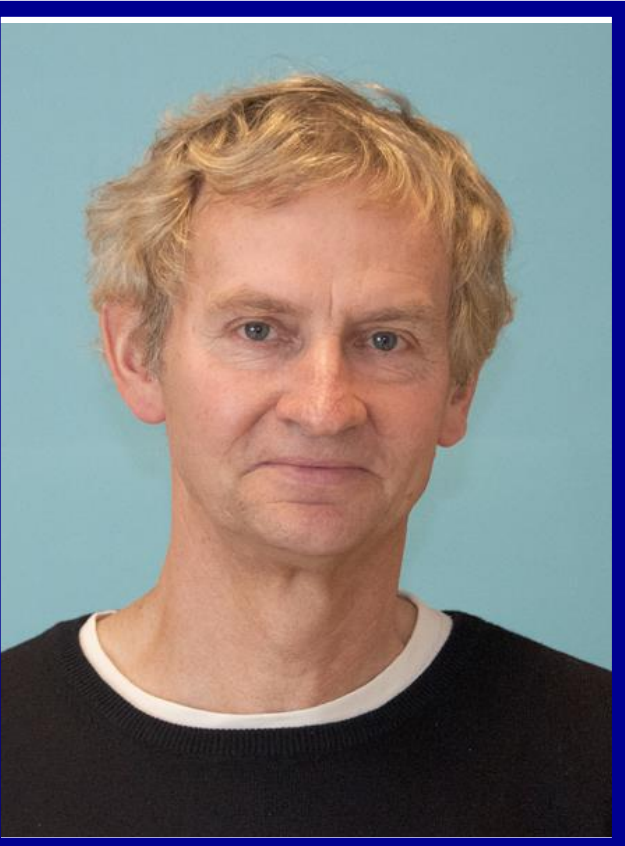


An Adaptive Network Model Covering Metacognition to Control Adaptation for Multiple Mental Models

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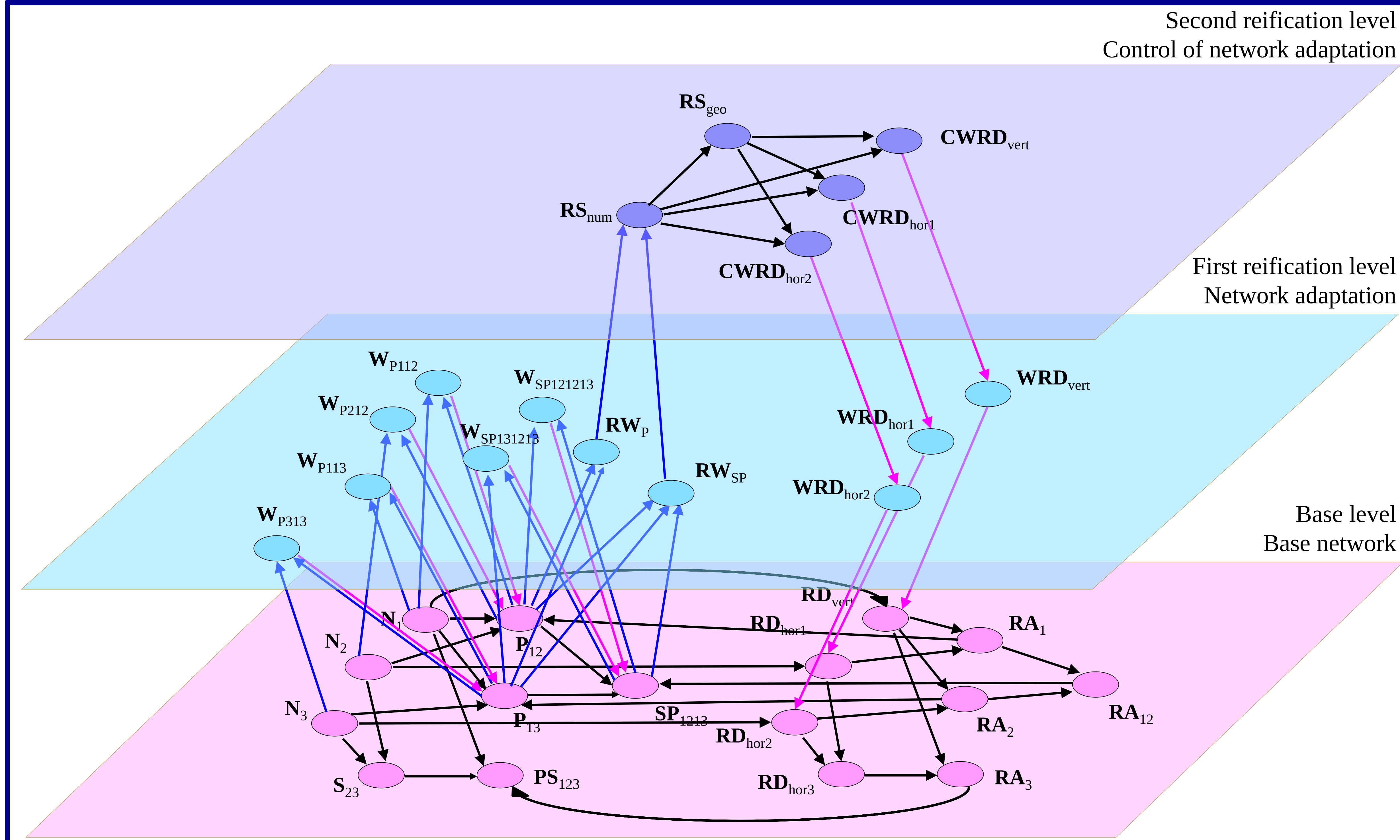
ABSTRACT

