

<b>A. Overview</b>	<b>A.1. Purpose</b>	<p>Organizational behavior in the hierarchy agent-based model is designed and developed to study process of the formation of teams, taking into account the mutual (generally speaking - asymmetrical) perception of the Head and subordinates and changes in the group performance of the teams.</p> <p>Group performance depends on the individual performance of team members and the relative position of group members and their Heads in space (World of model is space of perception). The location in space changes in accordance with the individual strategies of the behavior of agents.</p>
	<b>A.2. Entities, state variables and scales</b>	
	<i>Agents/individuals</i>	Agents in the model are operators and managers (Heads), which forms a team of operators.
	<i>Spatial units</i>	<p>Spatial units in the model are absent, in the sense that space (World) is used for visualizing the relations of objects (operators and managers).</p> <p>The space of the model is the space of perceptions, the distance between the two agents is determined (during the interaction process) by the mutual perception between the agents.</p>
	<i>Environment</i>	In the model there are no affecting (external) forces that drive the behavior and dynamics of all agents.
	<i>Collectives</i>	Collectives in the model are the groups (teams) of operators united by one Head (manager). The goal of group (literally - the Head) is to increase team productivity.
	<b>A.3. Process overview and scheduling</b>	<p>In a two-level hierarchical structure (consisting of the positions of managers and operators), persons holding these positions have a certain performance and the value of their own (personal) perception of each other.</p> <p>In the world of the model, which is the space of perceptions, agents implement two strategies: rapprochement with agents that perceive positively and distance from agents that perceive negatively (both can be implemented, one of these strategies, or neither, the other strategy, which makes the agent stationary). Strategies are implemented in relation to those agents that are in the radius of perception.</p> <p>The manager (Head) forms a team of agents. The performance of the group (the sum of the individual productivities of subordinates, weighted by the distance from the Head) varies depending on the position of the agents in space and the values of their individual productivities. Individual performance, in the current version of the model, are set as a random variable distributed evenly on a numerical segment from 0 to 100. The manager forms the team 1) from agents that</p>

		<p>are in operational (organizational) radius, 2) among agents that the manager perceives positively and / or negatively (both can be implemented, one of the specified rules, or neither, which means the refusal of the command formation).</p> <p>Agents can (with a certain probability, given by the variable PrbltyOfDecisn%), in case of a negative perception of the manager, leave his group permanently.</p> <p>The simulation experiment leads to the stabilization of the agents in space: the coordinates of the agents from a certain point in time become unchanged, and the group productivity stabilizes at a certain level.</p> <p>At the same time, characteristic for the behavior of agents in the model is the sporadic occurrence of cyclic structures (the spatial location of agents in which the coordinates of several agents and the group performance of individual groups experience quantitative fluctuations). The appearance of such structures precedes full stabilization or, under certain initial conditions, oscillations can continue indefinitely. In this regard, the model operation time is formally limited to a period of 10,000 ticks. When stabilization occurs, the experiment can be stopped by the user using the interface (disabling the "Go" button).</p>
<b>B. Design concept</b>	<p>B.1 Theoretical and Empirical background</p> <p><i>Basic principles.</i></p>	<p>The model represents the first approximation to the implementation of the concept of mutual perception in the hierarchy formulated by the author in the works:</p> <p>1. Ivan Smarzhevskiy. The concept of mutual perception of persons in a hierarchy. Journal of Economy and entrepreneurship, 2018, Vol. 12, Nom. 12, p. 1120-1124. (И.А. Смаржевский, Концепция взаимного восприятия персон, занимающих позиции в иерархической структуре. // Экономика и предпринимательство. 2018. № 12. С.1120-1124).</p> <p>Abstract. The issues of mutual perception of persons holding positions in the hierarchical organizational structure engaged in (some) operational activities are considered. Theoretical concepts have been introduced and provisions have been formulated that reveal the interconnections of the individual perception of each other by persons. Aspects (sides) of perception are established, scales of measurement and potential values of aspects of perception are defined. The significance of aspects of perception is revealed depending on the relative positioning of the positions of the perceiving and perceived persons in the hierarchy. The basic statement of the concept is formulated: the essential content of perception by person A of person B is completely exhausted by three aspects: personal (personal) perception, social perception and</p>

