Introduction

Creativity has captured the minds of thinkers of numerous disciplines for centuries, with first references stretching back to antique times (e.g., Eysenck, 1995). Intuitively, this phenomenon seems to be at its highest potential in the world of cultural and creative industries, nevertheless creativity emerges in any context where original solutions must be searched for. It can be defined as organized process through which an agent, both individually and collectively, creates a novel and useful idea (Amabile, 1983). Fundamental theories, such as Csikszentmihalyi' systems view of creativity (1988), or Amabile's (1983) componential theory of creativity, argue that individual creativity is firmly grounded in the social environment. It appears the pool of necessary domain specific information, extrinsic motivation and support, inevitably influencing every stage of creative process, from idea generation to idea implementation (Perry-Smith and Mannucci, 2017). Metaphorically, it is the origin and final destination of all creative outputs that spreads beyond the ends of creativity continuum, as it sparks creative ideas in the beginning, and transfers them to the future generations thereafter.

Interpersonal networks literature tends to represent the structure of human interactions more systematically. Pictured as a set of nodes that stand for people, and links that connect them, capturing interactions that take place, network approach allows researchers to put the complexity of communication patterns on one graph and scrutinize it as a whole (Kilduff and Brass, 2010). It has been shown that those agents who hold advantageous positions in the network have more means to be creative, since information inflow obtained through the network helps generate better ideas, optimize the overall process and soothe idea acceptance (Kijkuit and Van den Ende, 2007; Burt, 2004; Perry-Smith and Mannucci). In this vein, efficient networking and active interaction associated with it appears to be a necessary prerequisite to individual creativity.

But while research in organizational behavior and interpersonal networks literature claims the aforementioned, literature in psychology has another point to make. Personality studies remind us that creative tasks are not all alike, and for different kinds of those, various personality traits and communication patterns are beneficial. For example, extraversion is majorly expected to be a creativity trigger, as these people are outgoing and enthusiastic (Zare and Flinchbaugh, 2019). However, when we contextualize this personality trait to the field of expertise, we find that for certain fields, such as science or art, introversion is essential (Feist, 2006; Gotz and Gotz, 1973). If we look back in the history, it is not rare that highly talented creative people were in some way prone to lower extents of socialization, if not offishness. Reasons behind this vary from high levels of introversion to mental disorders (Silvia and Kaufman, 2010), and in any case, networkwise, the outcome is smaller networks with less power (Kaufman, 2001; Feist, 2006). Moreover, we find that for some creative tasks that require deep concentration networking may be a hindrance (Feist, 2006, 1998; Wolfradt, 2001), while solitary activities may be triggers. Interestingly, this is idea is partially mirrored in organizational behavior literature, showing, for example, that brainstorming sessions negatively affect the quality of creative ideas in comparison to isolation (Putman and Paulus, 2009), and that heterogeneous network ties of a broker constrain creativity when tasks are complex and outcomes uncertain (Stea and Pedersen, 2017).

In this article, we focus on interrelation of creative individual and solitude. Preference for solitude (PfS) is conceptualised as «desire do be alone in order to become engaged in an activity that has intrinsic appeal» (Marcoen and Goossens, 1993, p.198). Voluntary chosen solitude is an appropriate condition for enlightenment, known for unfolding creative potential, and helping to find the clarity of thought (e.g., Long et al, 2003; Nguyen et al., 2018). In a way, solitude as a setting and PfS as behavioral predisposition have always been essential to the lone genius type (e.g., Schumpeter, 1942; Storr, 1988). In the context of organization, such lone geniuses are usually those workers who produce innovative outputs independently, without much external stimuli or active networking (Shaffer et al., 2016). The phenomenon of solitude is particularly important to understand now, at the era of galloping growth of digitalization and overall connectedness. Paradoxically, solitude becomes an answer to ubiquitous pressure to network, taking shape of social media, the desire for which in fact signals the thirst for solitude (Hill and Zheng, 2017).

