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The Appearance and Promotion of Creativity by Various Levels of Interdependent Networks

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Abstract: Creativity and talent is promoted by specific network structures and positions. Creative nodes are positioned in the overlap of many network communities, and have a highly dynamic and independent status. Creative nodes appear at the molecular, cellular and social levels, and are supported by the rest of the network. As examples of talent support networks the Hungarian research student movement, its international network, the Network of Youth Excellence, the Hungarian talent support network (helping more than 25,000 talented people in the last two years) and the currently developing EU talent support network will be introduced. The establishment of a world-wide talent support network would uncover huge local talent reserves, would provide the best support to them, and by creating millions of novel creative node positions would magnify the talent-capacity of the whole Earth.

Keywords:
creative nodes, networks, talent support

Growing Importance of Talented People in the 21st Century

Our world is facing new challenges requiring novel solutions. Creative solutions need creative minds. Thus the world has a rapidly increasing talent deficit. Firms, governments, countries are searching for more and more talented people. It is often said, "We are in a war for talented people" (Larkan, 2009). The real situation is not a zero-sum game, where the only task is to select the more able and let them win. The world not only has a huge talent deficit, but also has an enormous talent reserve. Hundreds of thousands of talented people remain undiscovered each year. Talent search and talent support often concentrates only on the top of the top: the geniuses. However, the distribution of talent is like a pyramid. This pyramid does have a peak. This is where the very few extraordinarily talented, the geniuses are found. However, as with all pyramids, the pyramid of talented people also has a base. In the base of the talent-pyramid we find the vast reserve of undiscovered, young children who have a touch of originality, a special element of hidden quality. With encouragement and with proper support a lot of them might become talented people.

Moreover, we have a plethora of talent types. Schools usually discover talented people only by the subjects taught in the curriculum. The math teacher sees only mathematical talent (if any…) and he is blind to observe anything else. One of my best students, who later won the EU contest of science and innovation (Sreedhar et al., 2003), was discovered by the mathematics teacher not because he solved mathematical problems brilliantly. He was discovered, because he misbehaved. He drew naked women during the explanations of the teacher. This school was a catholic school, so there was every reason to scold the student of this behaviour. Fortunately, the teacher had the sense to recognize the unusual. So he started to think about the possible reasons for the behaviour. Perhaps he is a bad boy with too much testosterone. But maybe he is simply bored. He gave much harder problems to the boy – which he solved easily. The boy started to find the work challenging only when presented with mathematical problems of five times higher level. In fact, these were the first mathematical problems which presented a challenge to the misbehaving

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young boy, making the first intellectual excitement of his life – ever. Due to the curiosity and non-conventional thinking of the teacher, a new talent was born.

Talent may not be hidden only in mathematics. The multitude of talented people warns us that the recognition and support of talent needs a lot of creativity, patience, long-term thinking, trust, love and belief. A good mentor is not seeing the student who is standing before her, but the student who may develop after twenty years, if everything goes in an optimal way.

Creative Nodes: the Position of Creative Behaviour in Networks

Creativity reveals itself not only from the originality and usefulness of its result. Creativity can also be detected from the network position of the creative actor. From the point of creativity three basic network roles can be discriminated (Csermely, 2008a; 2008b; Farkas et al., 2011). Most nodes are 'problem solvers'. These nodes are specialized to a certain task that they can complete (solve) with high efficiency. A few nodes are 'problem distributors'. These nodes have a large number of neighbours, thus they are hubs, and are specialized to the distribution of the problems arriving to the network from the environment. Both problem solvers and problem distributors have rather predictable behaviour patterns. Nodes of the third type exhibit a more exotic behaviour. These 'creative nodes' are extremely dynamic, and, by continuous change in the structure of their links, sample practically the entire network. In contrast to the other two types of nodes, the actions and outputs of creative nodes are highly unpredictable. Obviously the three types of behaviours described above can be mixed in more complex networks, particularly those encountered in the real world.

Are there any characteristic features of network positions of creative nodes? Active centres are segments responsible for the 'work' (i.e. for the catalytic activity) of proteins (enzymes). Network analysis revealed that active centres (1) occupy a central position in networks; (2) most of the time, but not always, are hubs, i.e. have many neighbours; (3) give non-redundant, unique connections in their neighbourhood; (4) integrate the communication of the entire network; (5) are individual, and do not take part in the actions of other network nodes and (6) collect most of the information of the whole network (Amitai et al., 2004; Csermely, 2008a; 2008b; David-Eden & Mandel-Gutfreund, 2008; Del Sol et al., 2006; Piazza & Sanejouand, 2008). In summary, active centres are different: they are unique, unpredictable, and they influence the communication of all other network nodes while maintaining their individuality. In analogous terms, the above summary may well sound like the characterization of a mastermind, broker, innovator or network entrepreneur: all being creative nodes of their social circles.

