d	C	(0, 1)	$p_d(\gamma)$ yields the (constant) predisposition on the issue
a_p	$\mathcal{C} \times \mathcal{T}$	(0, 1)	$a_p(\gamma, t)$ yields the current attitude position on in the issue
m_m	$\mathcal{C} \times \mathcal{T}$	$\mathbb{P}$(M)	$m_m(\gamma, t)$ yields the subset of assertions (memos) currently in γ's memory
m_p	$\mathcal{C} \times \mathcal{T}$	$\mathbb{P}$(M)	$m_m(\gamma, t)$ yields the subset of assertions (memos) having been posted by γ
a_s	S	(0, 1)	$a_s(\sigma)$ yields the (constant) attitude position of source σ (which, according to rules A18–A20, "is estimated [empirically] and input to the computer"
m_c	$\mathcal{X} \times \mathcal{T}$	$\mathbb{P}$(M)	$m_m(\chi, t)$ yields the subset of assertions (memos) currently available from channel χ
m_p	$\mathcal{P} \times \mathcal{T}$	$\mathbb{P}$(M)	$m_m(\pi, t)$ yields the subset of assertions (memos) having been posted at place π
μ	$\mathcal{C} \times \mathcal{S} \times \mathcal{T}$	(0, 1)	$\mu(\gamma, \sigma, t)$ yields the current value of the assertion match between citizen γ and source σ (see equation 1)
a_{tt}	$\mathcal{C} \times \mathcal{S} \times \mathcal{T}$	(0, 1)	$a_{tt}(\gamma, \sigma, t)$ yields the current value of the attitude of citizen γ towards source σ
r	$\mathcal{C} \times \mathcal{S} \times \mathcal{T}$	(0, 1)	$r(\gamma, \sigma, t)$ yields the current value of the receptivity of citizen γ to source σ
s_at	$\mathcal{C} \times \mathcal{S} \times \mathcal{T}$	(0, 1)	$s_{at}(\gamma, \sigma, t)$ yields the current value of the satisfaction of citizen γ with source σ
a_tr	$\mathcal{C} \times \mathcal{X} \times \mathcal{T}$	(0, 1)	$a_{tr}(\gamma, \chi, t)$ yields the current value of the attraction channel χ has for citizen γ
μ	$\mathcal{C} \times \mathcal{C} \times \mathcal{T}$	(0, 1)	$\mu(\gamma_i, \gamma_j, t)$ yields the current value of the assertion match between citizen γ_i and citizen γ_j (see equation 1)

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a_{tt}	$C \times C \times \mathcal{T}$	$(0, 1)$	$a_{tt}(\gamma_i, \gamma_j, t)$ yields the current value of the attitude of citizen γ_i towards citizen γ_j

$\mathbf{M}_p$(CR)

functions			rules	explanation
name	domain	range		
g_m	$C \cup \mathcal{S}$	$\mathcal{M}$	(A1, A2)	generates a new memo for a citizen to post or for a source to distribute it over a channel
a_{ms}	$\mathcal{X} \times \mathcal{S}$	$\mathcal{M}$	(A1, A2)	moves a memo from a source to a channel
g_m	$C \times \mathcal{X}$	$\mathcal{M}$	(A1, A2, B1)	moves a memo from a channel to a citizen
r_u	$\mathcal{M}^n$	$\mathcal{M}^m$	A1	removes memos that were transferred via unattractive channels
r_ℓ	$\mathcal{M}^n$	$\mathcal{M}^m$	A2, B1	removes memos for lack of interest
c_m	$C \times \mathcal{S}$	$(0, 1)$	(A5)	calculates the match memo opinions between a source and a citizen for details see equations 1–7
c_r	C	$(0, 1)$	A3–A10, B2–B5	calculates the receptivity of a source for a citizen
c_d	C	$\mathcal{M}$	A11	changes the state field for memos which came from disliked sources
χ_{i1}	C	$(0, 1)$	A12–A14	changes a citizen's interest in the issue for details see equations 1–7
χ_{s1}	$C \times \mathcal{S}$	$(0, 1)$	A15–A17	changes a citizen's satisfaction with a source
χ_p	C	$(0, 1)$	A18–A20	changes a citizen's own position
χ_{as}	C	$(0, 1)$	A21	changes a citizen's attitude toward a source
$\chi_{a\chi 1}$	C	$(0, 1)$	A22	changes the attractivity of a channel for a citizen
a_{mc}	$\mathcal{P} \times C$	$\mathcal{M}$	(B1)	moves a citizen-posted memo from a place blackboard to a citizen
f	$\mathcal{M}^n$	$\mathcal{M}^{m\,1}$	B22–B24	removes forgettable memos from a citizen's memory
χ_{s2}	$C \times \mathcal{S}$	$(0, 1)$	B25	changes a citizen's attitude toward a source
χ_{i2}	C	$(0, 1)$	B26	changes a citizen's interest in the issue
$\chi_{a\chi 2}$	$C \times \mathcal{X}$	$(0, 1)$	B27	changes the attractivity of a channel for a citizen
v		{-1, 0, 1}	C1–C2	determines whether and how a citizen will vote

