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The Universal Interductive Modification Model as a Theoretical Framework for Precise Description of Interactions in Neural Systems and Environment

Waldemar Schwarzkopf

Abstract

The previously elaborated Interductive Modification model (hereinafter IDM model) occurs to include both formally mathematical and theoretical inadequacies. Latter have been announced to be revised, which is the main issue of this article. Beside the declared corrections, this work aims to provide a universal approach of the known interductive modification concept, which leads to the formulation of the *Universal Interductive Modification Model* (hereinafter UIDM model). As mentioned in the previous article, the intention of this elaboration includes a prearrangement of the theoretical construction for the development of actual instructions for experimental approaches and distinct applications. Consequently, the already presented concepts are partially to be dismissed, whereas new concepts and model elements are to be introduced. Accordingly, this work results in a more sophisticated model, which can be used to describe neural functionalities as well as environmental interdependencies with the same precision. Therefore, the UIDM represents the next step to a blueprint for artificial neural systems, following the requirements of already developed concepts [1,2].

1. Introduction.

Beside the already announced elaborations, this article includes corrections of formal nature within the theoretical framework and transfers the elaborated IDM model into a universal concept to describe the environment with the same precision as the cerebral system. Accordingly, the newly developed version is to be referred to as the universal interductive modification model (hereinafter UIDM model). The current model is to be developed in order to be adjusted to experimental data, as has been stated already quite in the beginning of its elaboration. Hence, this article provides the necessary adaptations. These include the equalization of the environment and cerebral system description, the explanation of variability of time intervals and an introduction of an asymmetric timeline. Latter shall allow optimization processes, leading to a distinct framework for artificial consciousness (hereinafter AC) in further researches[1,3]. In order to follow these elaboration requirements, it is crucial to develop a new vocabulary, which will be provided by a new nomenclature of element description. First, an overview about the current state of the IDM model will be provided. Additionally, the implicated challenges will be depicted as well.

2. Current State of the IDM Model and Pending Challenges.

In the previously published article [4], the IDM model describes the modification of neural networks as an accumulation of several functions. Their classifications depend on the input and the output elements of both the neural structure itself and the environment. Albeit the cerebral development has been dealt with in detail, the environmental changes and interactions remained undescribed. Furthermore, as can be seen in the multidimensional perspective, the model allows the input of solely one affect at once. Hence, the resulting challenge is to occupy a far more abstract perspective, in which both the environmental and the cerebral elements must be considered as equivalent in terms of description granularity. This requirement arises from the realization, that the differentiation between environment and neural structures is not settled. Moreover, multiple ducti need to be formulated as the outcome of functions within a given time interval. Furthermore, time intervals themselves need to be scaled concretely and dependent on the situative parameters, since their length has an impact on the granularity of process descriptions, and, therefore, the latency of information transfers. Summarizing, the aspired concept is to include a functional symmetry of all described elements on the one hand, and a time asymmetry in terms of latency-based information uncertainty on the other hand. The elaboration of the two-sided concept and all relevant considerations to be taken into account will be shown in the following paragraphs, as they are crucial to provide an adequate ground for the according expressions.

Beside the purely content inadequacies, the previously published article happened to include some formal errors, which need to be erased. First, the false formulation of the reactivation term as a sum of the compatibilities instead as a product need to be corrected. Consequently, the mirror-term is to be reformulated as well. Additionally, the functional logic of interductive functions occurs to be incorrect, which will be extinguished by a completely new derivation. The corresponding corrections will be mentioned when appropriate.

3. The Universal Nomenclature.

In order to fulfill the requirement of functional symmetry stated in 2. , it is significant to provide a nomenclature of element description. Hence, both the environment and the cerebral dimensions need to be constructed symmetrically, which requires an equal subdivision concept. This requirement follows the concept discussed by Peters and Skowron in 2016 [5]. The elaborated nomenclature may be referred to as the *universal nomenclature*. As the previous article already provides a sufficiently precise description of the neural structures as a starting point, we may begin with the cerebral elements first [4]. In order to shorten the formulation, a new notation is to be introduced, resembling the notation used in Excel, for instance [6]: If a variable k runs from l to m, we can write $k[l:m]$ (read: k running from l to m). If l and m are the only two possible states of k, we can write $k[l;m]$ (read: k possible as l or m). Combinations and formulations with more than two possible (edging) states are possible, but will not be needed in this article. Furthermore, it is to note that all introduced variables are integers.

In the first step, we define the term *major elements* as distinct metafinalities, which are either agents or distinct parts of their environment. The used variable $a[1:e]$ can be kept, whereas the new nomenclature needs to be evolved to cover the whole brain structure, if needed. Thus, we state that an agent A has an arbitrary amount of cerebral parts. Since we are interested in the neural structures only, A stands for the brain itself. Whether an agent recognizes itself as a self, is a matter of environment nomenclature regulation. Therefore, this aspect will be discussed later. In order to enable the model to describe more than one brain, which are recognized as such ones and not as a part of environment (this differentiation may be important in group behavior analysis, for instance [7,8], we introduce the variable $q[1:\alpha]$ to depict the individual agents. q is written as an exponent of A: A^q. After describing the macro level, we need to elaborate a more sophisticated system for differentiation of the cerebral parts. For instance, it is important to know whether a signal aims on the telencephalon as a whole, the frontal lobe, the superior frontal gyrus or even single neuronal clusters. In order to follow this requirement, we can formulate this condition in terms of the MS, as has been done before. According to MS, a brain itself is a finality, consisting of an arbitrary number of subfinalities, which consist of smaller subfinalities by themselves etc. On each subdivision level, each finality implicates a special value for *e*, which is the amount of its own subfinalities. Theoretically, we could continue to increase the subdivision process until we reach quantum states. However, it is crucial to use a further run variable to describe the subdivision level. Thus, we introduce $b[1{:}f]$. f describes the deepest subdivision level of a brain description, whereas b=1 may be the differentiation between the two cerebral hemispheres, for instance. b is written as an index belonging to the according value of a, which means that the element $A^q a_b$ is the a^{th} element on the b^{th} subdivision level of the q^{th} agent A. If solely one agent is focused on, one can leave the capital out and simply write $a^q{}_b$. If it is helpful to note which metafinalities' the regarded cerebral element is part of, one can write the corresponding "path" of subdivision elements in brackets, from a_1 to a_{b-1}, as shown in (1). To illustrate the nomenclature concept, fig. 1 show an abstract scheme of subdivision and the according notation, both for a specific and a non-specific nomenclature with respect to the observed time point.

