Mental Space Psychology – a Review of some Clinical Experiments and their Neuroscientific Background

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Abstract

Introduction: *Therapy methods using mental space representations have a long history. The program of mental space psychology (MSP) has recently shifted them into focus.*

Objectives: *The objective of this article is to review clinical experiments in mental space and discuss the neuroscientific background.*

Methods: *The concepts of mental space psychology are being introduced and clinical experiments in mental space are being reviewed. A review of the literature about the neural background is provided.*

Results: *Clinical experiments in mental space show promising results for a variety of psychological problems. A review of the literature on the neural background shows a number of neuroscientific studies supporting the assumptions by mental space psychology.*

Conclusions: *Clinical experiments in mental space can be connected to a lot of existing knowledge about neural processing.*

Keywords: mental space, spatial cognition, clinical experiments, neural representation of space, mental space psychology, social panorama

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The role of space

Aristoteles (DA II.7–11) has already mentioned that people perceive the world using different sensory modalities. This classical view was turned into a practical tool by Bandler & Grinder (1976), the founders of Neurolinguistic Programming (NLP). They described the role of the Visual, Acoustic, Kinesthetic, Olfactory and Gustatory channels in psychotherapeutic communication. They stated that people build mental representations with the help of their senses and changing these mental representations may be regarded as the core of psychotherapy. To do that effectively, the sensory qualities of these representations should be approached at a more detailed level (Bandler, 1986). The distinct sensory properties of these five modalities are called submodalities in NLP, of which Nielsen & Nielsen (2011) gave the following examples:

V: color, brightness, size, location, shape, intensity, etc.;

A: sound/melody, volume, theme, word, sentence, etc.;

K: sensation, respiration, temperature, motion/rest, weight, gesture, etc.;

O: fresh, fruity, flowery, like a particular perfume, etc.;

G: spicy, mild, sweet, tasty, etc.

More examples can be found in Ready & Burton (2010). Mental representation means the imagining of things in such a way that makes it possible to think of them, even when they are not actually there. The latter subject has fascinated philosophers and psychologists from Plato (Philebus 39b) to Mckellar (1957), up to Ganis, Thompson, & Kosslyn (2004).

Recently, mental representation became the focus in relation to how people find their way in the world: how they navigate their environment (Burgess, 2014). This all starts with the notion that we live in a three-dimensional world (some physicists even claim that there are many more dimensions) and that it is useful when the mind creates a similar model. Then there clearly exist a number of psychological principles that automatically register where objects are located relative to our own bodily position. Over the last 40 years a field of study called "spatial cognition" devoted itself to the question: how people behave in space and what underlying mechanisms and associated representations does this take (e.g., Siegel & White, 1975; for a review see Denis & Loomis, 2007).

Neuroscience established that stimuli are coded differently according to whether they are at or outside hands' reach (Colby & Duhamel, 1996). For this to work, organisms need a sophisticated way to discern the location of things. It was found, by implanting microelectrodes in primates, that the "where" of a stimulus is registered in the backside of the brain (dorsally), while many other aspects are processed elsewhere (Mishkin & Ungerleider, 1982). This matched earlier ideas from Schneider (1969) and led to the postulation of the so called "where stream", which is involved in spatial attention, and which communicates with regions that control both eye and hand movements. The same type of research showed the existence of the more ventral running "what stream". This stream is concerned with the recognition, identification and categorization of stimuli. Both streams continuously interact with each other. The existence of an entire stream to process "just only" the spatial characteristics shows how important this feature must be and that large numbers of neurons are dedicated to this function.

Returning to navigation, it was Tolman (1948) who introduced the concept of "cognitive maps". These maps help an individual acquire, encode, store, recall and decode information about the relative locations of objects in space by integrating them in some sort of internal topographic landscape. In the current time, with people being very familiar with navigation devices, it is easy to see that the mind needs maps for knowing where to go. However, just finding one's way is not the whole story. It has been suggested that this type of spatial thinking is also used as a metaphor in non-spatial tasks, i.e. tasks that are not concerned with real life spatial information (like streets, cities, buildings etc.). However, people seem to use the same type of spatial knowledge to facilitate any type of cognitive task (e.g. Kitchin, 1994). All thoughts, images, feelings and sounds appear on a certain location in the mental sphere in and around a person (Derks, 2016). The same conclusion was already drawn by Levinson (2003), Tversky (2004), Barcalou (2012), Spivey, Richardson & Zednik (2010) and Groh (2014)). Neuroscience supports that spatial thinking is in a way scaffolding non-spatial information processing and that both rely on the same neural structures. The neural basis of spatial cognition is found in the hippocampus (Burgess, 2014). The creation of cognitive maps seems to specifically rely on this limbic structure as was shown by the research of the Nobel prize laureates O'Keefe & Nadel (1978). The hippocampus has connections with the rest of the brain that appear ideal for integrating both spatial and non-spatial information (Manns & Eichenbaum, 2009). Non-spatial information comes from connections with the perirhinal cortex and the lateral entorhinal cortex, which brings non-spatial information to the hippocampus where it can be further integrated into cognitive maps.