Rules in parentheses only mention such a function without describing them in detail.

A few examples for functions which are sufficiently well described are given in the following (the names of the functions are the ones used in the chapter to which this ODD description belongs):

$c_m : C \times \mathcal{S} \to (0, 1)$ calculates the assertion match between a citizen and a source (according to rule B5, the latter might also be a citizen). According to A5, this

> "is positive when s's assertions agree with those already accepted by i, and negative when they disagree. . . . The 'assertion match' index between i and s is computed by scoring +1 for each single assertion agreement, −1 for each single assertion disagreement, and summing."

Informally described, this function goes through the list of memos in i's memory and counts the absolute differences between the o- and s-entries of the memos in this list (which are either 0 for agreement or 2 for disagreement, as o and s are coded +1 and −1 for both opinion and acceptance, respectively). This yields exactly what is described in rule A5 (in the NetLogo replication this is normalised to the set of real numbers $(0, 1)$ for further treatment). More formally this function yields

$$c_m(\gamma, \sigma) = \frac{\alpha(\gamma, \sigma) - \delta(\gamma, \sigma)}{2(\alpha(\gamma, \sigma) + \delta(\gamma, \sigma))} + \frac{1}{2} \tag{1}$$

$$\text{where} \tag{2}$$

$$\alpha(\gamma, \sigma) = |\{m \in \mathcal{M}_\gamma(t) | S(m) = \sigma \wedge o(m) = s(m)\}| \tag{3}$$

$$\delta(\gamma, \sigma) = |\{m \in \mathcal{M}_\gamma(t) | S(m) = \sigma \wedge abs(o(m) - s(m)) = 2\}| \tag{4}$$