(1) $$a_b^q(a_1, a_2, \dots, a_{b-1}) = a_b^q(a_{b-1}) = a_b^q = A^q a_b$$

Analogically to the cerebral dimension, we introduce the element O as an object in the environment. Since each brain has its own perception, there must be a given number $p(q)[1{:}\beta(\alpha)]$ of environmental objects percepted by the agent A^q, thus one can write $O^{p(q)}$. If the agent, as mentioned before, recognizes itself as a special part of that environment, one can exclude all the agent's elements from the rest of the environment via this variable. Indeed, this seems to be in opposition to the required symmetry, but one needs to take into account, that the perception of each agent is crucial for the development of its neural structures [2] thus the cerebrally relativistic view has to be maintained. However, the subdivision notation of environmental objects is mirrored to the notation of the cerebral dimension. While $i[1{:}j]$ represents the individual objects, the subdivision levels are depicted by the variable $c[1{:}g]$. Accordingly, the notation is similar to the cerebral dimension as well, as shown in (2).

(2) $$i_c^{p(q)}(i_1, i_2, \dots, i_{c-1}) = a_c^{p(q)}(i_{c-1}) = i_c^{p(q)} = \mathrm{O}^{p(q)} i_c$$

As we intend to provide a universal nomenclature to treat both the cerebral and the environmental dimension equally, for each pair of variables from both dimensions, we introduce a universal variable. In 1) to 7), all seven variables are defined.

1) For agents and major environmental objects, the variable $\Omega[A;O]$ is introduced. In this article, this variable will not be used, as we solely regard one single major element. But as soon as at least two major elements are taken into account, Ω has to be used.

2) The running variable for the exponent notification is $\Phi[q;p(q)]$. By using Φ, we combine both the cerebrally relativistic view and the symmetry requirement, as we enable to treat both variables in the same way, but also remain the dependence between p and q.

3) For elements within agents or major environmental objects, the variable $\chi[a;i]$ is used.

4) Subdivision levels of each dimension are depicted by $\psi[b;c]$.

5) In order to merge the both maximal values for a and i, the variable $X[e;j]$ is used.

6) $\Psi[f;g]$ depicts the maximum values of subdivision levels.

7) Finally, $Y[\alpha;\alpha(\beta)]$ resembles the two possible maximum values for Φ.

Summarizing, Chart 3.1 presents all seven universal variables used for the universal nomenclature. In 4. , the variables are be used for the multidimensional version of the model. It may be mentioned, that the starting values for the running variables are always set to be one, since a non-existent variable does not have to be considered in a description.

4. The Universal Interductive Function.

After the development of a nomenclature to provide the boundary condition for functional symmetry of the multi-dimensional IDM model, it is crucial to implement a timeline orientation, which provides the time asymmetry as has been required before, as well. However, the summation terms need to be shortened at first, since the nomenclature takes several subdivision levels into account. As the attributes of any higher subdivision levels need to be considered to describe the ducti of any chosen subfinality within a major element, we need to shorten the formulation of multiple summations. Afterwards, the time asymmetry and final formulation of the universal interductive function will be discussed.

4.1. Multiple Summation Convention.

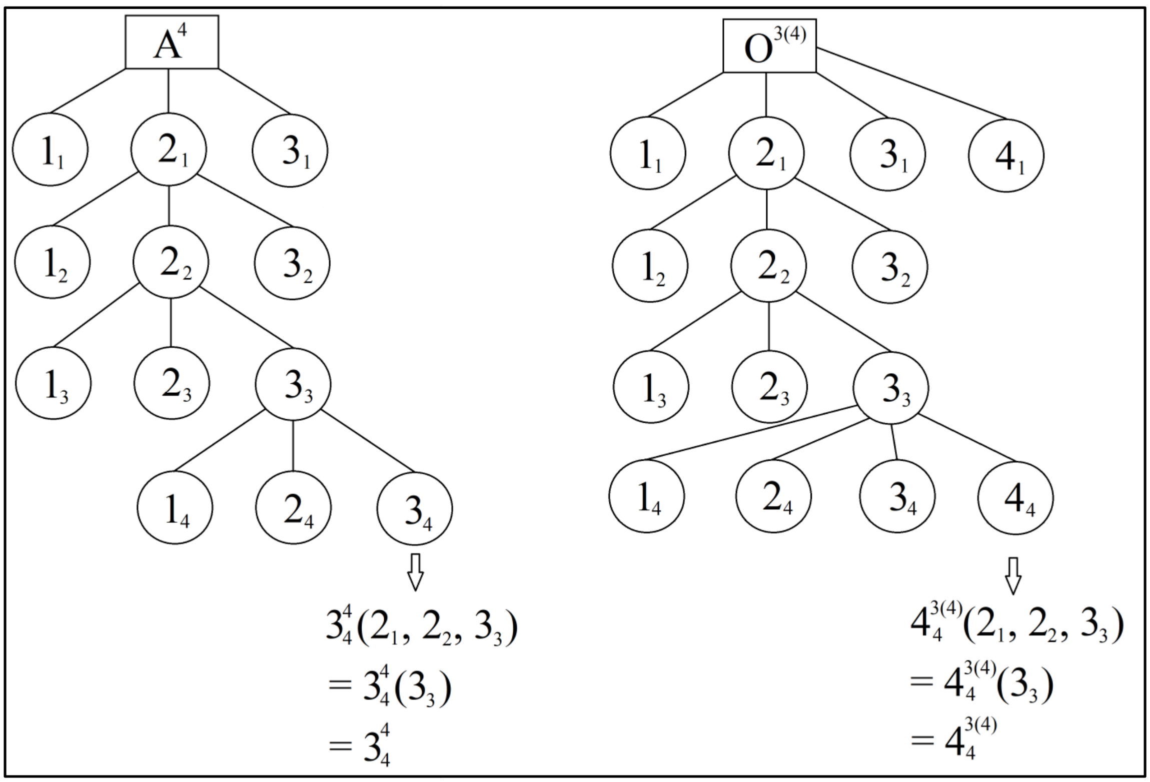
In order to shorten the formulations and provide an overall view of the multiple summation processes, we introduce the *multiple summation convention* (hereinafter MSC). Similarly to the well-known Einstein notation [9], the MSC aims to shorten out the sum-symbol out of the notation and condense the information. However, in order to distinguish it from the Einstein notation, the MSC uses square brackets instead of parentheses. If a multiple summation consists of n summations, we can solely write the terms to be summed over with the according variables in square brackets and add the first and the last variable to be summed over after the closing bracket. If needed, one can also write the range in the known notation behind the running variables. For declaratory overview, one can also add an *s* for *sum* in front of the square brackets. Furthermore, if solely one summation is to be done, one can leave the second space for the last summation variable out. Albeit this notation leaves out the information of all the variables in between, the "path" information about the according variables in subdivision levels are provided already by the universal nomenclature. (3) shows the general example for a countable set of summations. A concrete example is shown by (4), in which the two variables $a[2:\alpha]$and $b[3:\beta]$have different range intervals.

