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Blending in action: Diagrams reveal conceptual integration in routine activity

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1 Introduction

Picture a first-time participant in a "brainwave" study. He is seated in the recording room, the experimenter shows him his brainwaves, and then leaves the room. The student watches his EEG with fascination until abruptly all the lines on the screen go flat. Does this mean his brain stopped working? His confidence only returns when the experimenter reassures him that she blocked the transmission of his brainwaves onto the screen.

Why was the student afraid of being brain dead? The student did not distinguish between his brain activity and the lines on the computer screen. He treated brain activity and lines on the screen as one unique thing, and thus inferred that flat lines must mean no brain activity. Conceptual integration, or blending, is a framework for the analysis of phenomena such as this, where information from two separate domains is brought together and integrated, producing emergent structure and generating new insight (Coulson & Oakley, 2000; Fauconnier & Turner, 2002).

In the present paper, I will discuss conceptual integration processes in everyday activity. The examples come from a routine activity in a cognitive neuroscience laboratory, preparing a participant for the recording of his EEG. The experimenter needs to work with several artifacts, such as an electrode cap and an impedance meter. The coordination of these artifacts is made easier by particular diagrams and charts located throughout the lab. My central claim is that activity and conceptual integration mutually influence each other. On the one hand, the intensity and extent of interaction with and coordination between artifacts finds a reflection in the extent of integration between the two domains. Activity gives rise to blends. On the other, the integration of domains may lead to action that would not have been performed in either of the original domains. Blending gives rise to activity.

2 Background: The Capping Process

In order to understand the discussion that follows, a short and partial overview of the artifacts used and actions taken during the process of preparing a participant for the recording of the EEG is needed. Two caveats up front: First, this description is not intended as an accurate description of technical details or guidelines for the recording of the EEG. Technical descriptions, if included, are often simplified. They aim to provide insight on the more informal understanding that an experimenter might draw upon during the setup process. Second, the artifacts and processes may not be the same in all labs using the methodology.

Figure 1: Electrode Cap with Quick Inserts

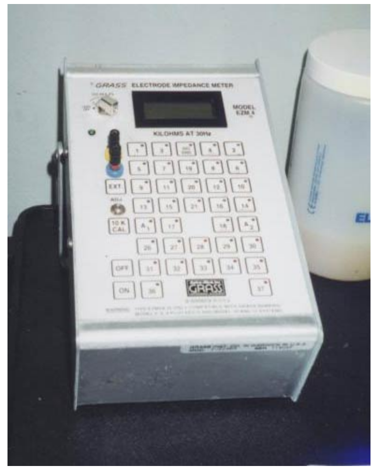


Figure 2: Impedance Meter

This includes, among others, the diagrams and charts in the lab as well as the number and location of the electrodes on the cap. This paper is not intended to make any general claims about the recording of the EEG. Instead, it aims to show that blending and activity can interact in routine activities.

Preparing a participant for an experiment is usually referred to as *capping*, because the main task is putting an electrode cap onto the head of the participant. The *electrode cap* (Figure 1) is a cap with several electrodes that are spatially arranged in a special configuration. It resembles a tight-fitting swimming cap with chinstraps and little cylinders containing the electrodes. The electrodes, which are arranged on the cap in a geometric pattern resembling four concentric circles, are placed within white plastic cylinders. Each cylinder has a small whole in the middle that will be filled with conducting gel in preparation for the experiment. The wires of the electrodes are threaded through the cap, and combined in two flat band cables. Each cable combines half the electrodes of the cap.

The *impedance meter* (Figure 2) is used for checking the impedance of the electrodes. It resembles a bulky pocket calculator. It has about 40 buttons, which correspond to individual electrodes in the cap. A panel near the top of the box displays the impedance at the electrode when the corresponding button is pressed.

The *numbered layout* (Figure 3) is a diagram that maps the correspondence between the electrodes and the impedance meter. The diagram is a schematic top-view drawing of am electrode cap as it sits on the head. The nose and the ears are sketched on the top and the left and right sides, respectively. The diagram contains four concentric circles, mirroring the layout of the electrodes on the cap. The electrode locations are noted as little circles embedded in the concentric circles at the appropriate location. Each circle contains the number of the corresponding button on the impedance meter.