		<p>professional perception. These aspects are not reducible to each other.</p> <p>2. Ivan Smarzhevskiy. The development of the concept of mutual perception of persons in a hierarchy: the dynamics of perceptions. Journal of Economy and entrepreneurship, 2019, Vol. 13, Nom. 1, p. 830-833 (И.А. Смаржевский, Развитие концепции взаимного восприятия персон в иерархической структуре: динамика восприятий // Экономика и предпринимательство. 2019. № 1. С. 830-833.)</p> <p>Abstract. The work develops the concept of mutual perception of persons holding positions in a hierarchy engaged in (some) operational activities. The potential dynamics of the social and personal aspects of perceptions are investigated. As applied to the simplified case (the professional aspect of perception is accepted unchanged), the most probable combinations of personal and social perceptions are defined and the probable ways of changing such combinations are established (routes in the “personal x social” perception matrix). The second main statement of the concept is formulated: in the case of individual personnel decisions, the dynamics and mutual influence of aspects of the person’s perception, which is the object of the decision, the decision maker determines the content of the (personnel) decision itself.</p>
	<i>Emergence</i>	<p>The main result observed in the simulation is the sporadic occurrence of cyclic structures (the spatial location of agents in which the coordinates of several agents and the group performance of individual groups experience quantitative fluctuations). The appearance of such structures precedes full stabilization (when from a certain time, the coordinates of the agents’ no longer change) or, under certain initial conditions, oscillations can continue indefinitely.</p> <p>Stabilization occurs during a time period from 200 to (approximately) 3000 ticks. Stabilization time depends on the number of agents, values of perception radius and operational radius (<b>PerRadius</b>, <b>OpRadius</b>) and the speed of agents moving in the process of implementing their individual strategies.</p>
	B.2. Individual decision making ( <i>Adaptation</i> )	
	<i>Objectives</i>	<p>Objective is group productivity, number of subordinates in groups and group composition dynamics.</p> <p>They are measured quantitatively and are available to the survey in the model interface (plots, figures on World window and digitals in Observer window, see B.8. Observation section for details).</p>

	<i>Learning</i>	Managers are trained in the process of the model as follows: they remember the subordinates who were included in the team, but they took it down because they perceived the manager negatively. Such subordinates are included in the manager's list of "prohibited" and are not included in the team of this manager in the future.
	B.3. Individual prediction	Individuals do not predict future condition.
	B.4. Stochasticity	The value of the perception of each other by agents is defined as a random variable that has a normal distribution (distribution parameters are set by the control elements of the interface). Initial agent's coordinates in the World is random value.
	B.5. Observation	Reports: Group Productivity (for groups of Heads ## 0-6, plot) Group_Productivity_Per_Worker (for groups of Heads ## 0-6, plot) Total number of links between agents (plot). Free operators / managers (out of group's operators and Heads with no suborders) (plot). Agents with positive strategy (in the World window). Agents with negative strategy (in the World window). Perception of the person (agent) by other persons (in the World window). Perception of other persons (agents) by the person (in the World window). Group Productivity of all groups (numbers in Observer window). Suborders lists for all Heads (numbers in Observer window).
	<b>B.6. Implementation Details</b>	The model is coded in Netlogo 6.0.4, Open source and available on CoMSES ( <a href="https://www.comses.net">https://www.comses.net</a> )  If you mention this model or the NetLogo software in a publication, we ask that you include the citations below. For the model itself: Ivan, Smarzhevskiy (2019, June 18). "Organizational behavior in the hierarchy model" (Version 1.0.0). CoMSES Computational Model Library. Retrieved from: <a href="https://www.comses.net/codebases/3a538672-cc55-497c-8f9c-1f3a9522fcd1/releases/1.0.0/">https://www.comses.net/codebases/3a538672-cc55-497c-8f9c-1f3a9522fcd1/releases/1.0.0/</a>  Please cite the NetLogo software as: * Wilensky, U. (1999). NetLogo. <a href="http://ccl.northwestern.edu/netlogo/">http://ccl.northwestern.edu/netlogo/</a> . Center for Connected Learning and Computer-Based Modeling, Northwestern University, Evanston, IL.
<b>C. Details</b>	<b>C.1. Initialization</b>	During the initialization process, data is generated for: 1) Agents quantity and coordinates 2) Agents individual performance

		<p>3) Values of mutual perception by agents of each other.</p> <p>It is possible in the model to change on the fly radii values, update the perception value across the entire population and the perception of an individual agent by its neighbors within the perception radius, and the probability values for a subordinate to make a decision about leaving the group.</p> <p>You can also change the set of strategies for moving agents and strategies for recruiting a team manager.</p> <p>It is possible to add a randomness factor to the movement of agents (<b>Stoch_Motion_Speed</b>, the default is set to 0, that is, there are no random movements).</p>
	<b>C.2. Input data</b>	The model does not use input data to represent time-varying processes.
	<b>C.3. Submodels</b>	
	<b>setup</b>	The procedure creates a specified numbers ( <b>Quantity</b> and <b>managers</b> ) of all agents and managers, sets random (from 1 to 100) values of individual performance. Calling procedure <b>perception</b> .
	<b>perception</b>	The procedure assigns the attribute <i>pers_list</i> of all agents the values of their perception of all other agents. Values have a normal distribution with parameters <b>NormMean, NormStdDev</b> .
	<b>go</b>	<p>Implements the simulation process.</p> <p>Call procedure <b>connect</b>.</p> <p>Realize (if select <b>Attraction</b> is ON) for all agents positive strategy (moves each agent to the geometric center (with coordinates (<i>xpos ypos</i>) of all agents that are positively perceived by this agent. Formula: <math>xcor = (t * xpos + (1 - t) * xcor)</math> set <math>ycor (t * ypos + (1 - t) * ycor)</math>, where local variable <i>t</i> (equal 0.5, value can be changed in model code) is parameter that determines the speed of moving agents in the model World.</p> <p>Realize (if select <b>Rejection</b> is ON) for all agents negative strategy (moves each agent to the geometric center of all agents that are negatively perceived by this agent. Formula: <math>xcor = (-t * xneg + (1 + t) * xcor)</math> set <math>ycor (-t * yneg + (1 + t) * ycor)</math>, where local variable <i>t</i> (equal 0.5, value can be changed in model code) is parameter that determines the speed of moving agents in the model World.</p> <p>Call procedures <b>set_strategy_goals_wghd,</b>  <b>group_productivity,</b> <b>head_behaviour,</b>  <b>OperatorsDecision,</b> <b>team_update,</b>  <b>candidate_elimination,</b> with <b>probability</b>  <b>PrbltyOfElimination%</b> call <b>procedure</b></p>