Chart 3.1: Summarization of universal variables for the universal nomenclature of the UIDM model. For each variable, its range or its possible values are depicted, respectively. Furthermore, brief descriptions explain their purposes.

Universal variable	Range or possible values	Explanation
Ω	$[A;O]$	Describes the major elements' dimension, which is either environmental (O) or cerebral (A). A represents solely the agents' cerebral structures, excluding their bodies, as they are considered to be parts of the

		environment.
Φ	[q;$p(q)$]	Describes the distinct elements of the dimensions mentioned above. Since agents occupy relative perspectives, *p*, which is the variable for environmental elements,is dependent on *q*, variable of the corresponding agent.
χ	[a;i]	Describes the minor elements as subfinalities of the major elements of both dimensions. Generally, they are dependent on the subdivision level and their metafinalities, as each finality has its own set of subfinalities.
ψ	[b;c]	Describes the subdivision levels of major elements of both dimensions. It is free to choose how many subdivision levels are considered. In general, no subdivision at all or an arbitrarily high number of levels can be considered, too, if it appears to be useful for the description.
Χ	[e;j]	Describes the maximum amount of subfinalities for each level and metafinality for both types of major elements.
Ψ	[f;g]	Describes the maximum amount of subdivision levels of major elements for both types of major elements.
Y	[α;$\alpha(\beta)$]	Describes the maximum values of subelements of a given subdivision layer of both cerebral and environmental major elements, thus the maximum values for Φ.

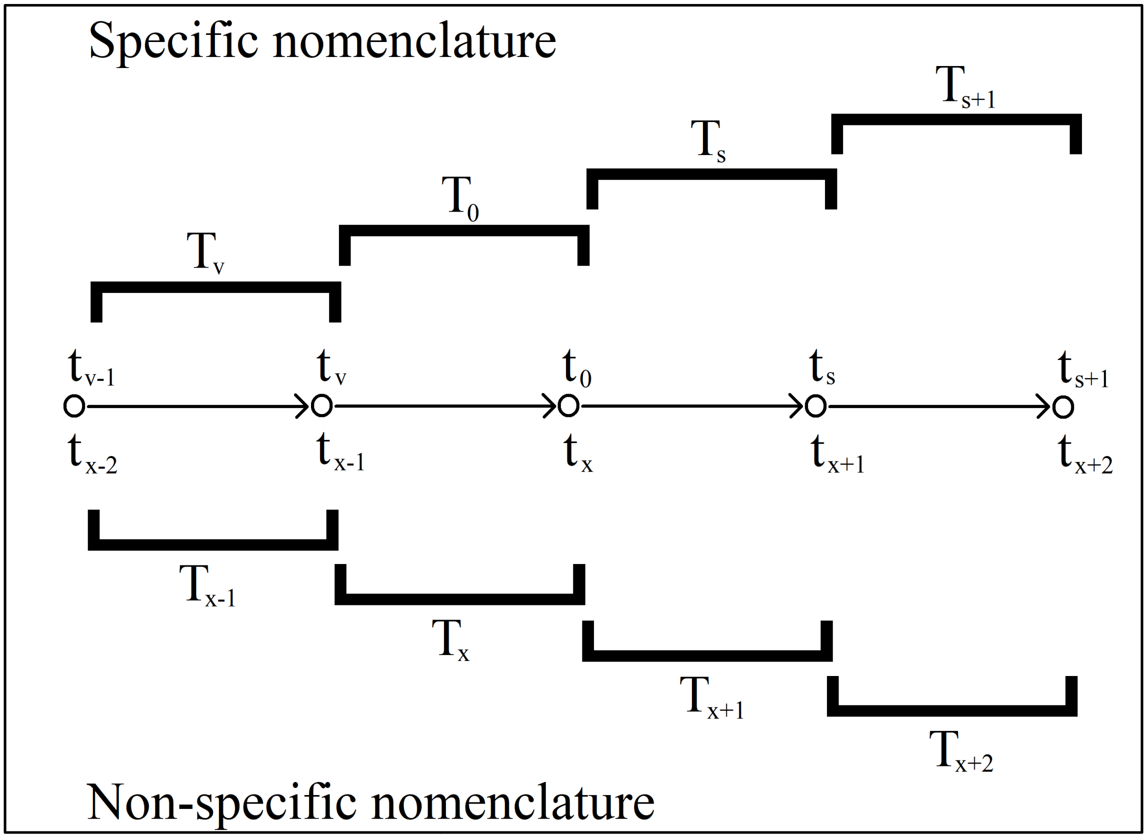
Fig. 1: Schematic illustration of the universal nomenclature concept. On the left side, an agent A^4 is described, which consists of three parts on the first subdivision level, which are referred to as 1_1, 2_1, 3_1. While 1_1 and3_1 are not further described, 2_1consists of three further elements in the next level of subdivision. Accordingly, 2_2consists of three elements on the third subdivision level. Finally, 3_3 consists of three elements on the fourth subdivision level, which 3_4 is the subject of our interest. Using the nomenclature, we can describe it as shown in three possible ways, whereas the first shown notation includes the path from the major element, A^4, to the minor element 3_4 throughout the whole structure with increasing granularity. The second notation is shorter, but solely consists of the final element and its metafinality, 3_3. The shortest way to notate the minor element of interest is the sole depiction of its name (or number), the subdivision level and the according declaration of the agent, which is shown in the third row. Accordingly, the same procedure is done for a major element of environment, $O^{3(4)}$. The notation *3(4)* classifies the environmental element as the third one, which is percepted by A^4. Therefore, its structure is completely dependent on A^4's copula (potential). $O^{3(4)}$ consists of four elements on the first subdivision level, whereas 2_1 is described to consist of three elements on the second subdivision level, and so on. The last element is depicted as the fourth minor element of the fourth subdivision level, using all three notations as used for the agent before.