$$\text{and} \tag{5}$$

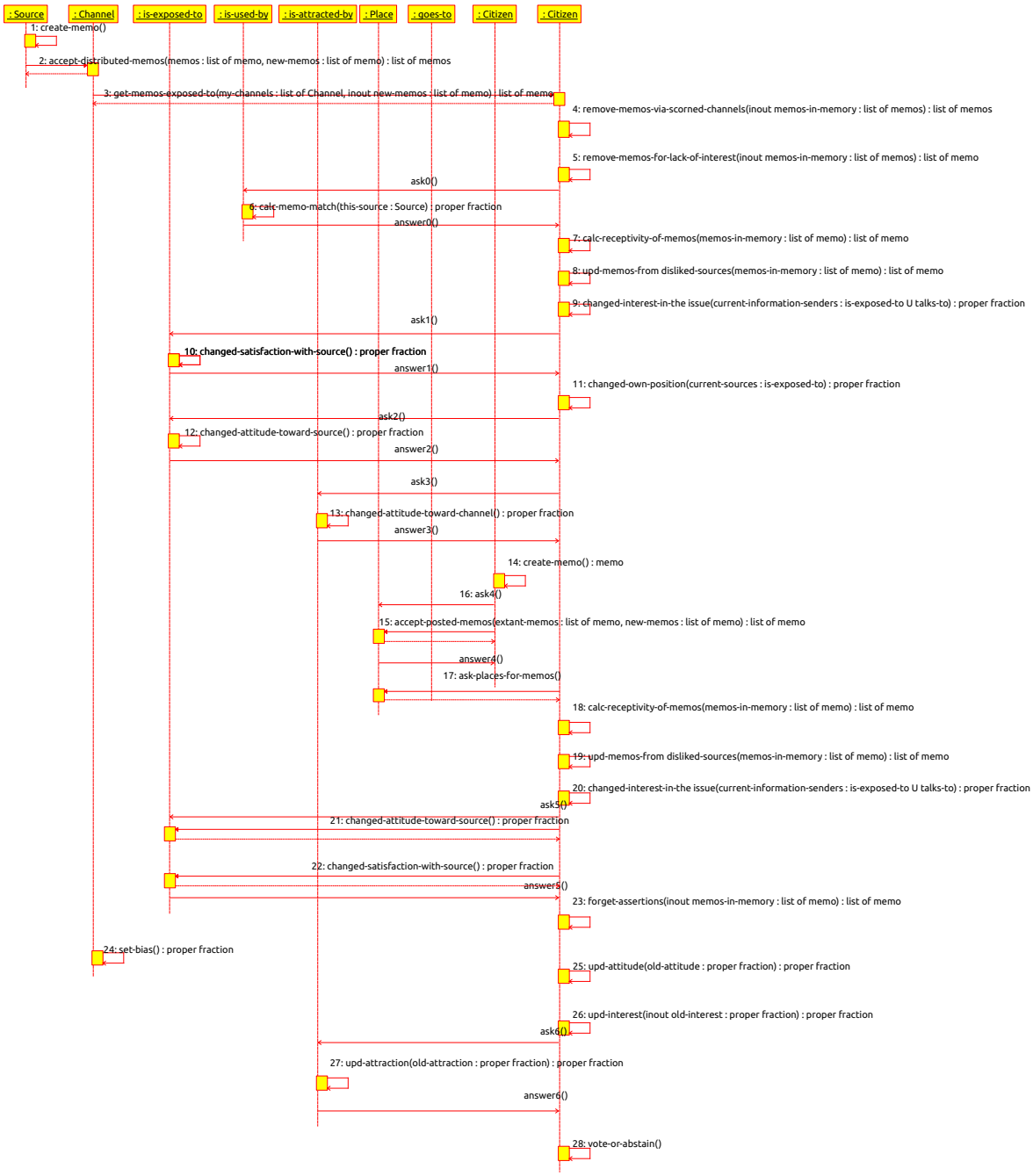
$$0 < c_m(\gamma, \sigma) < 1 \tag{6}$$

where $\gamma \in C$ and $\sigma \in \mathcal{S}$ denote the citizen and the source in question and S, o and s are functions yielding the source, opinion and state attributes of the memo or assertion in question (see Subsection **??** I.ii.a).

$\chi_{i1} : C \to (0, 1)$ changes a citizen's interest in the issue. According to A12 (A13 and A14 are not considered here as this would make this discussion even more complicated), a person's interest "increases as a direct function of the assertion match c_m between i and s" where i is the person in question and s is the source of the assertion (either another a citizen or a source sending its assertion via a channel). Calling again the citizen γ and the source σ and γ's interest in the issue at time t $i_i(\gamma, t)$, then the changed interest $i_i(\gamma, t^+)$ in the issue is

$$i_i(\gamma, t^+) = i_i(\gamma, t)(1 + \rho(c_m(\gamma, \sigma) - 0.5)(c_m(\gamma, \sigma) - 0.5) \tag{7}$$

Fig. 2 Sequence diagram for the Abelson Bernstein model and its NetLogo replication



where ρ is a functions which rounds its argument ($\rho(x)$ is 0 for $0 < x < 0.5$ and 1 for $0.5 \leq x \leq 1$, such that $i_i(\gamma, t)$ is only changed when $\alpha(\gamma\sigma) > \delta(\gamma\sigma)$ as in rule A12 Abelson and Bernstein argue that "it is not clear how to view the potential effect on interest of disagreement (i.e. a negative assertion match) between self and source" (in terms of

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