In social networks the archetype of creative nodes is the 'stranger' described by one of the forefathers of sociology, George Simmel a hundred years ago (Simmel, 1908). The stranger is different from anyone else. The stranger belongs to all groups, but at the same time does not belong to any of them. A later, well-known example of creative nodes came from Ronald S. Burt (1995), who proved that innovators and successful managers occupy 'structural holes', which are exactly the non-redundant, centrally connecting positions of the creative nodes. People bridging structural holes have 'weak links', e.g. they often change their contacts. Malcolm Gladwell describes several 'active centre figures' in his best-seller book, "Tipping point" (Gladwell, 2002). These 'connectors' (including the famous Boston citizen of American history, Paul Revere, who alarmed his fellows during the "Midnight Ride" to combat the coming danger at the beginning of the American Revolution) are interested in a large number of dissimilar persons and information. This wide and unbiased interest propels these boundary spanning individuals to an integrative, central position in the social and information networks. This is exactly the behaviour and position of creative nodes. Such a creative node can also be imported from outside. For example, consultants typically span otherwise isolating intra-organization boundaries.

A central position also offers a great advantage to groups. As an example of this creative node position at the group-level, biotech companies with diverse portfolios of well connected-collaborators were found to have the fastest access to novel information, and directed the evolution of the field. This was only possible in the long run, if most of these connections were transient (Powell et al., 2005). Their transient, far-reaching, exploratory contact structure of creative nodes helps performance only in those cases when the tasks are novel (e.g. those emerging in uncertain environments or in crisis) and require creative thinking to solve. Conversely, if the task is one that is typical, and the expertise that is already present within the group is enough to solve it, the maintenance of exploratory contacts is costly and being a creative node hinders performance (Hansen et al., 2001; Krackhardt & Stern, 1988). Creative persons are not very well tolerated in "business as usual" situations and often find themselves in the list of unwanted employees.

The properties of creative nodes require and predict each other and, therefore, make an integrated set of assumptions.

- Autonomy and transient links: creative nodes are the least specialized, and are the best among all network nodes to conduct an individual, autonomous life independent from the rest of the network – this independence explains why they might, and should, continuously rearrange their contacts.
- Transient links and structural holes: creative nodes must connect nodes, which are not directly connected to each other. If creative nodes introduced their new and unexpected content to multiple sites of a densely connected region, they would make an extremely large cumulative disorder, which would be either intolerable or would lead to a permanent change instead of a transient change. Due to the same reason creative nodes must preferentially connect to hubs to allow either the dismissal, or the fast dissipation of their novel content.
- Structural holes and network integration: if a node connects distant modules (with transient, weak links leading to the generation of important positions of the modules involved), this node performs a continuous sampling of key information of the entire network, and, therefore has a central and integrating role in network function.
- Network integration and creativity: if a node is accommodating key and representative information of a whole network, it (a) may easily invent novel means to dissipate an unexpected, novel perturbation or (b) may connect distant nodes of the network with ease and elegance helping them to combine their existing knowledge to cope with the novel situation. The re-formulation of the original problem (by translating it from one distant node to another), the generation of novel associations and novel solutions, flexibility, divergence and originality are all well-known hallmarks of creativity.

Creative nodes are the luxury of a network operating in 'business as usual' situations. Therefore, the number of creative nodes is usually very small. This situation may be characteristic of most man-made networks, such as the internet, traffic networks or power-grids. However, creative nodes are the 'life insurance' of complex systems helping their survival during any unexpected damage. Therefore, the number and importance of creative nodes increases, if the complex organism experiences a fluctuating environment (Mihalik & Csermely, 2011; Palotai et al., 2008). Creative nodes play a crucial role in the development, inheritance and regulation of the adaptation capacity of complex systems.

