Integrating verbal and nonverbal communication in a dynamic neural field architecture for human–robot interaction

Estela Bicho¹, Luis Louro¹ and Wolfram Erlhagen²*

¹ Department of Industrial Electronics, University of Minho, Guimarães, Portugal
² Department of Mathematics and Applications, University of Minho, Guimarães, Portugal

Edited by: Angelo Cangelosi, University of Plymouth, UK
Reviewed by: Domenico Parisi, The National Research Council, Italy

*Correspondence: Wolfram Erlhagen, Department of Mathematics and Applications, University of Minho, 4800-058 Guimarães, Portugal. e-mail: wolfram.erlhagen@mct.uminho.pt
Received: 01 December 2009; paper pending published: 29 January 2010; accepted: 27 April 2010; published online: 21 May 2010.
Copyright © 2010 Bicho, Louro and Erlhagen. This is an open-access article subject to an exclusive license agreement between the authors and the Frontiers Research Foundation, which permits unrestricted use, distribution, and reproduction in any medium, provided the original authors and source are credited.

This file contains additional model details regarding:

(i) Inter-field couplings
(ii) Connection scheme for the neural pools in the layered architecture
(iii) Numerical values for the dynamic field parameters
(iv) Numerical values for the inter-field synaptic weights

INTER-FIELD COUPLING
Figure S1 illustrates the coupling between two dynamic fields (DNFs), i.e. how an input to a field $u_i$ arises as the result of activation in a connected field $u_l$. Specifically it depicts how each term in Eq. 4 (i.e. input from connected fields $u_l$ modeled by Gaussian functions) is created.

CONNECTION SCHEME FOR THE NEURAL POOLS IN THE LAYERED ARCHITECTURE
Figure S2 illustrates in more detail (see also Figure 2B) the dynamic control architecture for the flexible mapping of action observation (layer AOL) onto complementary action selection (layer AEL), taking into account inferred goals (layer GL), detected errors (layer AML), contextual information (layer OML) and shared task knowledge (STKL). The goal inference capacity is based on motor simulation (ASL).

As a specific example we present the scheme of layers and corresponding pools of neurons regarding the joint construction of the toy object called L-shape used in the experiments reported in the paper.

The following tables list for the various layers which task-relevant information the different neural populations represent. For layers ASL and AEL this information has been given in the paper.
FIGURE S1 | The figure depicts two connected dynamic fields. For simplicity only one inter-field connection is shown. The activation pattern in field $u_i$ centered at $y_j$ (representing the center of subpopulation $j$) propagates through the inter-field synaptic link $a_{mj}$ to subpopulation $m$ in field $u_i$ and creates a Gaussian input (dashed line) as defined by Eq. 4.

FIGURE S2 | Scheme of layers and corresponding pools of neurons regarding the joint construction of the L-shape. Each ellipse represents a dynamic field and each circle represents a pool of neurons (i.e. a subpopulation). The straight lines represent the synaptic links between different pools in different dynamic fields. To avoid crowding not all connections are shown in the figure.
### Table S1 | Subpopulations in layer AOL.

<table>
<thead>
<tr>
<th>Four DNFs representing hand gestures</th>
<th>Subpopulation 'label'</th>
<th>Meaning: object type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toward objects:</td>
<td>C1</td>
<td>Short slat</td>
</tr>
<tr>
<td>Reaching</td>
<td>C2</td>
<td>Medium slat</td>
</tr>
<tr>
<td>Grasping</td>
<td>C3</td>
<td>Yellow bolt</td>
</tr>
<tr>
<td>Pointing</td>
<td>C4</td>
<td>Orange nut</td>
</tr>
<tr>
<td>Not toward objects:</td>
<td>C5</td>
<td>Other component (not part of the L-shape)</td>
</tr>
<tr>
<td>Hold out gesture</td>
<td>H</td>
<td>Hold out empty hand</td>
</tr>
</tbody>
</table>