The above lead to the general prominent role of space in all cognition. Derks (2016) states that "all cognition is spatial in nature". Tversky formulates "Space is the primary organizing principle in the mind", and Pinker says "Space is the medium of thought". Beenhakker & Manea (2017) state "you always think of something *somewhere*". In other words, all mental functions are built upon the same spatial cognition that an organism uses to know where its body is located in the environment and to find its way to food, safety and mates. This view helps psychology towards a new "core paradigm", that was already emerging over the last two decades under different titles such as: "embodied cognition" (Lakoff & Johnson, 1999; Bergen, 2012), "spatial cognition" (Bailey, 1997; Tversky, 1991, 2002, 2010; Burgess, 2014), "grounded cognition" (Barcalou, 2012) or "mental space psychology" (Derks, 2016).

Interestingly, linguistics indicated how the great role of space shows itself in spontaneous language (Bandler, 1986; Fauconnier, 1998; Lakoff & Johnson, 1999). Spatial expressions are found everywhere:

"I need to distance myself from the issue";

"He has risen above his problems";

"I have put this issue somewhere to let it rest";

"I left my traumatic youth behind me";

"I have put our conflict aside";

"I overcame the conflict with my parents";

"It stands still in my way" (Wilimzig & Nielsen, 2018).

Other proving sources for the central role of space in human thinking are found in various forms of psychotherapy (Satir, 2001; Pesso, 1969; Moreno, 1946; Hellinger, 1996). For instance, the work with the personal time line was developed in the late 80s and was the prototype for the Social Panorama model that came several years later (Derks, 1997). The social panorama in its turn was the breeding ground for mental space psychology (Hall & Bodenhammer, 1999; Van Ginniken, Derks, Koppelaar & Heemelaar, 2013). Next, we will take into consideration some examples of these therapeutic applications of space and further discuss the links to neuroscience.

Time line therapy

Time line work means that events in a person's life are put/transposed into space on a line. This significantly fits most people's intuition, since it seems clear that space is normally used that way, to orient oneself in time (Andreas & Andreas, 1988). In the so called "time line therapy" we see how the location of problematic events is analyzed and improved (James & Woodsmall, 1988). Over the time line, the client can be taken through time, from early childhood to present and even outside time or into the lives of others, like the ancestors. Skills from present can be transferred to ones from childhood and vice versa. Irregular breaks and turns in time lines may signal specific problems in dealing with life: dissociative disorders and/or trauma. Typically, events which are unresolved are located in the front – where most people hold the future –, whereas resolved events are kept in the past, in the back (Derks, 2016). By moving and improving mental representations over the time line, one can get to more adequate and helpful orientations in their life (Andreas & Andreas, 1988; Derks, 2016).

Social panorama

Social psychology studies and provides theories about how thoughts, feelings and behaviors of people are influenced by the actual, imagined, or implied presence of others (e.g. Allport, 1985). The social panorama model was developed by Derks during the 1990s, and it applies the importance of mental space to social psychology. It stems from noticing the strong emotional impact of mentally moving the images of people in the inner space. The social panorama model assumes that people build cognitive maps where each person we interact with on a regular basis – with whom we have a relationship – is held in a fixed position in the mental space. Basic social emotions, like authority, belonging, love and conflict are created by spatial constellations that have their own logic: that is according to the intuition of most people. For instance, when we see in our mind the eyes of a person above the level of our own eyes, we may feel shy and perceive the other as dominating the relationship. When there is a significant difference in level, we may feel suppressed and overwhelmed and consider that this person may have lots of power over us. Thus, the location of social images is establishing the quality of relationships and is critical for the interaction with others. The area of application of the social panorama model in psychotherapy consists in the full range of interhuman issues.