Our interest in this study is to integrate the contributions of interpersonal networks and personality streams of research in order to assess individual creativity. Hence the research question of the paper is the following: *how do network centrality and PfS, entwined, affect creative performance?* Answering this question is important because it shows how seemingly undesirable personality trait in the context of intra-organisational network can have considerable positive outcomes in terms of creative performance. It also has the potential to advance our understanding of creativity in social networks by suggesting a novel explanation to a paradox of why advantageous network positions do not always have positive effects on individual creativity, and what it has to do with ones personal needs and abilities. Lastly, it can support organizations to better design the work process and modify organizational routines, given the interplay between the dimensions of network and personality, in order to exploit the creative potential of workers.

We test the theory in the engineering department of a large gas machinery company where creativity is part of the technical process of finding novel and useful solutions in terms of new products to satisfy the market. Here the creative dimension has two characteristics: it is a collective condition (Hargadon and Bechky, 2006) where the complexity of issues requires solutions that combine knowledge, efforts, and abilities of people with different expertise and abilities (Eisenhardt and Brown, 1998; Eisenhardt 1990), and is also connected with the individual ability for searching, focusing on the problem and organizing attention for individual creativity.

The findings demonstrate that while for those people characterized by low PfS, networking is positively associated with creative performance, for high PfS agents the opposite scenario evolves.

The paper proceeds as follows. In the next section, we overview interdisciplinary theoretical background on creativity embedded in social networks, on the one hand, and creativity rooted in personality traits, on the other, and suggest two hypotheses on the intersection of these two dimensions. Further, we describe methods and selected measures. Lastly, we provide results and discuss the findings.

THEORY

Social side of creativity

Creativity is a very large and ambiguous phenomenon. Analyzed as a source of innovation and economic development (Pratti and Jeffcutt, 2009), as goal and result (Oldham and Cummings, 1996), as a moral imperative (Osborne, 2003), and as a collective process (Weick and Roberts, 1993; Hargadon and Bechky, 2006; Perry-Smith and Shalley, 2003), creativity emerges as a key concept both in the domain of cultural and creative industries and in any organization striving to exploit its potential in terms of production of new ideas, processes, and products. Systems view of creativity (Csikszentmihalyi, 1988) urges scholars to contextualise the phenomenon of creativity, claiming its inseparability of creative individual from the social structure they are embedded in, as it appears to be a source of information and mutual influences. Creative outputs, be they ideas or products, undergo series of evaluations and judgements of the field (Zhou et al., 2019) that pick out the true creative from «statistically improbable or bizarre» (Csikszentmihalyi, 1988, p.48). In this vein, the very existence of phenomenon of creativity is deeply rooted in the fact of social agreement and, consequently, the society.

Not only the receiving side of creativity (Zhou et al., 2019), but the creative process, too, is rooted deeply into human relations. Elaborating on that, organizational behavior literature stresses that creativity is partially triggered by social contexts and networking, proving that even initially creative individuals need support and incur positive impacts of such aspects as presence of inspiring and encouraging supervisors (Oldham and Cummings, 1996), creativity prompts (George, 2007), and help and acceptance of colleagues (Amabile, 1998). In line with this logic, Calcagno (2017) writes: “Creativity is therefore a socially situated concept, identifying a collective process that in unforeseen moments happens to exhibit singular points of disruption in relation to previous traditions”.

Talking about how networking contributes to individual creative performance gradually takes us to social networks domain that structurally represents traces of interactions as a graph of nodes — people — and links that connect them. Social networks and creativity field has been unfolding lately and has significantly contributed to our understanding of individual creativity. Hereby Perry-Smith (2006) has shown that network ties stimulate creativity by means of linking an individual to heterogeneous contacts that provide one with non-redundant information. Professional domain-specific knowledge of that kind is essential component of creativity (Amabile, 1988), since it urges deliberate pondering process that results in creative performance enhancement (George, 2007).

Degree centrality that denotes the number of direct ties to network agents (Kilduff and Tsai, 2003), is known to facilitate creativity at work by providing one with power of masterly exploitation of the social capital (Perry-Smith, 2003; Wong and Boh, 2014; Tang, 2016). For example, Wong and Boh (2014) theorize that since central network agents are often in position of power and social influence (Ibarra and Andrews, 1993), their ideas are typically perceived as high quality, which attracts resources and social support.