(3) $$\sum_{a=0}^{\alpha}\sum_{b=0}^{\beta}\cdots\sum_{w=0}^{\omega}A_{a,b,\ldots,w}=s\left[A_{a,b,\ldots,w}\right]_{a[0:\alpha]}^{w[0:\omega]}=s\left[A_{a,b,\ldots,w}\right]_{a}^{w}$$

(4) $$\sum_{a=2}^{\alpha}\sum_{b=3}^{\beta}A_{a,b}=s\left[A_{a,b}\right]_{a[2:\alpha]}^{b[3:\beta]}=s\left[A_{a,b}\right]_{a}^{b}$$

Fig. 2: Illustration of the timeline used by equations (5) to (8), (12) to (17) and (23) to (27). The timeline consists of points*t*, and intervals *T.* The indices are used for both, a specific nomenclature and a non-specific nomenclature. Latter will be used for the universal notation, while the specific nomenclature is advantageous, if one relates the calculations to a specific point t_0. Its predecessor, t_v, and its successor, t_s, occupy a special role in the nomenclature, as the according intervals depend on the length of their predecessors, as will be described in 4.2. In general, each interval begins after a given time point and includes the successor time point, whereas the latter provides the notification for the interval. For instance, T_v ends in time point t_v. Therefore, the concept elaborated in [4] is kept, as T_x is to be described as $T_x:=[t_{x-1};t_x]$.



4.2. Timeline Orientation and ε-Function.

As has been mentioned in the previous article, the length of a time interval T_0 can vary. Albeit the reason for its variability grounded on the consideration of different granularities of description, the concept of variable time lengths between interactions is important in general. Especially, if one intends to describe the information flow with a limited velocity over arbitrarily long distances, a variable latency time between sending and receiving is crucial to provide correct calculations. Before the concrete application can be formulated, though, we can already set the boundary condition for a variable length of time intervals. In order to do so, we introduce the *ε*-function, which calculates an interval length dT_x as the product of its predecessor dT_{x-1} and an expansion factor ε as a positive real number. Furthermore, the *ε*-function also depends on the given element $\chi^{\Phi}{}_{\psi,tx-1}$, in accordance to the fact, that the previous time interval length represents the reference for every new time interval. The *ε*-function is shown in (5), and (6) sums up the dependence of the relation between dT_x and $dT_{x-1}$with respect to the expansion factor ε.

(5) $$\varepsilon\left(T_{x-1}, \chi_{\psi}^{\Phi}\right) = dT_x = \varepsilon \cdot dT_{x-1}\,,\; x[v; 0; s]$$

(6) $$\varepsilon < 1 : dT_x < dT_{x-1} \qquad \varepsilon = 1 : dT_x = dT_{x-1} \qquad \varepsilon > 1 : dT_x > dT_{x-1}$$

In order to provide an appropriate orientation, the notation of points is to be extended to include t_0 as the ending point of the observed time interval T_0, t_v as the time ending point of the previous time interval T_v and, finally, t_s as the ending time point of the successor time interval T_s. Further points and the according intervals beyond the three stages can be depicted by the indices v -1, s + 1 and so on. Different from the timeline concept from the previous article, this description solely depicts one single element and does not take the other elements into account. That is, because the functional symmetry already includes the variability of all possible elements. Hence, this timeline notation can be set for any single element, using a relative perspective for each [10]. Both time interval notations are presented in fig. 2.

Given the presented timeline notation, we can easily define the different time intervals using the time points and the according interval lengths, as shown in (7). By applying the ε-function and transferring the notation into an abstract manner, we obtain (8) as the description of any given time interval with respect to its predecessor. The exact derivation of the expansion factor is to be done in further research, as the necessary considerations need more detailed descriptions of the cerebral functionalities.