The social panorama can also be used as a social psychology research tool. Derks (2016) explored in a series of experiments how people generally distribute others in their mental space. A frequently repeated type of study, in which thousands of subjects took part, explored the patterns how people locate their partners and ex-partners. To investigate the location of the representation of a person in the mental space, specific protocols were used. Firstly, the participants were told to experience the general feeling they linked with being with that particular person to evoke the social emotion: in the experiment, this is "love" and "the current feeling for the ex-partner". When the participant is aware of his feelings, he points towards the direction corresponding to where the image is sensed/created. The researcher then walks to that position and uses his hands to figure out the right direction, the estimated distance and the level and direction of the target's eyes. Thus, these few characteristics seem to be the paramount of what defines a relationship.

When this experiment is done with a group, and all participants search the locations of their partners and ex-partners, the collective results show an overview of how people in general locate loved ones and ex-loved ones. To make these patterns visible, the spots are marked with pieces of colored paper on the floor. For example, the partners and ex-partners in one of these experiments were roughly distributed as follows: on the left 10%, in front 60%, on the right 20%, at the back 5% and inside the body (overlapping with self-position) 5%. Ex-partners are generally located at far greater distances.

One reason some people seek therapy is that their ex-partners may still be located within the intimate sphere (within an arm length radius around the self), which may prevent solid bonding with new partners. Moving the ex-partners out of the intimate sphere tends to resolve this type of issues. The results of this type of clinical experiments can be easily used by family therapists, like in the latter example.

Hemispheres in space

Differences in processing between both hemispheres have been repeatedly reported although some people point out that this concept is somewhat oversimplified (Springer & Deutsch, 1998), especially due to the high intersubject variability. Despite this criticism, this distinction has become mostly textbook knowledge. Verbal and logical tasks primarily involve the left hemisphere while artistic and spatial tasks (sic!) involve the right hemisphere, which provides a nice basis for the results of mental space psychology. A hypothesis that follows from experimenting with mental space in its broadest sense deals with the spatial difference between both cortical hemispheres (Derks, 2016). Based on a consistent research into this, done between 1970s and 1990s, one can state that the cognitive difference between the right and the left side is that the left side is specialized in focused, linguistic, detailed representation, while the right side holds the big picture in the background (McGilchrist, 2009).

A therapeutic technique called "The Other Mind's Eye" (Sargant, 1999) helps clients shift their attention from the "side" where they intuitively believe that their problem is thought/located, to the "other side". Derks (2016) observes that this seems to have a profitable effect. However, there was no solid research done on this method yet. The observations seem to be in line with the fact that the right hemisphere is more involved in spatial cognition and social relationships. The right hemisphere focuses on global aspects, general states of mind, emotional expression, and on creative associations like jokes and metaphors. The latter function better with an intact right hemisphere. Given this basis, it is hypothesized that the area of space in which the thinking of the left hemisphere takes place, has a relatively narrow cone shape, that is starting from the throat to culminate at about 50 to 100 centimeters in front in the center of attention, to narrow down from there. The area of space used for right hemispheric thinking goes around the entire body, to extend in a much wider field of awareness.

Some clinical experiments in mental space

In the following section we will look at some clinical experiments that support the role of space in cognition. At the end we will discuss the implications for neuroscience.

Relation equals location

In 2014 (Derks, Oetsch & Walker, 2014) conducted a simple experiment to test the basic assumption of the social panorama model: relation equals location. For this purpose, all subjects had to find the location of their loved ones and the intensity of the feeling of their love was measured. One group was asked to move the image of their loved one, three times as far away, while the control group was instructed to think of their favorite pizza. The intensity of feeling for their loved one was then measured again. Finally, they were asked to move the person back to the original location. Results showed a significant decrease in the intensity of the feelings of love when the image was put three times as far away, whereas the thinking about the pizza made no important difference. The measurements on scales were supported by open descriptions by the participants of "what happened". Derks and his colleagues concluded that this confirmed the hypothesis of relation equals location.