		<b>candidate_elimination</b> and control end of experiment after the time has expired (ticks = 10000).
	<b>connect</b>	The procedure establishes connections (visualized by gray links) with all agents that are in the radius of current perception ( <b>PerRadius</b> ) for a given geometric arrangement of agents. The numbers of perceived (at a given point in time, for a given geometrical arrangement) agents are remembered in the list <i>contacts_list</i> .
	<b>set_strategy_goals_wghtd</b>	The procedure determines the coordinates of the geometric centers ( <i>xpos ypos</i> ) of agents perceived by this agent positively and negatively. The coordinates are calculated taking into account the weights, which are the values of the perception of the other agents of each of the agents belonging to the first and second sets.
	<b>group_productivity</b>	The procedure calculates the value of the group performance of each Head and stores it in the Head's attribute <i>my_group_productivity</i> . The formula is $v = \text{SUM}(\text{productivity} * (59 - \text{distance}_{xy} \text{ vpx vpy}) / 59)$ , where <i>productivity</i> is the individual productivity of each team member, <i>distance<sub>xy</sub> vpx vpy</i> is the distance between the team member and the Head (his coordinates is ( <i>vpx vpy</i> )) and 59 is the maximum possible distance in the model's World.
	<b>head_behaviour</b>	Depending on the position of the selects <b>AskPOS</b> and <b>AskNEG</b> , each manager chooses among the free (not subordinate at the moment other Heads) operators in radius <b>OpRadius</b> to which he perceps positive and / or negative. The numbers of the members are stored in the Head's attribute <i>suborders_list</i> . Belonging operators to a group is visualized by a red link.
	<b>OperatorsDecision</b>	The procedure implements the individual behavior of the operator. If the operator perceives the Head negatively, then, with probability <b>PrbltyOfDecisn%</b> , the operator leaves his group. The Head remembers the number of such an operator (in the list <i>restrSbrdrs_list</i> ) and, further, such an operator, even if he is free, will not be included in the group of this Head.
	<b>team_update</b>	The procedure determines for each Head the operator with the lowest performance, i.e. candidate for removal from the group. Operator number is stored in the Head's attribute <i>candidate</i> . If there are less than two operators in the group, the <i>candidate</i> is -1, which means there is no candidate for removal from the group.
	<b>candidate_elimination</b>	The procedure removes from the group the operator with the lowest performance (with number equal to <i>candidate</i> ).
	<b>InvertPerceptonOfTurtle</b>	The procedure inverts the perception of the agent with the number entered in the editing window <b>TurtleWho</b> , by agents that are at a distance from it <b>PerRadius</b> .

	<b>show-value</b>	<p>Depending on the value of the selection (<i>PosStrategy</i>, <i>NegStrategy</i> and so on), the procedure visualizes the attributes of the agents and the quantitative indicators of the model.</p> <p>Agents with positive strategy (figures in the World window).</p> <p>Agents with negative strategy (figures in the World window).</p> <p>Perception of the person (agent with number entered in the editing window <b>TrtlWho</b>) by other persons (figures in the World window).</p> <p>Perception of other persons (agents) by the agent with number entered in the editing window <b>TrtlWho</b> (figures in the World window).</p> <p>Group Productivity of all groups (numbers in Observer window).</p> <p>Suborders lists for all Heads (numbers in Observer window).</p> <p>This procedure is recommended to run when the <b>Go</b> button is off (when the model time is stopped).</p>
	<b>Stoch_Motion_Speed (button)</b>	<p>It is possible to add a randomness factor to the movement of agents (<b>Stoch_Motion_Speed</b>, the default is set to 0, that is, there are no random movements).</p>
<b>References</b>		<p>Ivan Smarzhevskiy. The concept of mutual perception of persons in a hierarchy. Journal of Economy and entrepreneurship, 2018, Vol. 12, Nom. 12, p. 1120-1124. (И.А. Смаржевский, Концепция взаимного восприятия персон, занимающих позиции в иерархической структуре. // Экономика и предпринимательство. 2018. № 12. С.1120-1124).</p> <p>2. Ivan Smarzhevskiy. The development of the concept of mutual perception of persons in a hierarchy: the dynamics of perceptions. Journal of Economy and entrepreneurship, 2019, Vol. 13, Nom. 1, p. 830-833 (И.А. Смаржевский, Развитие концепции взаимного восприятия персон в иерархической структуре: динамика восприятий // Экономика и предпринимательство. 2019. № 1. С. 830-833.)</p>