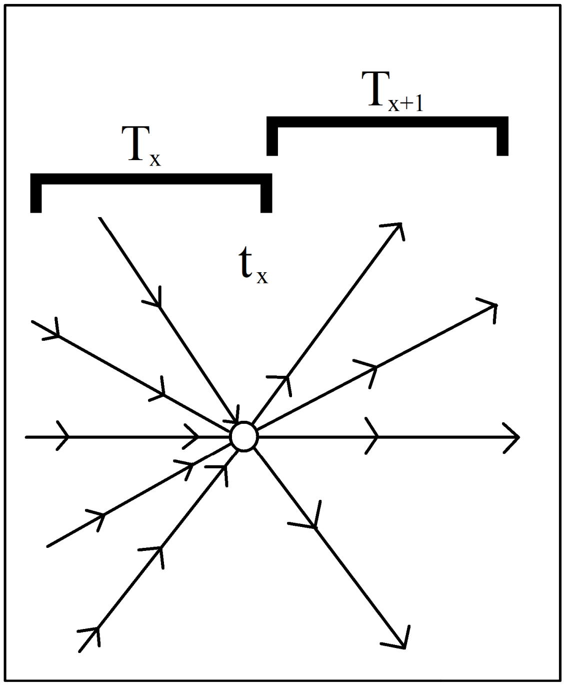
(7) $$\begin{aligned} T_v &= \left(t_0 - dT_0 - dT_v ; t_0 - dT_0\right] = \left(t_{v-1} ; t_v\right] \\ T_0 &= \left(t_0 - dT_0 ; t_0\right] = \left(t_v ; t_0\right] \\ T_s &= \left(t_0 ;\, t_0 + dT_s\right] = \left(t_0 ; t_s\right] \end{aligned}$$

(8) $$T_x = \left(t_x - \varepsilon\left(T_{x-1}, \chi_{\psi}^{\Phi}\right) ; t_x\right] = \left(t_x - \varepsilon \cdot dT_{x-1} \; ; t_x\right]$$

4.3. Derivation of the Universal Expressions.

Before the universal interductive function can be derived, we need to reformulate the expression for reactivation, which included a mistake in the previous article. As the reactivation can be expressed by the product of the two corresponding compatibilities, the summations need to be multiplied as well. (9) and (10) show the explicit expressions using the MSC for a conceptual interductive relation between the states *A* and *B*. Accordingly, the transformation from $T_{A,B}$ to $\Phi_{B,C}$ of given ducti $D_{A,B}$ and $D_{B,C}$, which describe the classification function between the three states *A, B, C,* can be derived in an according manner. It is important to note, that in terms of the UIDM model, the distinction between the different ducti is not necessary anymore, since any element is to be treated equally, following the functional symmetry requirement. This means that we completely abandon the previously used D_m axis concept and can find the ductus in any possible place, either in the cerebral or the environmental dimension. Hence, we can call any ductus D_y. One can refer to this concept as *ductive isotropy*. The influence on an element by multiple ducti, followed by an emission of also multiple ducti, is illustrated by fig. 3.

Fig.3: Schematic depiction of the ductive isotropy principle. An element at time point t_x is aimed by a given number of ducti, which occur during the time interval T_x. Subsequently, the element emits a number of ducti during the time interval T_{x+1}.



The interductive function between $D_{A,B}$ and $D_{B,C}$ is derived in (11), similarly to the derivation of the interductive functions in the previous IDM model. In the first step, the reactivation expression is divided by both the square of the basal similarity grade and the from-term. In the next step, this process is repeated for all incoming ducti D_y at the time interval T_x, hence the running variable $n(y_{Tx})[0{:}v(y_{Tx})]$ is used for their summation. Afterwards, the already known $(\delta,\kappa)_{ex}$– function is applied, which extracts destruction and construction terms for the next ductus from the remaining effects. To obtain the affection term, the extracted values are concerted and added by the attributes of the new target state *C*. Accordingly, the attributes are summed over the variables *b* and *c*.

(9) $$T_{A,B} = C_{A,B} \cdot C_{B,A}$$

(10) $$T_{A,B} = Æ^2_{A,B} \cdot s\left[\sqrt{\left(\delta_{A,B}(B)\right)^2 + \left(\kappa_{A,B}(B)\right)^2}\right]_a^b \cdot s\left[\sqrt{\left(\delta_{B,A}(A)\right)^2 + \left(\kappa_{B,A}(A)\right)^2}\right]_b^a$$

(11) $$\Phi_{A,B} = s\left[\left|Sit\eta_c\right| + C\left[(\delta,\kappa)_{ex}\left[s\left[\frac{T_{A,B}}{Æ^2_{A,B} \cdot s\left[\sqrt{\left(\delta_{b,a}(a)\right)^2 + \left(\kappa_{b,a}(a)\right)^2}\right]_b^a}\right]_{n\left(yT_x\right)}\right]\right]\right]_b^c$$

After the conceptual interductive function between two ducti is derived, we can now apply it to the nomenclature elaborated in 3. , in order to obtain its universal pendant. First, we describe the function $[f]_{tx}$ as the assignment of a $\Phi_{tx}((D_y)_{tx})$ to a given $T_{tx+1}((D_y)_{tx+1})$, as shown in (12). We obtain the universal interductive function by simply inserting the corresponding indices of the universal nomenclature. The resulting expression is shown in (13). Different to the formulation of (11) is the final summation over $n(y_{Tx+1})[0{:}\nu(y_{Tx+1})]$, since we need to formulate all affection terms in the interval T_{x+1}. It is important to note, that the basal similarity grades are still symmetric because of set theory arithmetic laws [11] and thus can be summed up in a quadratic expression. Furthermore, the different subdivision variables ψ and $\psi+1$ indicate, that the calculation of the subfinalities needs to be done in their consecutive subdivision level.

According to the used method, we can derive the intraductive functions $\rho(\Phi_{Tx}(D_y))$ and $\tau(\Phi_{Tx}(D_y))$ in their universal form by simply inserting the according indices in the corresponding way. As mentioned in 2. , the mirror term for the ρ-function is to be corrected, since the reactivation term consists of a product instead of an addition. Consequently, we can simply write μ and re-interpret it as a function which multiplies the argument with its mirrored counterpart. The according expressions for the intraductive functions are shown in (14) and (15). Although it has been stated already by Tononi, Oizumi and Albantakis in [12] that relations of neurons to themselves do not contribute to a neural structure's ability to develop an artificial consciousness, such relations are to be considered as possible for environmental elements, thus the notations does not differ between subjects and objects. This general view can be contracted for cerebral dimension, if required.