Neutral objects in mental space

Derks (2016) also evaluated the impact of moving a neutral object, e.g. light bulb, a baking glove, a banana or a sock. The participants were asked to find something in the room that had no emotional meaning to them, then close their eyes and move this object (which originally had an unknown location) at 15 centimeters in front of their nose and double its size. Then, they were asked to evaluate the emotional impact of this manipulation. The majority reported that it was not neutral anymore but became interesting, disgusting, fascinating or desirable. This experiment clearly shows the importance of where an object is located in imagined space. The closer an object is located, the more emotional impact it has. This corresponds to clinical observations: if a person has a problem with anything, a universal coping method is to place it at a certain distance (Thomas & Tsai, 2011; Davis, Gross, & Ochsner, 2011; Walker, 2014).

Where to worry?

Another experiment directly addressed the location of things the participants were worrying about. With the help of a partner, the exact location of the worrisome thoughts in mental space was found. The search for a better location, by moving these ideas in a suggestive manner, was proposed next. The participants gave direct feedback to the experimenter: "better" or "worse". After the localization of the better spot, the question whether the worrying ideas could stay in the new spot or whether anything was lost by doing this was asked.

This experiment with worrisome ideas has been, for more than 20 years, part of a training program and has been used by approximately 400 participants. Almost all subjects ended up with a less negative affect towards the problematic thoughts. Because the experiment follows the feedback of the subject, the tendency is that almost all subjects end up with a more positive experience: since an improved feeling is the criterion to stop. That is why this procedure has an extremely high rate of positive effect. However, there is no follow-up material that shows whether this effect remains outside the experimental context. If it were sustainable, it is a confrontation for classic insight-oriented talking-about-psychotherapy.

The location of awareness in mental space

Most people intuitively believe that they perceive the world from a spot in their head, behind their eyes. After studying Buddhist and Hindu psychology, Connirea Andreas (in print in 2018) concluded that the spatial positions where people can become aware of the world and themselves are far more varied.

In an experiment, Derks (2016) explored the spots from where people were aware of their psychological issues, and the interconnectedness of these locations. At first, the mental spatial position of a problematic feeling was found (most often within the body). The next step consisted of asking the participants to search for the spot in the mental space from where they were aware of the problematic feeling. That led to a newly found location in the mental space: the site of the awareness of the problem (quite often outside the body). Then again, the search was for the spot from where the participant was aware of the latter location. And when that location was found, the following such spot of awareness ("I – position") was looked for. The process is repeated until no new spot can be found. When well conducted, most participants find in between 4 and 8 of such "I – locations".

The last found "I – location" is then invited "to let itself dissolve and relax in the wider field of awareness". This standard suggestion leads to a fascinating response which shows how one can orally communicate with the neural principles of the mind and that can let go the integrity, sturdiness and boundaries of concepts. It is hypothesized that the right words at the right moment can help the brain release the inhibitory networks that keep a concept stable. After the last found "I– position" is reported to have dissolved, the earlier found positions are consecutively visited one after the other, by using the same suggestion until the problematic feeling is also finally dissolved. This procedure leads to an alleviation of symptoms in almost all participants. When we take the results of this clinical experiment face value, it brings up a number of ideas about the neurological underpinning of the processes involved. Derks (2016) also tried to formulate the psychological questions that this experiment raises.

The location of depression

Mental space psychology investigates the spatial structure of coping strategies, among which one finds the moving of a problematic concept away from the center of attention. However, by simply moving it away or to the side it does not automatically mean that people can fully deal with that issue. It is not a form of definitive coping but more a shift out of attention (Walker, 2014). Additionally, a person can block, inhibit the difficult idea before it can come into consciousness. Freud called this repression, which, on the long run (Singer, 1990), can lead to depression.

The next experiment conducted by Derks (2016) aims at investigating the spatial nature of depression and how to find its relief. The central discovery was that the actual feeling of sadness that depressed people experience goes together with the awareness of the areas of darkness in their mental space. By locating the exact contours of such darkness, the participant is ready for the first step: to imagine the sun shining on this darkness and, at the same time, to move the area of darkness into the center of attention – in front of the eyes. Within approximately 10 minutes, the dark area tends to shrink and become lighter in shade. This is the moment to ask the client investigate what is *hidden behind* the dark area. Quite often, the answers deal with a great loss, things that had to be given up in life, or a lost vision of the future.

The issues which are discovered behind the area of darkness are translated into something stemming from the participant not having been able to deal with (like a loss) in a different, more creative definitive way. Therefore, the search is for a better coping skill than those used – moving away and repression. This missing ability is then looked for in an as wide as possible range of coping models. The used examples may exceed what is considered humanly possible (which leads to angels, saints, virtual heroes, etc.). Through the classical NLP technique "the new behavior generator" (Bandler & Grinder, 1979), the participant is helped to acquire this skill. He is further asked to go back in the time-line, to the moment when this skill would have made all the difference in their life. When the participant has imagined how to apply this skill in his life, and has been growing up in his/her imagination to the present moment, the feelings of depression's intensity and the area of darkness are checked as a final test for the effect.