Efficiencywise, network ties help to optimize the creative process, and scholars highlight reasons that are threefold. Firstly, if networks are pipes in which information flows (Podolny, 2001), then network ties represent the access to those pipes (Cattani and Ferriani, 2008), and the inflow of relevant information is particularly relevant at the early stages of creative process (Perry-Smith and Mannucci, 2017). Secondly, connections with agents help enhance the timing and pursue legitimacy (Burt, 1992). Thirdly, central network positions signal power (Wong and Boh, 2014) that helps find understanding and shared vision (Perry-Smith and Mannucci, 2017) and increase the probability of creative idea acceptance (Kijkut and van den Ende, 2007).

At the first glance, it may seem that we have arrived to the point when one can confidently say that powerful network position is a guarantee of better creative performance. Nevertheless it is not exactly so. As Burt et al. (2013) mention, it is not networks that take actions, but people. People are not utterly rational and they don't always use — or cognize — available opportunities. One can have all the network tools to be more creative and yet not use them (e.g., Wong and Boh, 2014). Empirical evidence illustrates that even those individuals who hold powerful network positions do not always make perfect use of it, and do not always perform better than the rest (see Burt et al., 2013, for a review). This, of course, may be due to the fact the perception of self-position in the network is usually biased (Brands, 2013), which constrains the agency. But another reason to such network behavior is also the fact that some people are less willing to get involved in a certain model of interaction due to a set of psychological traits or contextual characteristics (e.g., Kim et al., 2016; Baer, 2012). In the following chapter, we undertake a modest attempt to turn creativity and networks stream of research away from homo economicus scenario by proposing a complimentary explanans to individual creativity in interpersonal networks.

Preference for Solitude as creativity fount

As we turn to a creative individual as a human being having an established set of aspirations, talents, and psychological traits, we discover a brave new world of personality studies (see Feist, 2006), and these characteristics can significantly affect ones networks position and behavior (see Landis, 2016, for a review). Previous research has demonstrated that creativity is rooted deeply in such personal capacities and abilities as creative thinking skills, intelligence, intrinsic motivation, passion, out-of-the-box approach, curiosity and other (e.g., Amabile, 1998, 2005; Sternberg, 2006; George, 2007). Beyond doubt, such powerful drivers of creativity can shape one's success. But even a lucky person possessing all of these outstanding qualities would still need to facilitate their natural abilities and take some time pondering in order to understand how to apply them correctly. Intense thinking associated with it requires sufficient cognitive effort and deep concentration, a condition that usually happens when people encounter solitude (Storr, 1988; Long et al., 2003; Nguyen et al., 2018).

Solitude is known for its controversial standing in the field of social psychology. On the one hand, it is often associated with highly negative effects, such as depression, boredom and loneliness and sometimes is attributed to consequences of those (Larson, 1990). Historically,

coercive solitude has been applied as punishment (Suedfeld, 1974). In this vein, one can masterfully derive that being alone is an undesirable condition that one should never desire.

But on the other hand, however, solitude leads to a number of positive outcomes. Storr (1988) has provided numerous examples of religious leaders, famous writers and other historical figures belonging to various historical epochs who experienced solitude — on their free will or under compulsion — and benefited from it. For example, Fyodor Dostoevsky has developed three ideas for novels during the short period of time at the very beginning of his imprisonment when he was not allowed to read and write (Storr, 1988). These ideas and experiences have later became the basis and plot of «The House of the Dead», and further several ideas from this one were extrapolated to one of his most celebrated novels, «Crime and Punishment» that has unprecedented cultural influence. But would Dostoyevsky discover his inner genius if he never experienced confinement? Would he be able to devote enough time to mentally decompose events of his life and then merge them up in a completely different way, to see them from another angle, — and to write about it in a way that he did?