Recording good data requires that the impedances of the electrodes are below a certain threshold. *Lowering impedances* is one of the main tasks during the capping procedure. Three routine steps for lowering the impedance of an electrode are *moving the hair* below an electrode to the side, *squirting conductance gel* into the electrode with a syringe, and gently *scratching* the skin below the electrode with a sharp needle. The *impedances* are *checked* using the impedance meter. If the impedance (displayed on the panel of the impedance meter) is above threshold, the standard procedure is to continue scratching the skin below the electrode and/or to apply more gel to the electrode. Sometimes, however, an electrode

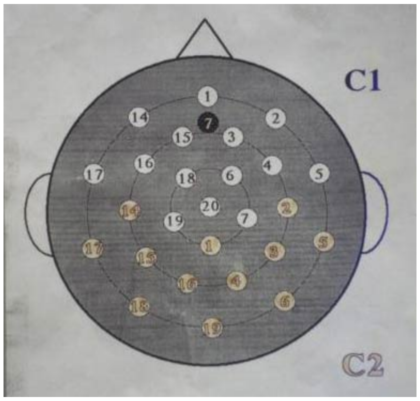


Figure 3: Numbered Layout

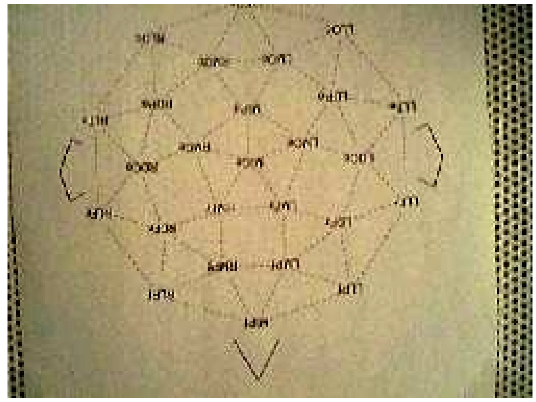


Figure 4: Labeled Layout

may be faulty, rendering it impossible to lower the impedance below threshold. In this situation, a *quick insert* is used, which overrides the cap electrode. The quick insert is inserted in the cylinder containing the electrode. It is usually fastened to the cap with a strip of tape. Figure 1 features a quick insert in one of the electrodes.

Capping is done in a small room adjacent to the recording chamber in which the experiment itself is conducted. The participant, wearing the electrode cap, sits on a chair. The numbered layout is taped to one of the walls. The impedance meter is easily portable, thus does not have a standard location. The process of reducing all impedances below threshold takes half an hour or longer. During this time, the electrodes on the cap and the impedance meter need to be constantly coordinated. The numbered layout displays the (nontrivial) correspondences between the impedance meter buttons and the electrode locations.

After all impedances are below threshold, the electrodes need to be connected to the EEG recording equipment. This takes place in the recording room itself, where the participant is seated in a comfortable chair, facing a computer monitor. Again, several different artifacts and diagrams are used in the process.

The *labeled layout* (Figure 4) is a diagram similar to the numbered layout. Instead of numbers, it gives names for the individual electrodes. The names are associated with the electrodes throughout the preparation and later the data analysis process. The electrode labels roughly correspond to the parts of the brain over which the electrode is located. For instance, the electrode placed over the left outer part of the prefrontal lobe is called LLPF, short for left lateral prefrontal.

The *connector boxes* (Figure 5) are two square boxes, located in the back of the recording room. Each connector box contains plugs in a rectangular grid pattern. Each connector has a number, and a wire sticking out of it. Connectors on a box can be uniquely identified either by their number or by the unique wire color/connector color combination. The wires from each connector box are combined in a flat-band cable. For the EEG recording, these cables are connected with the cables from the cap.

The chart labeled *connectors for cap/quick inserts* (Figure 6) is used to cross-reference the connector boxes and the cap electrodes. This mapping is needed whenever a quick insert is used. The electrodes are labeled according to their names described in the labeled layout. If there is a quick insert in one of the electrodes, the connection of the cap electrode to the connector box needs to be replaced by the wire coming from the quick insert. The cross-reference table gives the connector number corresponding to the electrode label.