Given all the required expressions in terms of the universal nomenclature, we can formulate the universal ductus as the classification function of a given effect in the time interval T_{x+1}. This formulation includes any possible ductus which arises from a given $\chi^{\Phi}_{\psi,tx}$. Whether a ductus occurs, depends on the δ and κ values. If the values appear to be zero for a given object, the ductus simply does not arise. The universal ductus expression is shown in (16) in implicit and in (17) in explicit form, respectively.

(12) $$[f]_{t_x} := T_{T_x}\left(\left(D_y\right)_{T_x}\right) \rightarrow \Phi_{T_{x+1}}\left(\left(D_y\right)_{T_{x+1}}\right)$$

(13) $$[f]_{t_x}\left(T_{T_x}\left(\left(D_y\right)_{T_x}\right)\right) = [f]_{t_x}\left(T_{\left(\chi^{\Phi}_{\psi,t_{x-1}};\chi^{\Phi}_{\psi,t_x}\right)}\right) = s\left[\Phi_{T_{x+1}}\left(\left(D_y\right)_{T_{x+1}}\right)\right]_{n\left(y_{T_{x+1}}\right)} =$$

$$s\left[s\left[\left|Sit\eta_{\left(\chi^{\Phi}_{\psi+1,t_{x+1}}\right)}\right| + C\left[(\delta,\kappa)_{ex}\left[s\left[\frac{T_{\left(\chi^{\Phi}_{\psi,t_{x-1}};\chi^{\Phi}_{\psi,t_x}\right)}}{\textit{Æ}^2_{\left(\chi^{\Phi}_{\psi,t_{x-1}};\chi^{\Phi}_{\psi,t_x}\right)} \cdot s\left[\sqrt{\left(\delta_{\left(\chi^{\Phi}_{\psi+1,t_{x-1}};\chi^{\Phi}_{\psi+1,t_x}\right)}\left(\chi^{\Phi}_{\psi+1,t_x}\right)\right)^2 + \left(\kappa_{\left(\chi^{\Phi}_{\psi+1,t_{x-1}};\chi^{\Phi}_{\psi+1,t_x}\right)}\left(\chi^{\Phi}_{\psi+1,t_x}\right)\right)^2}\right]_{\chi^{\Phi}_{\psi+1,t_{x-1}}}^{\chi^{\Phi}_{\psi+1,t_x}}}\right]_{n\left(y_{T_x}\right)}\right]\right]\right]_{\chi^{\Phi}_{\psi+1,t}}$$

$$\tau\left(\Phi_{T_{x+1}}\left(\left(D_y\right)_{T_{x+1}}\right)\right) = T_{T_{x+1}}\left(\left(D_y\right)_{T_{x+1}}\right) =$$

(14) $$\textit{Æ}^2_{\left(\chi^{\Phi}_{\psi,t_x};\chi^{\Phi}_{\psi,t_{x+1}}\right)} \cdot \mu\left[\left\|C^{-1}\left[\Phi_{T_{x+1}}\left(\left(D_y\right)_{T_{x+1}}\right) - s\left[\left|Sit\eta_{\left(\chi^{\Phi}_{\psi+1,t_{x+1}}\right)}\right|\right]_{\chi^{\Phi}_{\psi+1,t_{x+1}}}\right]\right\|\right]$$

(15) $$\rho\left(\Phi_{T_{x+1}}\left(\left(D_y\right)_{T_{x+1}}\right)\right) = R_{T_{x+1}}\left(\left(D_y\right)_{T_{x+1}}\right) =$$

$$\Phi_{T_{x+1}}\left(\left(\mathrm{D}_y\right)_{T_{x+1}}\right) - s\left[\left(\delta_{\left(\chi^{\Phi}_{\psi+1,t_x};\chi^{\Phi}_{\psi+1,t_{x+1}}\right)}\left(\chi^{\Phi}_{\psi+1,t_{x+1}}\right)\right)_C + \left(\kappa_{\left(\chi^{\Phi}_{\psi+1,t_x};\chi^{\Phi}_{\psi+1,t_{x+1}}\right)}\left(\chi^{\Phi}_{\psi+1,t_{x+1}}\right)\right)_C\right]_{\chi^{\Phi}_{\psi+1,t_x}}^{\chi^{\Phi}_{\psi+1,t_{x+1}}}$$

(16) $$\left(\mathrm{D}_y\right)_{T_x} = \begin{pmatrix} T_{T_x}\left(\left(\mathrm{D}_y\right)_{T_x}\right) \\ \Phi_{T_x}\left(\left(\mathrm{D}_y\right)_{T_x}\right) \\ R_{T_x}\left(\left(\mathrm{D}_y\right)_{T_x}\right) \end{pmatrix}$$

5. Information Loss.

As mentioned before, the time asymmetry of the UIDM model implicates an information uncertainty, hence a loss, between two interacting elements. This is to be explained as follows: Given a limited transmission velocity, the latency interval can include a certain amount of interactions with other elements. Furthermore, any interaction has the intrinsic potential to change the element's subattributes. As an interaction grounds on the term of compatibility, thus the sets of subattributes of both the subject and the object of an affect, a change of the initial set of subattributes implicates consequently a corresponding change of information perception [13]. Therefore, latency leads to information loss. In fact, one can minimize the effect by synchronizing information interchange for all cerebral elements, but given a sufficiently high complexity, a tendency to desynchronization is inevitable. Moreover, one cannot affect the environmental elements to be synchronized. Hence, at least the environmental dimension will include a certain information loss either way. Therefore, we must take the loss into account. In order to provide a theoretical ground for its calculation, we need to occupy another perspective on the copula potential first.