### Table S2 | Subpopulations in layer speech.

<table>
<thead>
<tr>
<th>DNF representing speech input</th>
<th>Subpopulation 'label'</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Requesting a component</td>
<td>C1</td>
<td>Short slat</td>
</tr>
<tr>
<td>‘Give me a/the …’</td>
<td>C2</td>
<td>Medium slat</td>
</tr>
<tr>
<td></td>
<td>C3</td>
<td>Yellow bolt</td>
</tr>
<tr>
<td></td>
<td>C4</td>
<td>Orange nut</td>
</tr>
<tr>
<td></td>
<td>C5</td>
<td>Other component (not part of the L-shape)</td>
</tr>
<tr>
<td>‘Yes’</td>
<td>Yes</td>
<td>Affirmative verbal response by the user</td>
</tr>
<tr>
<td>‘No’</td>
<td>No</td>
<td>Negative verbal response by the user</td>
</tr>
</tbody>
</table>

### Table S3 | Subpopulations in layer STKL.

<table>
<thead>
<tr>
<th>Four DNFs representing shared task knowledge</th>
<th>Subpopulation 'label'</th>
<th>Meaning: serial order of subtasks/components</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present subtasks</td>
<td>T1</td>
<td>Use short slat</td>
</tr>
<tr>
<td>Next subtasks (taking into account user’s inferred goal)</td>
<td>T2</td>
<td>Use medium slat</td>
</tr>
<tr>
<td>Past subtasks</td>
<td>T3</td>
<td>Use yellow bolt</td>
</tr>
<tr>
<td>Not yet possible</td>
<td>T4</td>
<td>Use orange nut</td>
</tr>
</tbody>
</table>

### Table S4 | Subpopulations in layer OML.

<table>
<thead>
<tr>
<th>Two DNF representing the distribution of relevant pieces in the two workspaces</th>
<th>Subpopulation 'label'</th>
<th>Meaning: in the workspace there exists a…</th>
</tr>
</thead>
<tbody>
<tr>
<td>Robot’s workspace</td>
<td>C1</td>
<td>Short slat</td>
</tr>
<tr>
<td>Human’s workspace</td>
<td>C2</td>
<td>Medium slat</td>
</tr>
<tr>
<td></td>
<td>C3</td>
<td>Yellow bolt</td>
</tr>
<tr>
<td></td>
<td>C4</td>
<td>Orange nut</td>
</tr>
</tbody>
</table>

### Table S5 | Subpopulations in layer GL.

<table>
<thead>
<tr>
<th>DNF representing</th>
<th>Subpopulation 'label'</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>G1</td>
<td>User wants to use a short slat</td>
</tr>
<tr>
<td></td>
<td>G2</td>
<td>User wants to use a medium slat</td>
</tr>
<tr>
<td></td>
<td>G3</td>
<td>User wants to use a yellow bolt</td>
</tr>
<tr>
<td></td>
<td>G4</td>
<td>User wants to use an orange nut</td>
</tr>
<tr>
<td></td>
<td>G5</td>
<td>User wants to use other type of component (not part of the target object)</td>
</tr>
</tbody>
</table>

### Table S6 | Subpopulations in layer AML.

<table>
<thead>
<tr>
<th>DNF representing</th>
<th>Subpopulation 'label'</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detected conflicts underlying user’s action and/or goal (in this example corresponds essentially to serial errors)</td>
<td>E1</td>
<td>User wants to use a short slat again</td>
</tr>
<tr>
<td></td>
<td>E2</td>
<td>User wants to use a medium slat again</td>
</tr>
<tr>
<td></td>
<td>E3</td>
<td>User wants to use a yellow bolt again</td>
</tr>
<tr>
<td></td>
<td>E4</td>
<td>User wants to use an orange nut again</td>
</tr>
<tr>
<td></td>
<td>E5</td>
<td>User wants to use a short slat but he cannot yet</td>
</tr>
<tr>
<td></td>
<td>E6</td>
<td>User wants to use a medium slat but he cannot yet</td>
</tr>
<tr>
<td></td>
<td>E7</td>
<td>User wants to use a yellow bolt but he cannot yet</td>
</tr>
<tr>
<td></td>
<td>E8</td>
<td>User wants to use an orange nut but he cannot yet</td>
</tr>
<tr>
<td></td>
<td>E9</td>
<td>User wants to use other type of component that is not part of the target object</td>
</tr>
</tbody>
</table>
**NUMERICAL VALUES FOR THE DYNAMIC FIELD PARAMETERS**
Details on the discretization and numerical computation of the dynamic field equation (Eq. 1) may be found in Erlhagen and Bicho (2006). We list in the tables below the parameters used to perform the experiments.