The labeled layout, the connector box, and the connectors for cap/quick inserts chart are

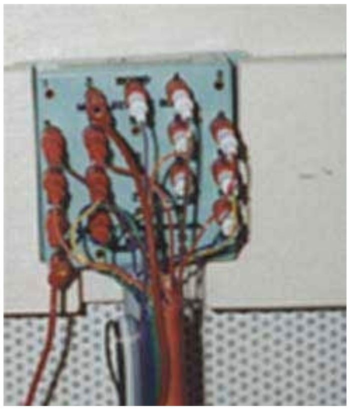
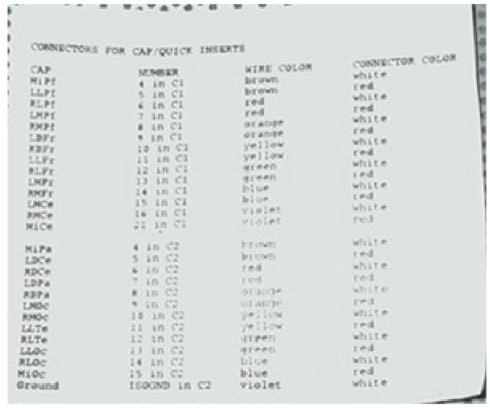


Figure 5: Connector Box



CONNECTORS FOR CAP/QUICK INSERTS

CAP	NUMBER	WIRE COLOR	CONNECTOR COLOR
MiPf	4 in C1	brown	white
LLPf	5 in C1	brown	red
RLPf	6 in C1	red	white
LMPf	7 in C1	red	red
RMPf	8 in C1	orange	white
LDFr	9 in C1	orange	red
RDFr	10 in C1	yellow	white
LLFr	11 in C1	yellow	red
RLFr	12 in C1	green	white
LMFr	13 in C1	green	red
RMFr	14 in C1	blue	white
LMCe	15 in C1	blue	red
RMCe	16 in C1	violet	white
MiCe	21 in C1	violet	red
MiPa	4 in C2	brown	white
LDCe	5 in C2	brown	red
RDCe	6 in C2	red	white
LDPa	7 in C2	red	red
RDPa	8 in C2	orange	white
LMOc	9 in C2	orange	red
RMOc	10 in C2	yellow	white
LLTe	11 in C2	yellow	red
RLTe	12 in C2	green	white
LLOc	13 in C2	green	red
RLOc	14 in C2	blue	white
MiOc	15 in C2	blue	red
Ground	ISOGND in C2	violet	white

Figure 6: Connectors for Cap/Quick Inserts

Figure 7: Brainwaves. Resetting MiPF.

mounted onto the wall behind the participant's seat in the recording chamber. The labeled layout is taped to the wall above the head of the participant. The upside down orientation of the labeled layout helps identify electrodes at a glance: this way, the right side of the participant corresponds with the electrodes labeled right in the diagram.

After the scalp electrodes are connected to the recording equipment, the EEG needs to be processed, displayed and recorded on a computer. These preparation processes are invisible to the participant: the amplifiers and computers are located in the room adjacent to the recording chamber. The experimenter can chose to display the EEG on the computer screen which the participant is facing.

The *amplifier* is part of the transmission of brain activity onto the computer screen. Brain activity is measured as voltage changes over time. Each *channel* corresponds to the voltage difference between one of the electrodes and a reference electrode, and this difference is eventually displayed on the screen. The amplifier contains a *reset button* for each channel, which prohibits the signal from passing through the amplifier.

A *computer screen* (Figure 7) is used to monitor the EEG during the recording period. On the screen, each channel is labeled with the name of the electrode whose signal it represents. The EEG itself is represented as wiggly lines on the screen. Pressing the reset button on the amplifier flattens the line on the screen. Figure 7 shows this for the electrode labeled MiPF.

3 Conceptual Blending: The Brainwaves Blend

Conceptual integration (or conceptual blending) is a framework for the analysis of higher cognitive phenomena, in which selected parts of two or more conceptual domains are brought together and combined ("blended"), producing emergent structure and allowing insight that is not contained in either of the original domains. Conceptual blends can be represented with conceptual integration networks. These networks contain two or more input spaces representing the different conceptual domains. Corresponding elements in the input spaces are connected via *cross-space mappings*. The blended space represents the integration of these spaces. Finally, the generic space contains structure that is shared among the input spaces and the blend.

I will use the Brainwaves blend as a case study of the blending process. First, I will discuss the Brain Electrodes blend, which serves as one of the input spaces for the Brainwaves blend. Next, the Brainwaves blend proper. Third, I will show how this blend can give rise to actions that are not meaningful in either of the input spaces alone.