(17) $$(\mathrm{D}_y)_{T_{x+1}} =$$

$$\begin{pmatrix} \text{Æ}^2_{\left(\chi^{\Phi}_{\psi,t_x};\chi^{\Phi}_{\psi,t_{x+1}}\right)} \cdot \mu \left\| \left| C^{-1} \left[\Phi_{T_{x+1}}\left((\mathrm{D}_y)_{T_{x+1}} \right) - s\left[\left| Sit\eta_{\left(\chi^{\Phi}_{\psi+1,t_{x+1}}\right)} \right| \right]_{\chi^{\Phi}_{\psi+1.t_{x+1}}} \right] \right| \right\| \\ s\left[\left| Sit\eta_{\left(\chi^{\Phi}_{\psi+1,t_{x+1}}\right)} \right| + \left(\delta_{\left(\chi^{\Phi}_{\psi+1,t_x};\chi^{\Phi}_{\psi+1,t_{x+1}}\right)}\left(\chi^{\Phi}_{\psi+1,t_{x+1}}\right) \right)_C + \left(\kappa_{\left(\chi^{\Phi}_{\psi+1,t_x};\chi^{\Phi}_{\psi+1,t_{x+1}}\right)}\left(\chi^{\Phi}_{\psi+1,t_{x+1}}\right) \right)_C \right]_{\chi^{\Phi}_{\psi+1,t_x}}^{\chi^{\Phi}_{\psi+1,t_{x+1}}} \\ \Phi_{T_{x+1}}\left((\mathrm{D}_y)_{T_{x+1}} \right) - s\left[\left(\delta_{\left(\chi^{\Phi}_{\psi+1,t_x};\chi^{\Phi}_{\psi+1,t_{x+1}}\right)}\left(\chi^{\Phi}_{\psi+1,t_{x+1}}\right) \right)_C + \left(\kappa_{\left(\chi^{\Phi}_{\psi+1,t_x};\chi^{\Phi}_{\psi+1,t_{x+1}}\right)}\left(\chi^{\Phi}_{\psi+1,t_{x+1}}\right) \right)_C \right]_{\chi^{\Phi}_{\psi+1,t_x}}^{\chi^{\Phi}_{\psi+1,t_{x+1}}} \end{pmatrix} \quad \textbf{5.1.}$$

Reformulation of the Copula Potential and Derivation of the Prediction Equation.

As already elaborated in [10] and applied for the derivation of the ducti in [4] the copula potential is equal to the reactivation term, whereas the according affect is limited to perception. However, one can also interpret the copula potential as a function of the relation between the cardinality of the set of perceived elements of a situative matrix and the cardinality of its total set of all elements. Indeed, this requires the penetrating knowledge about the matrix, which solely can provided by an absolute perspective. Albeit we cannot know everything about a given system [14], independent of how much information we gather, we may assume we could, or at least could know about every relevant information for our purposes. Given that assumption, we now have to multiply this relation by a specific factor π, in order to obtain equivalence to the product of the compatibilities. As we solely consider the interchange of two elements, we can formulate the equivalence of both interpretations as shown in (18) for a subject *FinA* and an object *FinB.*

(18) $$\text{Þ}_{A,B} = C_{A,B} \cdot C_{B,A} = \pi \cdot \frac{\left|\left\{ \mathrm{E}_{Ц} \,\middle|\, \mathrm{E}_{Ц} \in Sit\eta_B, \mathrm{E}_{Ц} \in \text{Ꝁ}_{A,B} \right\}\right|}{\left|\left\{ \mathrm{E}_{Ц} \,\middle|\, \mathrm{E}_{Ц} \in Sit\eta_B \right\}\right|}$$

To shorten the expression, we can use *p(A,B)* for the cardinality of the subattributes of *FinB* perceived by the subject *FinA* elements and *p(B)* for the cardinality of all elements of the object *FinB*, as shown in (19). The specific factor π can be expressed as shown in (20).

(19) $$p_{A,B} = \left|\left\{ \mathrm{E}_{Ц} \,\middle|\, \mathrm{E}_{Ц} \in Sit\eta_B, \mathrm{E}_{Ц} \in \text{Ꝁ}_{A,B} \right\}\right| \qquad p_B = \left|\left\{ \mathrm{E}_{Ц} \,\middle|\, \mathrm{E}_{Ц} \in Sit\eta_B \right\}\right|$$

(20) $$\pi = \frac{p_B}{p_{A,B}} \cdot C_{A,B} \cdot C_{B,A}$$

By applying the definition of compatibility, which has been shown in [4], we separate the symmetric basal similarity grade from the asymmetric summation of δ and κ values. Furthermore, we use (21) to shorten the summation expression, and obtain (22). Again, we can insert the indices of the universal nomenclature and obtain (23). As we have derived the universal interductive function in 4.3. att_x, our ductus of interest aims to an object at t_{x+1} . Thus, the expression is fitted to the interval T_{x+1} .By rearranging this equation, we obtain an expression for the cardinality of interchanging elements of a receiver element, which is to be referred to as the *prediction equation* (24).

(21) $$s\left[r_{Aj}\cdot\left(Sit\eta_{Bi}\right)\right]_{j[0:\alpha]}^{i[0:\beta]} = S_{rA}^{\alpha,\beta}\left(Sit\eta_A, Sit\eta_B\right) = S_{rA}^{\alpha,\beta}$$

(22) $$\pi\cdot\frac{p_{A,B}}{p_B} = Æ^2{}_{A,B}\cdot S_{rA}^{\alpha,\beta}\cdot S_{rB}^{\beta,\alpha}$$

(23) $$\pi\cdot\frac{p_{\left(\chi^{\Phi}_{\psi,t_x};\chi^{\Phi}_{\psi,t_{x+1}}\right)}}{p_{\left(\chi^{\Phi}_{\psi,t_{x+1}}\right)}} = Æ^2_{\left(\chi^{\Phi}_{\psi,t_x};\chi^{\Phi}_{\psi,t_{x+1}}\right)}\cdot S_{r\left(X^{\Phi}_{\psi,t_x}\right)}^{\left(X^{\Phi}_{\psi,t_x};X^{\Phi}_{\psi,t_{x+1}}\right)}\cdot S_{r\left(X^{\Phi}_{\psi,t_{x+1}}\right)}^{\left(X^{\Phi}_{\psi,t_{x+1}};X^{\Phi}_{\psi,t_x}\right)}$$