The results show that participants can easily get in contact with their feeling of sadness. Many people are willing to do so even in front of a group. After going through the full procedure, approximately 60% of the participants experienced a significant reduction in the feelings of depression. Beenhakker & Manea (2017) confirm these results in a controlled pilot study. The Society for Mental Space Psychology started an upscaled experiment in October 2017.

According to the WHO estimations, 350 million people worldwide suffer from depression and only 35 out of 100 get professional help (https://www.frnd.de/zahlen-fakten/).

The effect of increased spatial structure

The next clinical experiment in mental space explores the effect of an increased level of spatial structure during a coaching intervention. For that, the *desired outcome,* the *present state* and the emotional *obstacles* are firstly briefly discussed and explored with a participant. These three components are written on pieces of paper and then assigned a spatial location. Initially, this is done by putting them on a table and pointing at them at relevant moments during the conversation. Next, they are placed on the floor and the participant steps on them when talking about each of the three components. Finally, the participant can identify with these components and speak from the position of the *desired outcome* or the *emotional obstacle*.

The immediate conclusion is that, by using spatial positions, a therapeutic conversation becomes more effective: change takes less time to occur than in a plain verbal conversation. When the participants position themselves on top of the present state symbol, a spatial landscape starts to include a pathway – a trajectory between how things are now and the desired situation. Emotional obstacles become clearly positioned, which enables a view from different angles. This all seems to contribute to the therapeutic effect. Also, the client may move around without much speech, and make creative changes that only he or she understands.

Clean space

The next experiment Derks (2016) redesigned after Lawley & Tompkins (2006) and Lawley & Way (2017). The client starts to think about something that is worrying him, until he gets emotionally stuck in this problem state. Then the client is asked to look around, to identify a place "which knows more about the worrying issue than his current position does". By moving to the latter place, the client is connected to the knowledge found here, and this goes on until he gets stuck with that too. Then he looks for/moves to a next place that knows more, and so on. This procedure is repeated until the client no longer has negative feelings and is no longer locked in a problem state.

A major obstacle to this approach resides in that it seems too simple. The therapist does not even know anything about the client's problem and seems to hardly need any therapeutic skills.

The method is effective, yet it is hard to explain why. The question asked by the therapist, "Where is the place which knows more about this theme?", is a hypnotic suggestion implying both that such places exist and that it is normal to associate places with knowledge and resources. According to the social panorama model, a social representation is triggered in terms of personification (since typically people have knowledge). Some magical therapeutic rituals and shamanic healing rituals studied by anthropologists are not so different. They evoke the images of spirits, that may provide wisdom, insight and emotional flexibility. This experiment with clean space clearly shows how language is nearly set aside in the therapeutic interaction and just serves the purpose of helping the client navigate through their mental space effectively.

A discussion about the neural foundation of the phenomena under scrutiny

Space and the senses

Starting with 1986, submodalities, the qualitative sub-distinctions of the senses, occupy an important role within NLP. It is well established that changing the submodalities of mental representations can help reshape people's imagery and, thus, contribute to the resolution of psychological problems. It is equally well established that different modalities are represented in different parts of the brain – e.g. visual information in the visual cortex or auditory information in the auditory-parietal cortex. However, the time for neuroscience to analyze the influence of specific submodalities has still to come. Only the multi-cross-sensory submodality of location is heavily under scrutiny, as written about at the beginning of this article. And there it was already mentioned that location is not only a special submodality, but "the primary organizing principle in the mind". In accordance with this, representations in sensory areas have a specific structure, which reflects the spatial layout of peripheral sensory receptors. This type of representation is called "topographic map". This means that in the visual cortex neighboring points correspond to neighboring points in the retina; in the somatosensory cortex neighboring points correspond to neighboring points on the body surface; equally, there exists a tonotopic map in the auditory cortex and so on. In other words, sensory representations have a highly spatial nature. Furthermore, it was found that spatial representations are spread out over large cortical areas. And also, that areas specialized in spatial representation show a connectedness with a wide range of anatomical structures in the brain (see also below). Presumably, together they build a network that integrates all kinds of information into spatial contexts. Derks (2016) showed in the series of clinical experiments, of which several were summarized above, that changing the spatial position of mental representations can have an immediate psychotherapeutic impact, like, for instance, the moving of problematic concepts to larger distance leads to an instant alleviation of negative emotions. From the neuroscientific research, in the mental imagery we have learned that there is a correspondence between the physical characteristics of a stimulus and the neural processes going on when one imagines the stimulus (see above; Ganis, Thompson, & Kosslyn, 2004). Moving things farther away must mean a smaller representation at the sensory side of the brain, this logically implying that less neurons are activated, which would fit nicely with the results of the research conducted by Derks (2016), according to which images which are moved away decrease their emotional impact.