**Layer: ASL**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of pools of neurons, i.e. subpopulations: ( N_{\text{pools}} )</td>
<td>10</td>
</tr>
<tr>
<td>Centers of the subpopulations: ( x_m )</td>
<td>( x_m = (m-1) \times 10, m = 1, \ldots, N_{\text{pools}} ) (in Eq. 4)</td>
</tr>
<tr>
<td>Sampling distance along ( x ): ( dx ) (Eq. 1)</td>
<td>1</td>
</tr>
<tr>
<td>( \tau_i ) (Eq. 1)</td>
<td>5.0 ( \times dt ) (where ( dt ) is the computational cycle)</td>
</tr>
<tr>
<td>( h_i ) (Eq. 2)</td>
<td>(-0.7 \times \max W)</td>
</tr>
<tr>
<td>( A_i ) (Eq. 2)</td>
<td>13.5</td>
</tr>
<tr>
<td>( \sigma_i ) (Eq. 2)</td>
<td>1.5</td>
</tr>
<tr>
<td>( w_{\text{inh}} ) (Eq. 2)</td>
<td>10.5</td>
</tr>
</tbody>
</table>

**Layer: GL**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of pools of neurons: ( N_{\text{pools}} )</td>
<td>5</td>
</tr>
<tr>
<td>Centers of the subpopulations: ( x_m )</td>
<td>( x_m = (m-1) \times 10, m = 1, \ldots, N_{\text{pools}} ) (in Eq. 4)</td>
</tr>
<tr>
<td>Sampling distance along ( x ) ( : dx ) (Eq. 1)</td>
<td>1</td>
</tr>
<tr>
<td>( \tau_i ) (Eq. 1)</td>
<td>5.0 ( \times dt )</td>
</tr>
<tr>
<td>( h_i ) (Eq. 2)</td>
<td>(-1.1 \times \max W)</td>
</tr>
<tr>
<td>( A_i ) (Eq. 2)</td>
<td>6.0</td>
</tr>
<tr>
<td>( \sigma_i ) (Eq. 2)</td>
<td>1.5</td>
</tr>
<tr>
<td>( w_{\text{inh}} ) (Eq. 2)</td>
<td>4.5</td>
</tr>
</tbody>
</table>

**Layer: AML**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of pools of neurons: ( N_{\text{pools}} )</td>
<td>9</td>
</tr>
<tr>
<td>Centers of the subpopulations: ( x_m ) (in Eq. 4)</td>
<td>( x_m = (m-1) \times 10, m = 1, \ldots, N_{\text{pools}} )</td>
</tr>
<tr>
<td>Sampling distance along ( x ): ( dx ) (Eq. 1)</td>
<td>1</td>
</tr>
<tr>
<td>( \tau_i ) (Eq. 1)</td>
<td>5.0 ( \times dt )</td>
</tr>
<tr>
<td>( h_i ) (Eq. 2)</td>
<td>(-2.0 \times \max W)</td>
</tr>
<tr>
<td>( A_i ) (Eq. 2)</td>
<td>6.0</td>
</tr>
<tr>
<td>( \sigma_i ) (Eq. 2)</td>
<td>1.5</td>
</tr>
<tr>
<td>( w_{\text{inh}} ) (Eq. 2)</td>
<td>4.5</td>
</tr>
</tbody>
</table>

**Layer: AEL**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of pools of neurons: ( N_{\text{pools}} )</td>
<td>9</td>
</tr>
<tr>
<td>Centers of the subpopulations: ( x_m ) (in Eq. 4)</td>
<td>( x_m = (m-1) \times 10, m = 1, \ldots, N_{\text{pools}} )</td>
</tr>
</tbody>
</table>

**NUMERICAL VALUES FOR THE INTER-FIELD SYNAPTIC WEIGHTS**
The tables below show the numerical values for the synaptic weights of the connections between neural populations in different layers. Connections not included have weight zero.