(24) $$p_{\left(\chi^{\Phi}_{\psi,t_x};\chi^{\Phi}_{\psi,t_{x+1}}\right)} = \pi^{-1}\cdot Æ^2_{\left(\chi^{\Phi}_{\psi,t_x};\chi^{\Phi}_{\psi,t_{x+1}}\right)}\cdot S_{r\left(X^{\Phi}_{\psi,t_x}\right)}^{\left(X^{\Phi}_{\psi,t_x};X^{\Phi}_{\psi,t_{x+1}}\right)}\cdot S_{r\left(X^{\Phi}_{\psi,t_{x+1}}\right)}^{\left(X^{\Phi}_{\psi,t_{x+1}};X^{\Phi}_{\psi,t_x}\right)}\cdot p_{\left(\chi^{\Phi}_{\psi,t_{x+1}}\right)}$$

5.3. Information Loss during Latency.

The right side of the prediction equation (24) consists of the symmetric basal similarity grade, the asymmetric summation terms, as well as the cardinality of the total subattribute set of $\chi^{\Phi}{}_{\psi,tx+1}$. As we are interested in the information loss during the latency time, which is the length of the time interval T_{x+1} , dT_{x+1} , we need to express the cardinality of subattribute set at t_{x+1} in terms of the cardinality of subattribute set at t_x. Since we do not know *ex ante* how many interchanges occur within dT_{x+1}, we introduce the running variable $\tau[t_x{:}t_{x+1}]$ to count those interchanges. Therefore, we can define the carindality of the total subattribute set at t_{x+1} as the sum of all cardinality changes $dp(\chi^{\Phi}{}_{\psi,\tau})$ within the interval, ΔI or *gradual information loss*, added to the initial cardinality, as shown by (25) and (26).

(25) $$p_{\left(\chi^{\Phi}_{\psi,t}\right)} = p_{\left(\chi^{\Phi}_{\psi,t}\right)} + \Delta I$$

(26) $$\Delta I = s\left[dp_{\left(\chi^{\Phi}_{\psi,\tau}\right)}\right]_{\tau\left[t_x;t_{x+1}\right]}$$

As any $dp(\chi^{\Phi}{}_{\psi,\tau})$ may be negative or positive, which corresponds to an subattribute loss or gain (different balances of δ and κ values), its total balance does not tell the actual loss of any information loss in terms of modification of the initial subattribute set. Therefore, we need to consider the absolutes of cardinality changes, $|dp(\chi^{\Phi}{}_{\psi,\tau})|$. The corresponding summation provides $|\Delta I|$, or the *absolute information loss*, as shown in (27). Further research will include the elaboration of information loss as the consequence of a dynamic interchange between interacting elements and use it for a more detailed description of cortical functionalities.

(27) $$|\Delta I| = s\Big[\,\Big|dp_{\left(\chi^{\Phi}_{\psi,\tau}\right)}\Big|\,\Big]_{\tau\left[t_x\,;\,t_{x+1}\right]}$$

6. Conclusion and Further Research Potential.

Solved Problems.

As mentioned in 2., the previous elaboration of the UIDM model predecessor included several mistakes [4], which were managed to be solved. Beside the formal mistake in the reactivation expression, which consequence, the mirroring term, also had to be exchanged by a new formulation, also the functional logic has been improved.

Derivation of the ε-factor.

The introduced expansion factor ε needs to be derived yet, as has been said in 4.2. If its value can be calculated using known parameters of the environmental and the cerebral dimensions, one can derive how to optimize the latency time to be as low as possible, which leads to the mentioned optimizations of information flow. Furthermore, monitoring the expansion factor can provide insights in a structure's functionalities, which is helpful for medical applications.

Equalization of Environmental and Cerebral Dimensions.

Furthermore, both the environmental and cerebral dimension have been equalized and can be described and thus calculated with, at least theoretically, arbitrary grade of precision. This allows to collate actual environmental systems with what the cerebral structure perceives, leading to the possibility of adaptation of the neural imitation of the agent's environment, given a sufficiently high grade of the cerebral system's complexity. Hence, the universal nomenclature allows the formulation of learning and adaptation processes, which are driven by perception [2]. The development of such theory is to be left out for further research.

Time Asymmetry allows Process Optimization.

Any adaptation, and therefore, learning process, occurs in accordance with optimization of information flow [15,16]. As we have derived an expression for information loss during interaction between two elements of either dimension, we can elaborate a theoretical concept to identify the reasons of this unwelcome effect. In fact, this is what biological systems do when they follow the adaptation rule of evolutio [17,18]. Moreover, the time asymmetry allows us to monitor the development of information loss of a depicted system. Consequently, this provides insights in adaptation efficiency and, therefore, its regulation.

Universal Nomenclature Implicates the Ability to Create an Artificial Consciousness.

As already mentioned, the universal nomenclature enables a cerebral structure of sufficient complexity to imitate its surrounding. Since the first development of the UIDM model grounds on the IIT's framework conditions for AC [12,19] ,the UIDM model now offers the possibility to provide a distinct foundation for neural networks, which shall be able to develop AC. As already mentioned by several authors and assented by myself, a sufficiently high grade of perception is one of the main evolutional reasons – and neuromathematical framework conditions – to evolve consciousness [2,12,19-22]. Hence, the complexity-grounded problems as the information loss and communication between more than solely two neural elements need to be solved, if one intends to create neural networks capable of developing AC. However, the universal approach provides sophisticated and flexible bounding condition for this development.

These are some of the possible fields which may be covered up by following research. Indeed, after all theoretical framework is elaborated to a certain grade of precision, it is crucial to involve empirical data in order to provide a concrete description of neural structures and their functionalities.

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