According to Marcoen and Goossens (1993), «solitude implies a desire do be alone in order to become engaged in an activity that has intrinsic appeal» (p. 199). Despite the fact that is solitude commonly experienced by people when they are alone, physical separation from others is not a necessary condition. Unlike isolation, solitude can actually happen in the presence of other people (Burger, 1995; Long et al., 2003). In fact, some of the peripheral states of solitude appear quite social, such as desire of an intimate couple to get away together, feeling alone in the company (Long and Averill, 2003), or online social networking (Hill and Zheng, 2017). Not scared off by the pessimistic mainstream image, Long et al. (2003) list functions of solitude, mostly positive, naming problem solving, inner peace, self-discovery, and creativity. While the first three functions set overall favourable psychological environment for productivity, the latter one is the very focus of the current paper. When creator encounters temporal solitude, it is the way to escape disturbance and noise, and to focus all the attention and effort on creative output production. This is particularly important at early stages of creativity continuum, when sparks of ideas flash up and get washed away relatively easily. For workers of creative industries, such ideas are key inputs to the very outcome of their work, performance and overall professional success. Solitude brings deeper concentration and facilitates the thought by the means of temporal abstraction from the context and its ignorance. Supporting this logic, Putman and Paulus (2009) demonstrate that superior creative performance was achieved by those teams members of which have not interacted during idea generation stage, in comparison to those teams where such interaction did take place. Paradoxically, even in a study on how creators should exploit their social network in their creative journey, Perry Smith and Mannucci (2017) recognise a role for abstraction from the context peculiar to solitude when they claim that at early stage of the development of an idea, respective cognitive flexibility is crucial.

All of the aforementioned may be true to most individuals but the intensity and preferred regularity of solitude experience varies significantly (Burger, 1995), constituting a standalone personality trait. In other words, there are people who often long for solitude and mostly benefit from it, and there are people who try to avoid solitude as they mostly suffer from it. For example, extraverted individuals whose personality is characterised by openness to social interaction, talkativeness and joviality do not appear to desire solitary activities often. On the

contrary, they long for active communication as it charges them with energy (Fang et al., 2015; Burger, 1995). Introverts, on the other hand, lose energy when interacting with other people, and to them, solitude is an essential way to unwind, avoid distractions and enhance their creativity, therefore they seek for it (Nguyen at al., 2018; Ren et al., 2015; Furnham and Allas, 1999; Burger, 1995).

The empirical evidence also demonstrates that when solitude is forced to an individual, it triggers negative outcomes, such as feelings of loneliness, boredom and decreased life satisfaction, while people who voluntarily choose to spend time in solitude do not encounter these feelings (Chua and Koestner, 2008; Nguyen et al., 2018). In this vein, while certain kind of personality is consistent in having a need to spend time in solitude and reaps its fruits, being facilitated thinking, rejuvenation, unfolding intellectual capacities, imagination spring (Storr, 1988; Long et al., 2003; Nguyen et al., 2018); other kind of personality undergoes a completely different and opposed scenario.

To our knowledge, up to date the personality trait and behavioral predisposition that best captures individual's free desire to spend time in solitude is Preference for Solitude (PfS) scale that was developed by Burger (1995). PfS is conceptualised as the extent to which people prefer to spend time alone. People with higher levels of PfS, on the one hand, do not have a strong need to be around other people; time spent with other people is often boring and uninteresting to them, while time spent alone appears productive for them. People with lower PfS, on the other hand, highly appreciate the opportunity to interact with interesting people; time spent alone usually seems wasted to them, and on average they find solitary activities boring and uninteresting (Burger, 1995).

Taking all of aforementioned into consideration, we claim that when assessing individual creative performance, it is not enough to give characteristics of overall social network structure or ones position in it (e.g., Sosa, 2011; Perry-Smith, 2006). In addition to that, attention should be paid to the extent to which the person is naturally willing to make use of the social environment they are embedded in, and how their personality affects their networking (Kim et al., 2018; Landis, 2016) .

Taking a step further, we state that certain industries attract certain kinds of personalities (Feist, 2006). Moreover, empirical evidence shows that in various professions, creativity is driven by different traits (Feist, 1998, 2006). Yet the research up to date tends to overlook that network effects on creativity can — and should — vary depending on the context that it is placed to, namely, the industry.

Our interest here is the industry that disposes people to concentrate on sophisticated material objects rather than interpersonal relations, typically attracting thing-oriented rather than people-oriented professionals (Little, 1972). The very nature of such work outputs invites a certain extent of workplace solitude, since calculations and visualisations do not superpose with talking. However, sophistication of work outputs also makes networking inevitable, since work-related information is usually very heterogeneous, and in addition, team work is essential to complex projects.