A neural basis for coping in space

Attention is highly important in making images intentionally move away. Attention is described as "the process by which certain information is selected for further processing and other information is discarded" (Ward, 2015, p. 459). Attention is highly spatial in nature, as typically the focus of attention is coupled with a specific location in space (for an overview see Ward, 2015). On the neurophysiological level, attention increases the neural response as shown for superior colliculus (Goldberg & Wurtz, 1972), the prefrontal cortex (Boch & Goldberg, 1987), the highly spatial lateral intraparietal area (Colby et al., 1996; Colby & Goldberg, 1999) and even the visual representations in V1 (Lamme et al., 2000) and V4 (Moran & Desimone, 1985). Attention may zoom in and out (La Berge, 1983). Zooming out corresponds to making objects smaller (= moving them further away). Unfortunately, there is no data whether this zooming out decreases the amount of neural units involved and, by that, the emotional impact as MSP would predict it.

A neural base for seeing space as the primary organizing principle in the mind

MSP is based on the assumption that *all* cognitive events are spatial (see above). A fair neurophysiological example of how non-spatial information is still represented in a spatial manner comes from the representation of numbers. Numbers are language-like symbolic representations (Banich & Compton, 2018). Yet, clear evidence points that, both in humans and in monkeys, numbers are represented in areas for spatial information, particularly the intraparietal sulcus (IPS – for a review see Nieder & Dehaene, 2009). Numbers are represented in a topographic map with adjacent subregions of parietal cortex representing neighboring numerosities (Harvey et al., 2013). Even more striking, numerosity-preferring cells are intermixed in the IPS with cells that code for other spatial features such as line length

(Tudusciuc & Nieder, 2007). While in humans there might be the explanation that teachers use number lines as teaching tools (Banich & Compton, 2018), that certainly does not hold true for monkeys (the fact that monkeys represent numbers at all is, of course, interesting per se).

The neural side of the social panorama

A standing question is: how complex spatial arrangements, like a social panorama, are constructed neuro-scientifically? One would expect that even such a complex phenomenon as a social panorama is based on the function of the type of cells called "place cells". It is this hippocampal cell that becomes active when an animal enters a certain place (known as "place field"). Cognitive maps, as we reported in the introduction of this article, are believed to be underpinned by the activity in the hippocampal place cells (O'Keefe & Nadel, 1978; see below). On a single cell level these units have been shown to be present in different species of animals but not yet in humans. However, since the hippocampus becomes active during any kind of navigation, humans are thought to have the same type of neurons (O'Keefe et al., 1998).

The hippocampus also plays a role in the establishment of new memories about experienced events (episodic or autobiographical events), pointing towards a close connection between space and memory contents (Eichenbaum & Cohen, 1993). Some researchers have also hypothesized that the hippocampus is entwined in larger networks that integrate declarative memory facts (Squire & Schacter, 2002). There is consensus that the hippocampus is not involved in the storage of memory but in the integration of memory (Squire & Schacter, 2002). Thus, to be able to do its job, the hippocampus must have connections with a variety of brain regions which seems confirmed (Andersen et al., 2006).

These place cells become active when an animal actually enters a certain location (O'Keefe & Nadel, 1978). Since these single cell studies are only done in animals, no data exists on humans imagining to enter a certain location. However, it is generally accepted today that mental imagery does activate the same cells that an actual experience does (see above), so it seems safe to assume that these place cells would also fire when one imagines being in a certain location. The more global level hippocampal activation found in humans is the same for the navigation of an actual environment and an imagined virtual environment (O'Keefe et al., 1998).