The Brain Electrodes blend captures the idea that scalp electrodes register brain activity. The *input spaces* in the Brain Electrodes blend are the Brain and the Electrode Cap. The conceptual domain Brain provides elements such as the location of neural tissue, the activity of cortical neurons, and the changes in the electromagnetic fields that are caused by neuronal activity. The Electrode Cap provides elements such as the spatial layout of the electrodes in the cap (and thus on the scalp), and the signal that the electrodes record. The Brain and the Electrode Cap are related on many levels. For instance, the electrodes are placed on the scalp above certain standardized locations in the brain. Further, the signal that the scalp electrodes register is partially caused by the activity of cortical neurons. The correspondences between these domains are realized as cross-space mappings in a conceptual integration network. For instance, brain activity and the signal reading at the electrode are linked by a cause-and-effect cross-space mapping. The conceptual integration network for the Brain Electrodes blend is depicted in Figure 8. The two input spaces to this blend, Brain and Electrode Cap, are represented as circles. The cross-space mappings between the elements in these two domains are represented by lines, connecting the elements. Of course, there are elements in each input space that do not have a correspondence in the other input space: the colored fabric and the chinstrap of the Electrode Cap does not correspond to anything in the Brain input.

The *blended space* represents the integration of the Brain with the Electrode Cap. In the blend we can say that the electrodes register brain activity. The signal at the electrodes is identified with brain activity. Thus, neuronal activity and the readings at the electrodes, which were linked by a cross-space mapping in the input spaces, are *compressed into uniqueness* in the blend. That means that there is no distinction between brain activity and the signal at the electrode. Further, in the blend the electrodes are located above certain brain areas. The electrodes are not seen as placed on the forehead or over the back of the head, but as placed above the frontal or the occipital lobe. The blended space is depicted as the bottom circle in the conceptual integration network (Figure 8). The lines between the input spaces and the blended space represent selective projections from each of the input spaces into the blended space. Both the compression of neural activity and electrode recording and the correspondence between electrode location and neural tissue are marked in the blended space.

The final element of a conceptual integration network is the *generic space*, which captures commonality between the input spaces. In the Brain Electrodes blend, the structure common to both input domains, Brain and Electrode Cap, is the existence of an event, the neuronal activity or the electromagnetic signal, at a specific location, the neural tissue or the electrode location. In the network, the generic space is represented by the top circle.

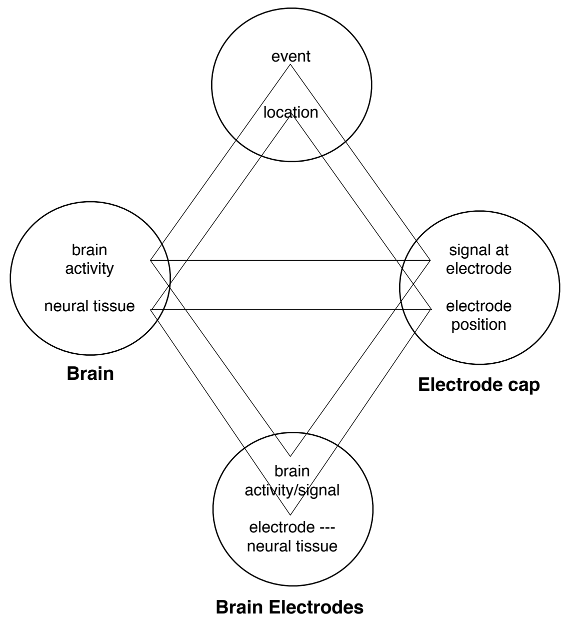


Figure 8: Brain Electrodes Blend

The generic space contains the elements and structures common to the input spaces, and therefore represents the most general underlying structures. As this general knowledge is not essential to any of the analyses below, I have omitted the generic space from my diagrams.

The Brain Electrodes blend is crystallized in the labeled layout (Figure 4). The diagram places labels, such as “LLPF” for left lateral prefrontal cortex, in a grid of concentric circles representing the positions of the electrodes on the cap. The two domains Electrode Cap and Brain are spatially superimposed, and thus spatially integrated. The labeled layout provides a stable, external representation of the correspondences between the electrode locations and the underlying brain areas. It serves as a *material anchor* (Hutchins, 2002), which is a physical object with spatial structure that brings stability into a blend.