### • Synaptic weights from AOL to ASL:

<table>
<thead>
<tr>
<th>DNFs in AOL (\rightarrow) ASL</th>
<th>Synaptic link ( a_{\text{AOL,ASL}} )</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reaching (\rightarrow) ASL</td>
<td>( a_{\text{A1,CL}} )</td>
<td>40</td>
</tr>
<tr>
<td>Grasping (\rightarrow) ASL</td>
<td>( a_{\text{A1,CL}} )</td>
<td>40</td>
</tr>
<tr>
<td>Holding out empty hand (\rightarrow) ASL</td>
<td>( a_{\text{A1,CL}} )</td>
<td>30</td>
</tr>
<tr>
<td>Pointing (\rightarrow) ASL</td>
<td>( a_{\text{A1,CL}} )</td>
<td>40</td>
</tr>
</tbody>
</table>

Frontiers in Neurorobotics www.frontiersin.org May 2010 | Volume 4 | Article 5 | 4
### Synaptic weights from speech layer to ASL:

<table>
<thead>
<tr>
<th>DNF in speech → ASL</th>
<th>Synaptic link $a_{\text{ASL,speech}}$</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speech → ASL</td>
<td>$a_{\text{E1,C1}}$</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>$a_{\text{E2,C2}}$</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>$a_{\text{E3,C3}}$</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>$a_{\text{E4,C4}}$</td>
<td>20</td>
</tr>
</tbody>
</table>

### Synaptic weights from OML to ASL:

<table>
<thead>
<tr>
<th>DNFs in OML → ASL</th>
<th>Synaptic link $a_{\text{ASL,OML}}$</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>OML – Robot Workspace → ASL</td>
<td>$a_{\text{E1,T1}}$</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>$a_{\text{E2,T2}}$</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>$a_{\text{E3,T3}}$</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>$a_{\text{E4,T4}}$</td>
<td>20</td>
</tr>
<tr>
<td>OML – Human Workspace → ASL</td>
<td>$a_{\text{E5,T1}}$</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>$a_{\text{E6,T2}}$</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>$a_{\text{E7,T3}}$</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>$a_{\text{E8,T4}}$</td>
<td>20</td>
</tr>
</tbody>
</table>

### Synaptic weights from STKL to present to ASL:

<table>
<thead>
<tr>
<th>DNF in STKL → ASL</th>
<th>Synaptic link $a_{\text{ASL,STKL,present}}$</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>STKL present → ASL</td>
<td>$a_{\text{E1,STKL}}$</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>$a_{\text{E2,STKL}}$</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>$a_{\text{E3,STKL}}$</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>$a_{\text{E4,STKL}}$</td>
<td>20</td>
</tr>
</tbody>
</table>

### Synaptic weights from STKL to ASL:

<table>
<thead>
<tr>
<th>DNF in ASL → GL</th>
<th>Synaptic link $a_{\text{ASL,GL}}$</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASL → GL</td>
<td>$a_{\text{E1,ASL}}$</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>$a_{\text{E2,ASL}}$</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>$a_{\text{E3,ASL}}$</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>$a_{\text{E4,ASL}}$</td>
<td>20</td>
</tr>
</tbody>
</table>

### Synaptic weights from OML to ASL:

<table>
<thead>
<tr>
<th>DNFs in OML → ASL</th>
<th>Synaptic link $a_{\text{ASL,OML}}$</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>OML – Robot Workspace → ASL</td>
<td>$a_{\text{E1,ASL}}$</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>$a_{\text{E2,ASL}}$</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>$a_{\text{E3,ASL}}$</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>$a_{\text{E4,ASL}}$</td>
<td>30</td>
</tr>
</tbody>
</table>

### Synaptic weights from OML to AEL:

<table>
<thead>
<tr>
<th>DNFs in OML → AEL</th>
<th>Synaptic link $a_{\text{AEL,OML}}$</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>OML – Robot Workspace → AEL</td>
<td>$a_{\text{E1,AEL}}$</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>$a_{\text{E2,AEL}}$</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>$a_{\text{E3,AEL}}$</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>$a_{\text{E4,AEL}}$</td>
<td>30</td>
</tr>
</tbody>
</table>
• Synaptic weights from STKL to AEL:

<table>
<thead>
<tr>
<th>DNFs in STKL → AEL</th>
<th>Synaptic link $a_{AEL,STKL}$</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>STKL present → AEL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$a_{A1,T1}$</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>$a_{A2,T1}$</td>
<td></td>
<td>-10</td>
</tr>
<tr>
<td>$a_{A3,T1}$</td>
<td></td>
<td>-10</td>
</tr>
<tr>
<td>$a_{A4,T1}$</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>$a_{A2,T2}$</td>
<td></td>
<td>-10</td>
</tr>
<tr>
<td>$a_{A4,T2}$</td>
<td></td>
<td>-10</td>
</tr>
<tr>
<td>$a_{A1,T3}$</td>
<td></td>
<td>-10</td>
</tr>
<tr>
<td>$a_{A2,T3}$</td>
<td></td>
<td>-10</td>
</tr>
<tr>
<td>$a_{A3,T3}$</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>$a_{A1,T4}$</td>
<td></td>
<td>-10</td>
</tr>
<tr>
<td>$a_{A2,T4}$</td>
<td></td>
<td>-10</td>
</tr>
<tr>
<td>$a_{A3,T4}$</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>$a_{A1,T5}$</td>
<td></td>
<td>-10</td>
</tr>
<tr>
<td>$a_{A2,T5}$</td>
<td></td>
<td>-10</td>
</tr>
<tr>
<td>$a_{A3,T5}$</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>$a_{A7,T1}$</td>
<td></td>
<td>-10</td>
</tr>
<tr>
<td>$a_{A8,T1}$</td>
<td></td>
<td>-10</td>
</tr>
<tr>
<td>$a_{A1,T2}$</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>$a_{A2,T2}$</td>
<td></td>
<td>-10</td>
</tr>
<tr>
<td>$a_{A3,T2}$</td>
<td></td>
<td>-10</td>
</tr>
<tr>
<td>$a_{A4,T2}$</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>$a_{A1,T6}$</td>
<td></td>
<td>-10</td>
</tr>
<tr>
<td>$a_{A2,T6}$</td>
<td></td>
<td>-10</td>
</tr>
<tr>
<td>$a_{A3,T6}$</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>$a_{A1,T7}$</td>
<td></td>
<td>-10</td>
</tr>
<tr>
<td>$a_{A2,T7}$</td>
<td></td>
<td>-10</td>
</tr>
<tr>
<td>$a_{A3,T7}$</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>$a_{A1,T8}$</td>
<td></td>
<td>-10</td>
</tr>
<tr>
<td>$a_{A2,T8}$</td>
<td></td>
<td>-10</td>
</tr>
<tr>
<td>$a_{A3,T8}$</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>$a_{A1,T9}$</td>
<td></td>
<td>-10</td>
</tr>
<tr>
<td>$a_{A2,T9}$</td>
<td></td>
<td>-10</td>
</tr>
<tr>
<td>$a_{A3,T9}$</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>STKL next → AEL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$a_{A1,T1}$</td>
<td></td>
<td>40</td>
</tr>
<tr>
<td>$a_{A2,T2}$</td>
<td></td>
<td>40</td>
</tr>
<tr>
<td>$a_{A3,T3}$</td>
<td></td>
<td>40</td>
</tr>
<tr>
<td>$a_{A4,T4}$</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>$a_{A5,T1}$</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>$a_{A6,T2}$</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>$a_{A7,T3}$</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>$a_{A8,T4}$</td>
<td></td>
<td>20</td>
</tr>
</tbody>
</table>

• Synaptic weights from AML to AEL:

<table>
<thead>
<tr>
<th>DNF in AML → AEL</th>
<th>Synaptic link $a_{AEL,AML}$</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$a_{A1,E1}$</td>
<td>-35</td>
</tr>
<tr>
<td></td>
<td>$a_{A2,E1}$</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>$a_{A3,E1}$</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>$a_{A4,E1}$</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>$a_{A5,E1}$</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>$a_{A6,E1}$</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>$a_{A7,E1}$</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>$a_{A8,E1}$</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>$a_{A1,E2}$</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>$a_{A2,E2}$</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>$a_{A3,E2}$</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>$a_{A4,E2}$</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>$a_{A5,E2}$</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>$a_{A6,E2}$</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>$a_{A7,E2}$</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>$a_{A8,E2}$</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>$a_{A1,E3}$</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>$a_{A2,E3}$</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>$a_{A3,E3}$</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>$a_{A4,E3}$</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>$a_{A5,E3}$</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>$a_{A6,E3}$</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>$a_{A7,E3}$</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>$a_{A8,E3}$</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>$a_{A1,E4}$</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>$a_{A2,E4}$</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>$a_{A3,E4}$</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>$a_{A4,E4}$</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>$a_{A5,E4}$</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>$a_{A6,E4}$</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>$a_{A7,E4}$</td>
<td>20</td>
</tr>
</tbody>
</table>

**REFERENCE**