The neural basis of time line work

When it comes to the neural underpinning of time lines, the first thing is the assumption that the hippocampus incorporates linear time tags storing the moments of visits to particular locations (O'Keefe et al., 1998). Then Eichenbaum (2014) showed the existence of "time cells" in the hippocampus. Besides that, it was found that the firing of time cells and place cells goes in parallel, and Eichenbaum thus suggests that time cells provide an additional dimension in spatial mapping. He thinks that the robust representation of both time and space in the hippocampus is a fundamental mechanism for organizing the elements of experience into coherent memories.

Buonomano (2017) argues that the human brain constructs our sense of the "chronological flow" and enables "mental time travel" – as we create simulations of future and past events. Buonamano (2017) speaks of "navigation through the world" with this very system of time processing (sic!). Damage to the temporal lobe, the structure that contains the hippocampus, not only disables the recall of past events but also the ability to look into the future (Buonamano, 2017). This shows again the close connection between structures that store spatial information and those that process time.

Despite this promising evidence, it should not be forgotten that it is not easy to study the representation of time. Buonamano (2017) points out that although "time" is the most commonly used noun in English, there is no real consensus on how it should be defined and operationalized. Buonomano (2017) claims that for humans time is more complicated to understand than space. For instance, we can not only see space but also hear it (through the movement of sounds). Hearing it however, is not possible for time. From this point of view, one can argue that linking space and time makes time easier to understand, and to "handle" in both research and everyday life.

Personifications in neurology

For the social panorama, another type of cells found in the temporal cortex may play an important role. These cells, close to the hippocampus, respond specifically to faces and show some degree of invariance to metric properties such as the stimulus size, position and viewing angle. That means they are specific for the recognition of persons and not for other characteristics of the stimulus (Quiroga et al., 2005). Considering that the hippocampus has widespread connections to other brain regions (Stickgold, 2002), a social map should be easily generated by the interplay of hippocampal cells and cells of the temporal cortex, by making connections between place cells and this type of (face recognition) cells. Thus, the connection between the processing of space, time and people may help us to conceive their neural basis.

A neuroscientific idea about depression in mental space

As for depression, several studies exist that show a reduced neural response in depressed patients (e.g. Weinberg et al., 2016; Antonesei et al., 2018). By imagining sunshine shining on the area of darkness that depressed individuals seem all to sense, this intervention uses strong, intense stimuli. It is textbook knowledge that intense stimuli elicit stronger neural responses than weak stimuli (e.g. Pinel & Barnes, 2017). Due to the similarity in response to physical stimuli and imagined stimuli, this holds true for both. Thus, the weak responsiveness in depressed people is coupled with a strong imagined stimulus, which compensates for the low reactivity in depressed people. However, Derks does not see the positive therapeutic results stem from the "sun imagination per se", but from the release of the prolonged repression of something that was very difficult to cope with, after an effective way of coping is learned with the aid of an imaginary coping model (the new behavior generator combined with change personal history).

Fast therapeutic results fit some old theories in neuroscience

We intend to briefly discuss the rapid positive results of the reviewed interventions. Neural learning is based on a discovery made by the Russian physician Ivan Pavlov, nowadays called "classic conditioning", which was worth a Nobel prize in 1904: if a neutral stimulus is combined with a stimulus that elicits an automatic response, the neutral stimulus becomes a trigger of the same response. Dogs have an automatic response to a biologically potent stimulus like food – salivating. If you combine the smell of food with another previously neutral stimulus, e.g. a bell, after a short while dogs react the same way to the bell – they salivate without being fed. The neural basis of this is the famous Hebb's law (Hebb, 1949) that describes that neurons that fire together become connected ("Neurons that fire together wire together"). NLP embraced classic conditioning and called it "anchoring". While animal trials with classic conditioning in general take a lot of repetitions, NLP assumes learning on a very short time in full awareness (in intense consciousness, one trail learning does happen). From the perspective of Behavior Therapy, Psychoanalysis and animal models of classical conditioning, one may frown at NLP and the type of interventions described here. Actually, this is not correct. Classic conditioning also shows examples of one trail learning: from a single experience – that can lead to long-term conditioning (e.g. Haggbloom et al., 2002). Thus, the very quick results in the clinical experiments reviewed above are not only supported by these interventions but by real therapeutic work and experiments with classic conditioning as well.

To summarize, results in mental space psychology, as shown in the review of Derks' clinical experiments on mental space (2016), can be connected to a lot of existing knowledge about neural processing.

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