The Brainwaves blend (Figure 9) captures the identification of the ups and downs of lines on a computer screen with the brain activity that is measured by the electrodes. The inputs in this blend are the Brain Electrodes, which register brain activity above specified parts of the brain, and the Screen, which features “wiggly” lines with labels. Changes in brain activity correspond to patterns of ups and downs of the line; the placement of the electrode (above a certain area of the brain) corresponds to the label to the left of the line. In the blended space, the inputs Brain Electrodes and Screen are combined. The patterns on the screen and the brain activity recorded by the scalp electrodes are compressed into uniqueness; we see the Brainwaves on the computer screen.

Consider the participant who was afraid of being brain dead when he saw his “brainwaves” go flat on the screen. Neither lines on a computer screen nor voltage changes by themselves could have triggered this reaction. Only in the Brainwaves blend, where the lines on the screen are identical to and inseparable from the activity of his brain, does this reaction occur. The student used the blend for an unpleasant, but creative inference that is not suggested by either of the input domains alone.

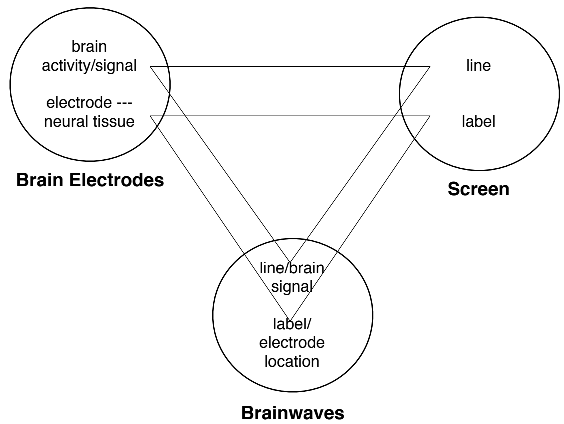


Figure 9: Brainwaves Blend

Emergent behavior that is not meaningful outside the Brainwaves blend can be observed with the experimenter, too, who has a much more sophisticated understanding of the concepts, for instance when dealing with electrode drift. Drift is a problem with registering the brain activity during the recording of the EEG. The problem originates directly at the electrodes. On the computer screen, drift is easily detectable. The lines on the screen, which are usually centered around a zero mark, quickly drift back and forth from the top to the bottom of the window and lose their zero-centering. Pressing the reset button on the amplifier flattens the lines on the screen: while the button is pressed, the line rests at zero. I have observed experimenters repeatedly pressing the reset button when they observe drift, in order to solve this problem.

Can pressing the reset button remove electrode drift? The problem occurs at the electrode, not on the screen. Recall that brain activity is transmitted in a unidirectional manner from the electrodes onto the screen. The signal is registered at the electrodes, changed and enlarged in the amplifier, and then displayed on the screen. Actions taken at later stages in this signal transmission can't change the signal at earlier stages. Pressing the reset button on the amplifier flattens the corresponding line on the computer screen, but it does not influence the way in which brain activity is registered at the electrodes. The reset button can not remove the conditions leading to drift, and thus is not a solution for the problem.

Why then does an experimenter press the reset button, if it does not solve the problem? Recall the Brainwaves blend: The key element in this blend was that the computer screen displays brain activity. Thus looking at the screen means looking at the brain activity, and looking at whatever the electrodes register. No distinction is made between the represented and the representation, they are compressed into uniqueness. Resetting a drifting electrode is emergent behavior arising from this compression. Resetting the channel zero-centers and flattens the line; the problem temporarily disappears. The compression of the line and the signal at the electrode leads to the inference that whatever causes the desired change to the line, causes the same change to the electrode.