One of professions matching aforementioned criteria, is, no doubts, engineering. Historically, engineering creativity is the source of technological progress and a lion's share of innovations the world has seen so far (Cropley and Cropley, 2005). Engineers combine pragmatic consecutive approach characterised by extensive set of rules to follow with inalienable aim to create something that has never existed before, at least in a certain form. On the one hand, engineers are known to be introverted (Feist, 2006), therefore, naturally seeking more solitude (Burger, 1995) than extraverts. In a way, it corresponds with the purpose of coming up with a novel product, be it mechanical object, software or a prototype. Without workplace solitude, it would be impossible for engineers to dive deep into creation process in all its complexity. On the other hand, engineers' projects are usually vast and enduring, which makes it impossible to fulfill the task alone. Team work or other form of collaboration is networking by definition, therefore social network analysis is an appropriate tool to analyse the social side of engineering creativity.

In sum, our claim is that when assessing individual creative performance, it is particularly important to pay tribute to the personality types that constitute the sample and to consider how task specificity can affect the very nature of creative thinking. In the following section of the paper, we entwine intrinsic and extrinsic factors by matching PfS with network degree centrality and, in the context of an engineering department, we verify which combinations of PfS and degree centrality are beneficial to the individual creative process resulting in higher creative performance.

Interplay of personality traits and contextual characteristics

People with high levels of PfS are comfortable spending time in aloneness, generally perceiving it as productive and pleasant (Burger, 1995). High PfS's naturally seek for solitude and comfort that it provides them with. They heavily rely on intrinsic rather than extrinsic resources when working on creative task. Empirical evidence shows that solitude, when voluntary encountered, leads to a set of aforementioned positive outcomes (Nguyen et al., 2018). In creative professions, solitude can help enhance creative ideas at early stages of creative process, and thoroughly polish up the details at the stage of idea elaboration. In addition, solely generated creative ideas and outputs usually come up more original, as they are unsmudged by the viewpoint of others (Putman and Paulus, 2009).

In the context of social network, high PfS best matches with low degree centrality, since in that way the behavioural «request» for solitude is fulfilled by the network structure. High PfS's with lower network centrality spend less time interacting and more time by themselves, which, in the context of organisation, implies independent work, be it a solo project or an individual contribution to the team project.

Conversely, intense interaction associated with high degree centrality affects high PfS's creative performance negatively. Emotionally, exuberant interaction with a big amount of people causes tiredness and boredom to high PfS's, and it often appears a source of disturbance and confusion. Stea and Pedersen (2017) prove that for engineers who have to deal with large amount of highly heterogeneous information on a daily basis, such excess of networking negatively affects creative performance, appearing a powerful environmental stressor. To individuals with high PfS, networking can be even more harmful when it is forced

on them by organizational culture and routines. Under these circumstances, High PfS's natural need for higher levels of privacy is neglected by such conditions as working in open box, daily plenary meetings and inability to disengage and unwind.

Objectively, it tends to wash away originality of high PfS's creative ideas and style, and also draws attention away from the work output. Hence we suggest the following:

> *Hypothesis 1: Individuals with higher levels of PfS rely on intrinsic resources at work, thus their creative performance will be positively associated with PfS.*
>
> *Hypothesis 2: For individuals with high PfS, the relation between PfS and creative performance will be negatively moderated by degree centrality.*
>
> *Hypothesis 3: For individuals with high PfS, collaborative environment will have a negative impact on creative performance.*

However, a different scenario evolves for those people who demonstrate low levels of PfS. The very nature of such personality requires intense and frequent communication, such people are more responsive to external stimuli and are more ready to receive, process and apply the information acquired from colleagues. Low PfS's genuinely benefit from brainstorming, design thinking and knowledge sharing arising in more casual chats. Solitude appears unpleasant to them, as time alone is perceived as inefficient and «wasted» (Burger, 1995).