Learning processes can be described by adaptive mental network models. If **metacognition** is used to **regulate learning**, the adaptation of the mental network becomes itself adaptive as well: second-order adaptation. In this paper, a second-order adaptive mental network model is introduced for metacognitive regulation of learning processes. The focus is on the role of multiple internal mental models, in particular, the case of **visualisation** to support learning of numerical or symbolic skills. with a case scenario for the role of visualisation to support learning multiplication at the primary school.

INTRODUCTION

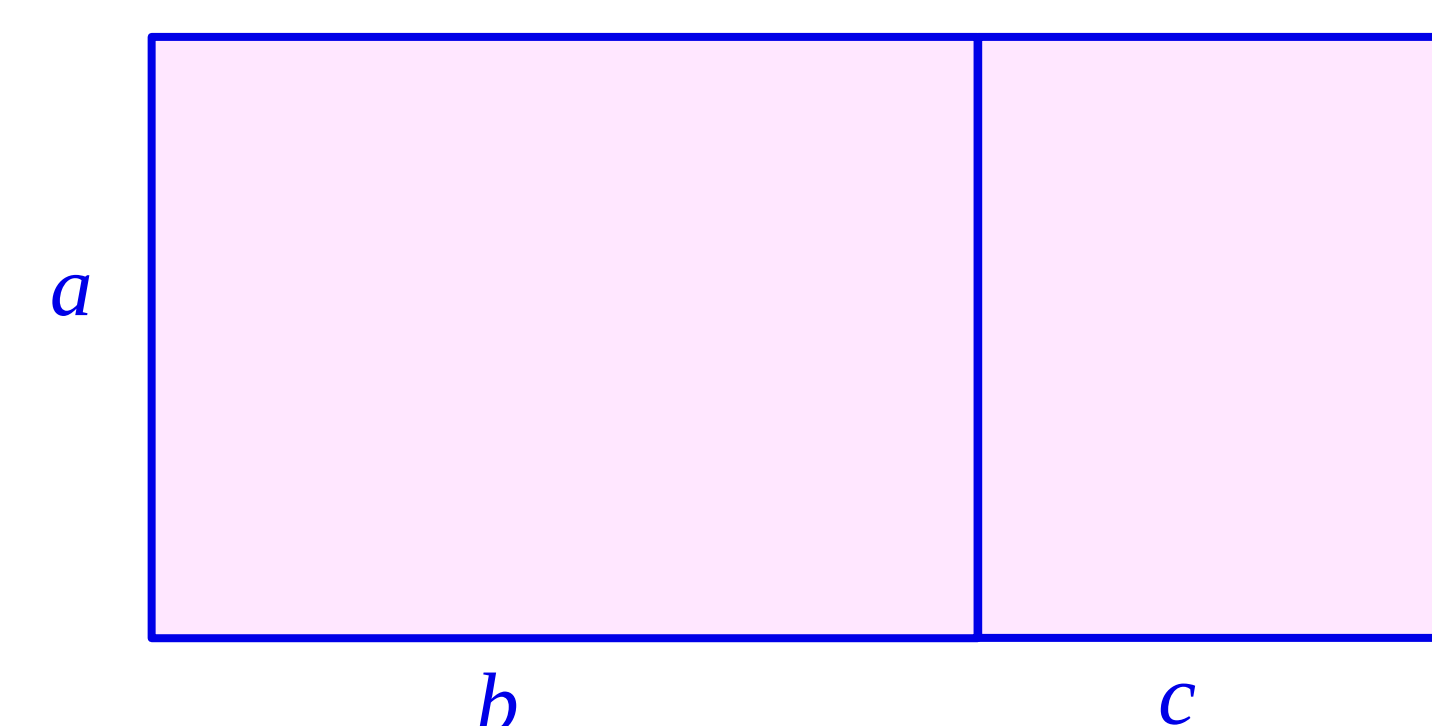
Metacognition describes what people know about their own cognitive processes and how they put that knowledge to use in regulating their cognitive processing and behavior. For learning, the term self-regulated learning is used. In learning, often **different mental models** play a role, for example, in visualisation to support learning of more abstract (numerical or symbolic) skills. An important metacognitive control decision then is whether or not and when to **switch from one mental model to another** one. From a network-oriented modeling perspective, learning is usually described by adaptive mental (or neural) network models. In the current paper, a **second-order adaptive mental network model** is introduced for metacognitive regulation of such multi-mental-model learning processes.