In the following analysis (see Figure 10), the Amplifier is added as a new input domain to the Brainwaves blend. The channel numbers on the amplifier, the electrodes and their labels correspond to each other. The status of the reset button is a bit more complicated. Pressing the reset button interrupts the transfer of the electrode signal onto the screen. The screen then no longer displays brain activity, but rather a flat, zero-centered line. Pressing the reset button thus causes a change in the line. This causal relationship is captured in a

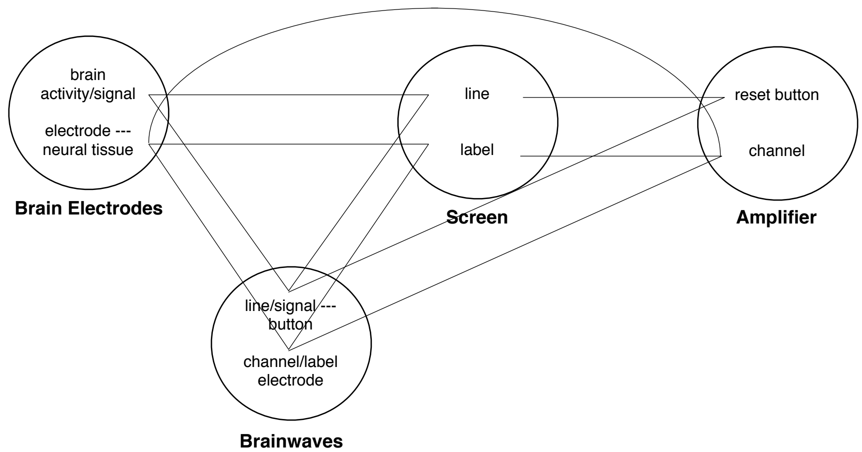


Figure 10: Backwards Causality

cause-effect cross space mapping. Note that the reset button is not connected to the signal at the electrode: reset button and brain signal don't influence each other. In the blended space, the electrode, its label and the amplifier channel are not distinguished: they are compressed into uniqueness. The electrode signal and the line on the screen are integrated in the same way: they are compressed into uniqueness. The reset button and its power to change the line on the screen are projected into the blended space. But note that in the blend the line on the screen is compressed into uniqueness with the brain activity measured at the electrode. The reset button causes a change with the line, but the line is not only a line: it is the measurement of brain activity at the electrode. Only in the blend does the reset button have an effect on the signal at the electrode: only in the blend can it be used to make the signal better. In the input spaces, the reset button does not and can not have this influence. It is at a much later stage in the unidirectional signal transmission process than the electrode itself.

The conceptual integration network is displayed in Figure 10. The input domains Brain Electrodes and Screen are the same as in the Brainwaves blend, the Amplifier is a third input domain. The electrode labels (in the Brain Electrodes and the Screen inputs) and the corresponding channel number on the amplifier are linked via cross-space mappings, indicating that they represent each other. Labels and channel numbers are projected into the blended space. They are compressed into uniqueness. As discussed in the Brainwaves blend, the signal at the electrode and its representation on the screen are linked by cross-space mappings and compressed into uniqueness in the blend. The line on the Screen and the reset button on the Amplifier are connected by a cause-and-effect relation. Pressing the reset button causes the line on the screen go flat. This relationship is projected into the blend: the line and the reset button in the blend are still causally linked. Note that the line on the screen and the signal from the electrode are compressed into uniqueness in the blend. There is no distinction between the electrode signal and its representation on the screen. Thus, the reset button is not only causally linked to the line, it is causally linked to the electrode signal which is the line on the screen.

I call this scenario *backwards causality*, because an action that can cause changes later in the signal transmission chain is taken to cause changes earlier in the signal transmission. Within the blend, the causal chain runs backwards.

4 Two Activities: Checking Impedances vs Quick Inserts

In this section, I discuss two of the diagrams that are used during the capping process. The diagrams are used to coordinate between artifacts with close to identical structure. In both cases, each electrode on the cap corresponds to a number on another artifact, the impedance meter or the connector box, arranged in a rectangular grid. The diagrams make these correspondences explicit. In contrast to their almost identical input structure, the diagrams look very different. I argue that the diagrams differ in the amount of integration between the input domains, and that the amount of interaction with the diagrams determines the extent of integration.

4.1 Checking Impedances

Recall that a major part of the capping process is the application of the electrode cap. All electrodes need to be prepared individually by lowering the impedance below the specified threshold. Pressing a numbered button on the impedance meter (Figure 2) displays the impedance for the corresponding electrode. A reading above threshold prompts the experimenter into a cycle of lowering the impedance at the electrode and checking the impedance at the impedance meter, with the purpose of bringing the impedance below threshold. Obviously, pressing the correct button is crucial, otherwise the experimenter's attempts at lowering the impedance will show no effect on the impedance meter. The numbered layout (Figure 3) displays the numbers of the impedance meter buttons at the locations of the electrodes, and serves as a mediating representation for the coordination between the cap and the impedance meter. It is frequently consulted during the capping process, both to look up the number corresponding to the electrode that was just worked on, and to make sure that the impedance meter number corresponds to the electrode that is being tested. Thus, an integral part of the capping process is the frequent coordination between cap electrodes and the impedance meter, and the numbered layout provides an integrated representation that allows the coordination of the electrodes on the cap and the buttons on the impedance meter.