Therefore the case of high degree centrality is highly beneficial for low PfS's for two main reasons. Firstly, it places them in their element and fulfils their essential desire for rich interaction, letting them avoid the feeling of boredom, loneliness and depressiveness (Long et al. 2003; Nguyen et al., 2018). Secondly, network centrality provides them with all the abundance of work-related information, sources of motivation, means and mechanisms to gain support and promotion (Perry-Smith, 2003; Kijkut and van den Ende, 2007; Sosa, 2011; Perry-Smith and Mannucci, 2017), and low PfS's are ready to accept and apply it to better their creative performance. When these personal qualities are supported by collaborative context promoted by top management, low PfS's are expected to be in the most advantageous position, as their willingness to engage into active communication is supported not only by their own position in the network, but also by organizational culture.

In the case of low degree centrality, on the contrary, low PfS's undergo difficulties. Here, not only solitude is perceived as unsatisfying and unpleasant circumstance, but it also cuts off the benefits suggested by positive networking. The lack of interaction with network members constrains informational and emotional support that can only be obtained extrinsically. By not communicating with others, and, more precisely, by not sharing advices with colleagues, such person reduces the amount of potentially relevant information, which constrains knowledge spillovers and reduces absorptive capacity (e.g., Perry-Smith, 2006; George, 2008; Kilduff and Brass, 2010). Therefore we posit:

> *Hypothesis 4: Individuals with lower levels of PfS rely on extrinsic resources at work, thus their creative performance will be positively associated with degree centrality.*

Hypothesis 5: For individuals with low PfS, the relation between degree centrality and creative performance will be negatively moderated by PfS.

Hypothesis 6: For individuals with low PfS, collaborative environment will have a positive impact on creative performance.

METHOD

Sample and Data Collection Procedure

Prior to starting collecting data authors communicated with GasMach management and explained the purpose of the study. Both sides were preliminary interested, and after thorough investigation authors agreed that GasMach matches the criteria selected for the case study.

First of all, GasMach has a big engineering department, and its employees produce novel and useful outputs. Secondly, when fulfilling work-related tasks, GasMach engineers intensively collaborate within and across sub-departments, as they often work in teams on certain projects. In addition to that, collaboration of engineers is fostered by the fact that produced outputs usually relate upward or downward the supply chain of the final product. Aforementioned reasons, to authors' expertise, make GasMach an appropriate setting for network research. Thirdly, technological sophistication of tasks performed requires high extents of concentration on the material-to-be object and deep immersion into prototyping, leaving, therefore, room for solitude.

After agreeing to run the survey, authors guaranteed confidentiality and accorded to share results of the research with GasMach top management and the head of design engineering department.

At the time of data collection, GasMach had 894 employees mainly involved in engineering and production. The design engineering department consisted of eight sub-departments and 83 employees involved in designing meter stations and its components, high and low pressure gas machinery, lock off valves, and the equipment necessary for maintenance of these products. In addition to that, two sub-departments were involved in automatization processes implementation, and one sub-department was responsible for GasMach products to be in accordance with GOST, Russian State Technical Standards.

Daily tasks of most of the engineers in the sample was to work on blueprints and 3D drawings for gas machinery prototyping. The gender breakdown was 32 percent female and 68 percent male.

Questionnaires used in the study were translated into Russian with translation–back translation procedure (Brislin et al., 1973). Respondents received paper sheets after plenary meeting and were asked to fill them in straightaway in author's presence, so that all sorts of respondents' misunderstandings regarding the questionnaire were clarified immediately. Each of employees filled in questionnaires including three blocks: PfS scale (Burger, 1995), roster of intra-firm advice network (Soda and Zaheer, 2012) and a set of demographic questions.

With 77 out of 83 employees agreeing to participate in the survey, we have obtained 93 percent response rate. The head of design engineering department and his vice were asked to evaluate creative performance of their subordinates. It took up to 15 minutes to complete the survey for respondents and up to 2 hours for evaluators.

Variables

PfS

PfS was measured with classic scale developed by Burger (1995) (Cronbach's Alpha was equal to 0,638). In over two decades, this scale has been explicitly used and validated by scholars in psychology and social sciences (e.g., Cramer and Lake, 1998; Ren et al., 2015). PfS scale consists of twelve pairs of contradicting statements capturing behavioral preference in particular situation or context. For each of the questions, respondents were suggested to select one statement that described them better. These are examples of statements indicating positive PfS:

> 1) After spending a few hours surrounded by a lot of people, I am usually eager to get away by myself.
>
> 2) I like to vacation in places where there are few people around and a lot of serenity and quiet.