THE ADAPTIVE NETWORK MODEL FOR METACOGNITIVE CONTROL



EXAMPLE SCENARIO

The example task is to show (in the numerical representation) for certain given natural numbers a , b and c that $a*(b + c) = a*b + a*c$. The detour via visualisation considers two rectangles 1 and 2 with vertical dimension a and horizontal dimensions b and c and their areas that are together equal to the area of a rectangle 3 with vertical dimension a and horizontal dimension $b + c$, as shown in the following figure:



X_1	N_1	Base state for number a
X_2	N_2	Base state for number b
X_3	N_3	Base state for number c
X_4	S_{23}	Base state for number $b + c$
X_5	P_{12}	Base state for number $a*b$
X_6	P_{13}	Base state for number $a*c$
X_7	PS_{123}	Base state for number $a*(b + c)$
X_8	SP_{1213}	Base state for number $a*b + a*c$
X_9	RD_{vert}	Vertical dimension of the rectangles
X_{10}	RD_{hor1}	Horizontal dimension of rectangle 1
X_{11}	RD_{hor2}	Horizontal dimension of rectangle 2
X_{12}	RD_{hor3}	Horizontal dimension of rectangle 3
X_{13}	RA_1	Area of rectangle 1
X_{14}	RA_2	Area of rectangle 2
X_{15}	RA_3	Area of rectangle 3
X_{16}	RA_{12}	Area of rectangles 1 and 2 together

X_{17}	W_{p112}	Representation state for the weight of the connection from N_1 to P_{12}
X_{18}	W_{p212}	Representation state for the weight of the connection from N_2 to P_{12}
X_{19}	W_{p113}	Representation state for the weight of the connection from N_1 to P_{13}
X_{20}	W_{p313}	Representation state for the weight of the connection from N_3 to P_{13}
X_{21}	$W_{SP121213}$	Representation state for the weight of the connection from P_{12} to SP_{1213}
X_{22}	$W_{SP131213}$	Representation state for the weight of the connection from P_{13} to SP_{1213}
X_{23}	RW_p	Mental representation state concerning the weights of the connections to P_{12} and P_{13}
X_{24}	RW_{SP}	Mental representation state concerning the weights of the connections to SP_{1213}
X_{25}	WRD_{vert}	Representation state used for execution of control decision $CWRD_{vert}$, representing the weight of the connection from N_1 to RD_{vert}
X_{26}	WRD_{hor1}	Representation state used for execution of control decision $CWRD_{hor1}$, representing the weight of the connection from N_2 to RD_{hor1}
X_{27}	WRD_{hor2}	Representation state used for execution of control decision $CWRD_{hor2}$, representing the weight of the connection from N_3 to RD_{hor2}
X_{28}	RS_{num}	Representation of the self-model for the own numerical skills
X_{29}	RS_{geo}	Representation of the self-model for the own geometric skills
X_{30}	$CWRD_{vert}$	Control state for the switch to the geometric mental model: representation of the weight of the connection from RW_{pSP} to WRD_{vert}
X_{31}	$CWRD_{hor1}$	Control state for the switch to the geometric mental model: representation of the weight of the connection from RW_{pSP} to WRD_{hor1}
X_{32}	$CWRD_{hor2}$	Control state for the switch to the geometric mental model: representation of the weight of the connection from RW_{pSP} to WRD_{hor2}

EXAMPLE SIMULATION

Adaptation and Metacognitive Control