The conceptual integration network with the input domains Electrode Cap and Impedance Meter is presented in Figure 11. The Electrode Cap provides the electrodes in a specific spatial arrangement. The Impedance Meter features numbered buttons in a different spatial arrangement. Electrodes and numbers are connected by a cross-space mapping. The two different spatial arrangements are not connected by a cross-space mapping, as they don't correspond to each other in any meaningful way. In contrast to the numbers and electrodes, which are both projected into the blend, only the spatial arrangement of the Electrode Cap is projected. The Electrode Cap and Impedance Meter domains are integrated by superimposing the numbers on the electrode positions in a diagram that preserves the topology of the arrangement of the electrodes in the cap.

The numbered layout serves as a material anchor for the blend of the Electrode Cap and the Impedance Meter. It is an external representation that gives stability to correspondences that can not be kept in memory without extensive training. The input domains are integrated in this representation: the button numbers from the Impedance Meter input are written into the circles representing the electrodes from the Electrode Cap, and are arranged within the layout of the cap.

4.2 Quick Inserts

The cap electrodes need to be connected to the amplifiers. This is normally accomplished by connecting the flat band cables of the cap with their corresponding counterparts in the connector boxes. However, when a quick insert was used to override a non-functional

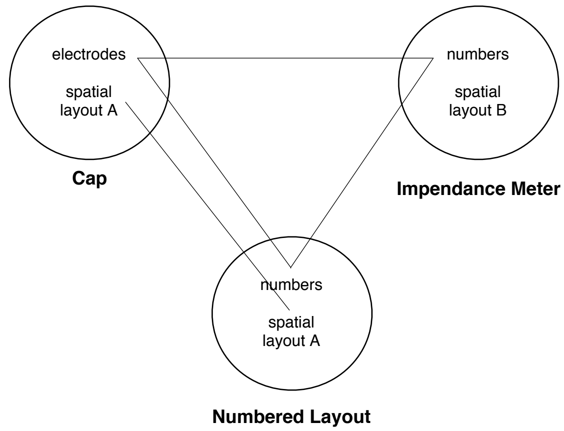


Figure 11: Checking Impedances

electrode, the experimenter needs to unplug the default connection from the flat band cable and replace it with the quick insert. The first two columns of the chart labeled “connectors for cap/ quick inserts” (Figure 6) gives the necessary information: the first column, labeled “CAP”, lists the electrode names, the second column, labeled “NUMBER”, refers to the corresponding number in the connector box (Figure 5). In order to replace the wire, the experimenter needs to look up the name of the electrode (using the labeled layout, Figure 4), find the label and the corresponding number in the chart, and then replace the electrode’s wire with the quick insert. The use of quick inserts during capping is an exception, so this task is only rarely performed.

The chart “connectors for cap/ quick inserts” combines information from two separate domains, the Electrode Cap and the Connector Box. The Electrode Cap is represented by the the electrode labels given in the labeled layout. The cap and the labeled layout both feature (labeled) electrodes in the same spatial layout. The connector box features numbers which are arranged in a square grid pattern on the connector box, and correspond to individual wires. The electrodes and the numbers on the connector box are connected via a cross-space mapping: the numbers stand for the wires which are connected to electrodes on the cap.

Unlike the numbered layout, the chart does not seem to reflect an integration of the two input domains. Neither of the input spaces provide their spatial layout for the chart. Instead, the correspondences of electrode labels and connector numbers are arranged in order of increasing number of the connection (column 2). Ordering a list in increasing order is a common ordering strategy, but this order is not particular to either of the inputs. Further, the information from the two domains is listed side by side in separate columns, not superimposed over each other. The chart thus represents the mapping between the labels and the numbers, not a blend between the domains. Figure 12 gives a schematic representation of the coordination of the input domains. The electrode labels correspond to the numbers in the connector box, and are thus linked by a cross space mapping. Labels and numbers are both part of the “connectors for cap/ quick inserts” chart, and thus projected, but neither of the spatial layouts is projected. The chart is represented as a rectangle instead of a circle, as a visual reminder that the two domains are not integrated.