Networking Strategies of Talented People

The full display of your creativity and talent needs the support of your neighbours. In proteins only a few, five to six amino acids of the active centre do the whole job of the protein. These amino acids are the creative nodes of the protein and 'have the talent of the whole protein'. But there is a trick here. Without the supporting neighbourhood of all the other two hundred amino acids these creative nodes could never do their job. All proteins work like this. We have the very same situation in our brain. Active neurons are

surrounded by other active neurons making them the creative nodes of this network. But there is a big difference in the brain compared to the situation in simple proteins. The brain is much more dynamic than a protein. Each second new active neuron is at the centre of other active neurons playing the role of creative nodes. In such a way all of our neurons may get the special, central position to be really creative. A good society works like our brain. Allows each of its members, each of its potential talents to have their "15 minutes of fame" (Csermely, 2008; 2009; Farkas et al., 2011) and to have the unique position of a creative node.

Thus successful networking to reach the creative node status in terms of their social network is a must for talented people. What does a talent need to develop a successful social network? First of all: she needs a positive self-image. How can she check that? She should take the bathroom mirror test. She enters her bathroom early in the morning. The first part of the test is whether she can actually look at her own face at the mirror or not. The second part is whether she can smile at her image in the mirror. The third and last part is, whether she can tell herself without laughing that, "I am witty, I am skilful, and I will be successful and beloved today". If she passed this test she will spread positive comments around her, which is a must for building any type of network. If she has not passed this test – she should practice! After seven consecutive mornings she will start to think that she is right: in fact, she is pretty, skilful, successful and lucky. And so she will be.

Positive content will bring us new contacts, trust and curiosity to build long-term contacts, weak links, resulting in a non-redundant personal social network, a typical contact structure for a creative node. This type of weak links in network theory has a positive connotation as the contact bringing new information and stabilizing complex systems (Csermely, 2009). Our willingness to spread positive content will also raise positive remarks on us. Smiles evoke smiles. This all will enforce our positive thinking, and will act as a self-amplifying circle. This self-amplification ensures both our short-term well-being and long-term success and gives a lesson, which we should teach to all of the gifted and talented around us (Csermely, 2009).

Ronald Burt, a member of the famous Chicago-school of sociology described 'structural holes' in his seminal book (Burt, 2005). If you are positioned in a structural hole, your immediate neighbours in the network do not know each other. Moreover, not only your immediate neighbours do not know each other, but their neighbours do not know each other either. This is the typical network structure of a creative node. When I made these statements at a lecture, which I had in Hungary, a teacher approached me later and said: "Professor Csermely, I would not want to live in your world". When I asked her the reason, she responded: "If people would live as you suggested they would carefully plan their friendships, and would not approach someone just because she is already a friend of their former friend. This is a world of cruel, planned contacts, a Phalanstery, where I would not live for a fortune." You do not have to worry about this. First, in reality you seldom start a contact by listing your friends to see how many of them are common. Second, and more importantly: these decisions are seldom conscious. Building 'high-value', non-redundant contacts needs a lifestyle that is open for novelty, and open for a change. It needs a creative lifestyle. If you treat novel situations and information as an exciting challenge instead of conceiving them as a problem, you will build a creative node position in your social network without ever thinking of it.

Another remark upon hearing the advice of building non-redundant contacts and thus reaching the creative node status came from a Hungarian high school student. "Peter, if I want to be successful and follow your advice, I have to quit talking to some members of my family. I have a family, where members know each other. My father knows my mother, both of them know my sister, and I know all of them. I should keep a contact with only one of them to become a winner in the networking game." No, your family ties are exceptions of this rule. You do need a very strongly-knit personal network around you to ensure your emotional stability. This is an equally important piece of success. The non-redundancy should come into the picture only at the second or third round of social contacts.

As a consequence of the duality described above there are two major networking strategies: 1) the safety-seeking and 2) the novelty seeking behaviour. Both are correct, if applied in a proper situation. The safety seeker is making contacts with the friends of her friends. In this way a tightly interwoven network is built, which is ideal if we speak about the closest family, or we became a member of a new community. However, in other situations novelty-seeking may bring larger benefits. A novelty-seeker creative node identifies the centres of the group, the opinion-leaders and builds a contact with them, since they more or less represent the whole group. The novelty-seeker creative node also identifies those unusual members of the group who are open to building novel contacts. These group-members may be the 'envoys' of other, distant groups in the social network bridging large social distances by their curiosity and openness. These nodes may introduce the novelty-seeker creative node to a completely new group, where he identifies the centres and unusual members again.