For every answer indicating willingness to encounter solitude rather than be accompanied by others respondent receives one point, otherwise zero. Thus the closer the overall score is to twelve, the higher is PfS. Scores closer to zero, on the contrary, indicate low levels of PfS.

Centrality

Degree centrality captures individual's position in the whole advice network within the R&D department (Soda and Zaheer, 2012). In order to calculate it, we adopted network roster approach. In this section of the questionnaire, each respondent was given a list with names of all employees of the R&D department and was asked to mark those to whom they refer for work related advice. For the sake of simplicity, this section was split to eight blocks corresponding to eight sub-departments where employees work on the regular basis.

The final value of degree centrality for each respondent was represented by numeric value computed by merging individual questionnaires into one matrix and summing up the rows. Thus for employee *i*, degree centrality value reflects the number of *i*'s colleagues who have marked *i* as their advice giver.

Collaborative environment

We have introduced a dummy variable for collaborative environment. There were several distinctive characteristics to consider an environment for certain sub-department collaborative or not. First of all, organizational routines were discussed with the top manager and the head of department prior to data collection. Secondly, we these sub-deparments were placed in one large open box office, which genuinely enhances the collaboration between teams.

Non-collaborative environment, on the other hand, included (a) lock off valves sub-department that was physically isolated from the rest, as it was located in a separate remote building; (b) automatization processes implementation, employees of which were not involved in team work; (c) GOST sub-department that was not engaged in team work either.

Creative performance

The dependent variable was measured with classic creative performance rating scale, Oldham and Cummings' (1996) Integrated Creativity (Cronbach's Alpha was equal to 0,723). With three-items scale, supervisors evaluated the degree to which each of the employees in the sample produces output that is novel and useful to the organization.

Seven-point Likert scale was applied, and for each employee, the results were averaged to form a unitary creative performance index (e.g., Sue-Chan and Hempel, 2016, Shin et al., 2016).

Control variables

We used demographic data from questionnaires to constitute control variables for statistical analysis. We controlled for age, gender and tenure.

———————*-insert Table 1 here* ———————-

Results

Table 1 reports descriptive statistics and bivariate correlations amongst variables for High PfS part of the sample. Creative performance has been found to be correlated positively with PfS, and negatively with collaborative environment and gender. Table 2 presents descriptive statistics and bivariate correlations for Low PfS part of the sample. As expected, intercorrelations are not found between PfS, degree centrality and collaborative environment in none of the two subsamples, indicating that these dimensions of interaction are indeed independent. Mean creative performance was relatively high, and slightly higher for Low PfS's than for High PfS's. Similarly, mean degree centrality of Low PfS's exceeded that of High PfS's. As for control variables, there has not been a significant difference in the mean values for the two subsamples.

———————*-insert Table 2 here* ———————-

Table 3 contains results of regression analysis. *Model 1* and *Model 3* are run for control variables, while in *Model 2, Model 4* and we control for company experience and job rank.

Model 2 tests hypotheses for High PfS part of the sample. Hypothesis 1 suggested that creative performance of individuals with higher levels of PfS relies primarily on internal resources as represented by PfS. This hypothesis is supported. Hypothesis 2 stated that the aforementioned relation will be negatively moderated by degree centrality. In fact, the model shows the opposite effect of the moderator. Hypothesis 3 assumed negative impact of collaborative environment on creativity of High PfS's, and this hypothesis was supported.

Model 4 is run for Low PfS subsample. Hypothesis 4 stated that such people prefer to rely on external resources when working on creative output, thus their creativity will be associated with degree centrality. This hypothesis holds. Hypothesis 5 proposed negative moderating effect of PfS. The coefficient is negative indeed, but yet insignificant. Lastly, Hypothesis 6 proposed that collaborative environment will be driving creativity of Low PfS's. Instead, we face the opposite effect.