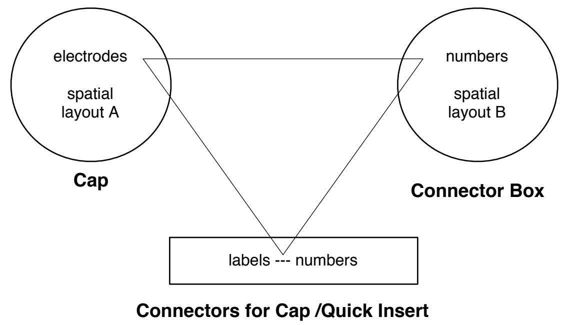


Figure 12: Quick Inserts

5 Discussion: The Relationship of Blending and Action

I presented several examples suggesting that conceptual blends play a role in everyday activity. Blends can trigger actions that are not meaningful in the input spaces alone. Backwards causality in the Brainwaves blend is the prime example: Actions later in a causal chain are taken to have an effect on events earlier in the causal chain. Since brain activity and its representation on the computer screen are compressed into uniqueness in the Brainwaves blend, actions that change the representation are taken to have an effect on the represented, the brain activity recording.

Backwards causality in the Brainwaves blend arises from the interplay of two principles of conceptual blending: topology and compression (Fauconnier & Turner, 2002). Preservation of topology of the input space mappings occurs when the cause-and-effect link between the reset button of the amplifier and the line on the screen is preserved in the blend: Pressing the button causes the line to go flat. Compression of cross-space mappings occurs when the electrode recording and the line on the screen are compressed into uniqueness in the blend: The line is the recording of brain activity. In conjunction, compression and preservation of topology introduce the novel cause-and-effect link between the electrode signal and the reset button into the blend: Only in the blend does the pressing of the reset button cause a change in the recording at the electrode. This novel cause-and-effect link is inconsequential in the input spaces. An interesting question is how expertise and training can change the interplay of the topology and compression principles in the conceptual government of activity.

Conceptual integration can guide activity, but, similarly, activity can determine the extent of the integration between two domains. Checking Impedances and plugging in Quick Inserts require the same sort of coordination: The electrodes on the cap need to be cross-referenced with an arbitrary set of numbers. The lab provides conversion charts for both. In the Checking Impedances example, the conversion chart displays the two domains in highly integrated form; this chart constitutes a material anchor for a blend between the two input domains. In the Quick Inserts example, the conversion chart shows no evidence of integration, and does not serve as a material anchor for a blend between the domains. Why are the domains integrated in one case but not the other?

The two examples strongly differ in the importance they have during the activity. The impedance meter is used constantly for at least 20 minutes. The numbered layout needs to allow cross-reference in both directions: from the cap to the impedance meter, and from the meter back to the cap. Presenting the numbers in the same spatial arrangement as the electrodes allows the identification of impedance meter button numbers in just a glance. The frequent use of the numbered layout makes its integrated form necessary for efficient capping.

In contrast, the connector boxes are used for only a short period of time, and they do not provide an output that is used in further action. The interaction with the connector box is usually unidirectional from the cap to the box: quick insert wires need to be plugged into the box. The opposite is conceivable: for instance, to double-check if the quick inserts are placed in the correct position, one might read the number on the connector box with the quick insert wire, look up the corresponding electrode, and check whether the quick insert is located in that electrode. It is an empirical question whether and with which frequency this occurs. In the normal case of events the interaction with the connector box and the "connectors for cap/ quick inserts" is so restricted that an integration of the two domains, Connectors and Cap, would not make the overall process any more efficient. In this situation, an integration is not needed.

Differences in activity and in the extent of interaction with artifacts can thus lead to completely different combination of identical input structures. Extensive interaction leads to strong integration, minimal interaction to minimal integration. Blends are thus tied in tightly with the activity in the lab.

In conclusion, blends can give rise to actions that are not meaningful when considered in separate input spaces alone. Blending results from action: a blend is likely to be constructed if it makes activities more efficient. Conversely, if the activity is not important enough within the overall task, integration is not needed. The presence and absence of integration is reflected in the mediating representations that make the correspondences between the artifacts in the lab explicit.

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