Talent-support will not lead to success, if we are unable to teach our talented students to appreciate networks and to use the creative node status of networks for their benefit. Networking is a must for success in a modern society (Christakis & Fowler, 2011; Csermely, 2009). Networking not only introduces us to completely novel skills, information and areas, and teaches us how to cooperate, but also lets us explain our own talent – in a thousand different ways. If we can put our talent into various different contexts, and can show its different values in all of these, the market value (and the success) of our talent will be multiplied. Successful networking techniques never forget that a good network is extremely dynamic. There is an inner core of contacts (our family, our closest friends), which stays stable for decades. However, the outer shells of our contact-structure continuously fade and recover.

The Hungarian Research Student Movement

A typical example of the creative nodes was the famous Hungarian mathematician, Pál Erdős. Professor Erdős never had a flat of his own. He lived in hotels, but most of the time at the apartments of fellow mathematicians. Pál Erdős had an insatiable appetite for novelty. Professor Lovász, another famous Hungarian mathematician told that if someone was able to maintain Pál Erdős's attention for more than five minutes, she was a truly good mathematician. Professor Erdős changed his hosts almost in each month. He was a typical creative node. He connected almost all the best mathematicians of his age, and made a continuous transfer of novel information all over the world – much before the internet. The famous Erdős-number showing the extraordinarily high number of his collaborators coming from widely different fields of mathematics – reflects well his creative node position of the social network of mathematicians.

The social networks promoting talented people do help to invoke and strengthen this novelty seeking creative node behaviour. As an example of this in practice in 1996 I started a program (www.kutdiak.hu) to provide top-level research opportunities for high school students typically in the age of 16 to 18 (Csermely, 2003). For the 15 years of this program more than 10,000 students were participating in research projects in Hungarian universities and research institutions. The first generations have their PhDs already. Several of them now run their own labs. Gradually they 'took over', and in the last five years they have run the program themselves. These students formed very dynamic social networks which helped them to find their creative nodes positions.

Let me introduce three examples of talented students: Ms. Brigitta Sipőcz, who discovered an asteroid at the age of 17 by coordinating two telescopes on the internet in Croatia and Spain, and named it after Ernő Rubik, the Hungarian inventor of the Rubik-cube; Ms. Eszter Végh, who had enough international publications in chemistry at the age of 18 to give her a PhD; and Mr. Tamás Révész, who at 18 summarized ten years of research on the history of a military airport in a 500-page book. Tamás led the Hungarian Research Student Association which is a self-organizing movement of two thousand high-school students involved in scientific research. In 2009 he took over the leadership of the whole movement

from me, and has since run the program successfully. During this period he completed his MSc in history and at the age of 22 he wrote a second monograph in war history – this time on the life of a Hungarian aviation pioneer. Brigitta, Eszter and Tamás were and are the creative nodes of their social environment.

To promote networking and attaining the creative node status, conferences, clubs, camps, discussions and evenings are organized for the students. This resulted in a few unexpected effects. We have dozens of research student couples by now. However, the creative node position has also been developed. As a mark of this former high school research students built up an extensive social network, which – as several case studies show – not only helped their multi-disciplinary science cooperation but also gave a special impetus to return to Hungary after their PhD or postdoctoral period.

The Network of Youth Excellence

The Hungarian high school research student movement has an international network, called Network of Youth Excellence (www.nyex.de) as well as a Hungarian 'younger and elder brother' in primary schools and universities with 500 and 10,000 members, respectively. We have many talent support networks world-wide promoting the establishment of the creative node position now in world-wide scale (Csermely & Lederman, 2003; Csermely et al. 2005; 2007).

The Hungarian Talent Support Program

The Hungarian Talent Support Council (www.tehetsegpont.hu) – which I served as its chair in the first six years and as its honorary chair by now – was established six years ago. This is an NGO-umbrella organization organizing talent support cooperation in Hungary and in the neighbouring countries. We promote all types of talents: science, technology, but also humanities, arts, sports and crafts. This gives extra dimensions to the development of the creative node status.

Recent studies established enormously beneficial effects of musical and physical training on creative behaviour in e.g. engineering. Humanities and arts provide a cultural context, which is needed by any type of talented people. The cross-effects provide an extremely useful way to help the talent of children coming from underprivileged (e.g. Roma) environments. Their first successes in music, dance, or in soccer often pave the way for later successes in history, mathematics, or entrepreneurship. The different social dimensions extend the possibilities of being a creative node.

In 2008 the Hungarian Parliament (with only seven opposing votes) accepted a 20-year-long National Talent Support Program. This program is not only a piece of paper. A National Talent Fund was also established to support the activities. This Fund has an annual 5 million EUR support from the national budget and an additional amount from tax-donations of 207 thousand citizens totalling 1.5 million EUR in the first year doubling to 3 million EUR in the second year. The Fund is open for additional donations. The Hungarian Genius Program (www.geniuszportal.hu) is an EU-supported part of the National Talent Support Program run by the Hungarian National Talent Support Council between 2009 and 2013. The core of this program is the development of a talent support network in the whole Carpathian-basin including Hungary, Romania, Serbia, Slovakia and Ukraine.

In the last four years close to 1000 Talent Points were established helping talented people to recognize and develop their abilities. Such Talent Points are nurseries, schools, universities, but may also be chess-clubs, soccer-teams, carpentry shops and even penitentiaries. A Talent Point not only runs its own talent support program, but also serves as an information centre. Any one may go there or bring there a student or child, who is a promising talent-candidate. Members of the Talent Point will help to assess the level of talent and to find adequate support. This is a grass-roots movement. Each week a dozen more new Talent Points ask for their registration. Talent Points form a network and help each other. These Talent Points discovered more than 25 thousand talented people in the

last two years. Talent Points and all other talent support options are listed at the Talent Map (http://geniuszportal.hu/tehetsegterkep) of Hungary and neighbouring countries.

The Program develops resources and offers several publications on topics related to talent support for the teachers and experts working in the Talent Points. The wide variety of tools and techniques include: aptitude and behavioural assessment, methods of mentoring, development of critical and reflective thinking, guidance on talent support in specialist fields, the role of talent care in integration, development of entrepreneurial and project management skills, etc. These materials are available for free in electronic and printed forms.

Teachers are key players in the recognition of talented people. In the Program more than 15 thousand teachers were trained to be aware of the hallmarks of talents, and to arrange adequate help via the nationwide support network developed. There were more than 1000 Talent Days informing teachers and parents of the novel possibilities. Such a Talent Day serves as a crystallization point of the local talent support community.

A recent development is the grass-roots establishment of more than 50 Talent Support Councils. These Councils organize local support options, as well as the cooperation of whole areas, like that of mathematical, musical, Roma talented people or talented people requiring special need education. Values of enthusiastically pursued high-quality work, perseverance, proper risk taking, Big-Thinking, long-term planning and cooperation are all promoted by talent fostering in Hungary. The wide talent support network opens more and more possibilities to establish a large variety of creative nodes in the Hungarian society.

The Developing European Talent Support Network

In April 2011 the first EU Presidential Conference on talent support took place in Budapest, Hungary. Experts and government officials of 24 European countries listed their best practices in talent support. Participants of the conference accepted the Budapest Declaration on Talent Support (http://geniuszportal.hu/content/budapest-declaration-talent-support). This calls for EU member states to establish an EU network of Talent Points and to celebrate the European Talent Day. An EU Talent Support Centre was established in Budapest serving the organization of EU-wide cooperation in talent support. Ireland was the first to declare 8th April 2011 a National Talent Awareness Day, but governments of Poland and Denmark (having the EU presidency after Hungary in 2011 and 2012), as well as Finland, experts of Germany and the UK are all building talent support networks. More than ten European countries have joined this movement (www.TalentDay.eu). A group of European Parliament members plans to submit a proposal for a non-legislative action supporting talented people in the European Parliament.

Towards a World-Wide Talent Support Network

Talent support gained a momentum in 2011: in the US Congress a Talent Act was introduced (http://www.opencongress.org/bill/112-s857/show) as an amendment of the "No child left behind" program, and after a nationwide discussion involving 30 thousand people, China accepted a talent support program in 2010 proposing the education of 50 million people in 10 years (Wang, 2010). Are these measures signalling a new battle in the war for talented people (Larkan, 2009)? Not necessarily. Talent support networks significantly increase the amount of discovered, properly guided and nurtured talented people. With a global talent support network we can increase and mobilize our talent pool in each country on Earth and grow the number of creative nodes in our society. With the millions and millions of newly discovered talented people we may overcome the zero-sum talent game. Instead of fighting talent wars for the best, and inducing new and new waves of brain drain, we should build a talent friendly society both at home and everywhere on Earth.

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