———————*-insert Table 3 here* ———————-

Discussion

A rich body of knowledge of creativity in interpersonal networks has promoted the idea that individual creativity is affected by the position in the network, claiming, among the rest, that central agents typically demonstrate higher levels of creativity, as they essentially have more means to for such performance. While this and other organizational behavior lines of research have emphasized the overall importance of embeddedness into the social structure for creative performance, personality literature viewed the phenomenon from another angle, concentrating on individual differences as creativity drivers. An interplay of network position and personality traits as creative performance determinant has barely been studied, and nor has the phenomenon of PfS ever been taken into consideration in such context. Thus we enrich the interpersonal network theory with dimension of individual PfS that captures individual predisposition to communication or offishness and, in a way, the ability to reap seeds of advantageous network position in terms of creativity. With a view of taking an integrated approach to this issue, we conceptualized that individual creativity can depend on combination of PfS, degree centrality and collaborative environment. We stated that for people scoring low on PfS, extrinsic factors are driving creativity, while for high PfS people it is the opposite. Hence we come up with a novel model of interplay of personality traits and network position. The developed model suggests a novel angle to organizational creativity and allows to consider both intrinsic characteristics of an individual and extrinsic characteristics of the social environment.

The results of our exploratory study are encouraging. The finding that people with low PfS are more creative when they hold central positions in the network supports our logic. From this perspective, when network agents are open and willing to communicate, and at the same time they dispose high degree centrality, their creativity flourishes. Besides increased emotional comfort, they have all the benefits of efficient networking, of which they do make good use. Without network centrality, however, low PfS's wither. External orientation of these creators does not receive reply and acceptance of the social context. Such involuntary solitude not only triggers dissatisfaction (Nguyen et al., 2018), but also rules out support, sufficiently constrains non-redundant information inflow and takes away the power in the organization. All together, it results in worse creative performance. This idea is perfectly in line with social side of creativity literature (Amabile et al., 2005; Perry-Smith and Shalley, 2003; Sosa, 2011; Tang, 2016; Perry-Smith and Mannucci, 2017) that perceives networking as a powerful antecedent to individual creativity.

The other finding is more intriguing. As counterintuitive as it seems, our theory and results demonstrate that in the context of intra-firm advice network, high PfS, when combined with

high network centrality, leads to better creative performance. On the one hand, it indicates that PfS indeed is a creativity driver, as it allows one to focus, unwind, and enhance unique personal vision. Being intrinsically oriented by relying on their inner resources, High PfS's unfold their creative potential in disengagement from instant interactions (Storr, 1988; Long et al., 2003). On the other hand, on the contrary to what we expected, such people also benefit from network centrality, and it complements their PfS. In this way, High PfS can rely both on intrinsic and extrinsic resources, rather then just on intrinsic ones. Interpreting these results, we make a suggestion that predisposition to solitude can be crucial during idea generation phase, when recombination of existing information plays a major role (Perry-Smith and Mannucci, 2017) and requires considerable cognitive effort. On consequent stages of creative process, however, it is support, trust, and ability to reach consensus that matters. In engineering department setting, creative tasks are commonly fulfilled in a team, and ability to reach necessary network contacts and gain their understanding can be necessary for creative success.

Perhaps surprisingly, both High and Low PfS encountered lower creativity levels when placed in collaborative environment. In case of High PfS's, we assumed that collaborative environment can indeed be a hinder, as it pushes one out of comfort zone and can be associated with disturbance, boredom and inability to focus on work-related issues. The magnitude of this effect increases significantly when such collaboration promotion is embedded deeply into organizational routines. Possibly, same logic works also for people scoring low on PfS. Focusing so much on individual differences in terms of attitude to solitude, we might have missed that at times we all might need this condition for our emotional comfort and subsequent creative productivity. Collaboration, when imposed administratively at top management level, significantly affects organizational culture, and does not take into consideration the needs of specific subdepartment, team or an individual. In this vein, even naturally open and outgoing people start to long for more privacy and quietness at work place.

More generally speaking, our findings are valuable to the young discipline of social networks and personality, as we introduce a new personality trait to the field. Besides, it has been previously shown that personality traits affect ones network position and structure (Landis, 2016), but less attention has been paid to outcomes of such consequences (Fang et al., 2015), and particularly no one have focused on how it may result in creator's performance.

Our research is also important from contextualization of network research perspective. Our attempt here was to draw attention to the fact that network effects have different magnitude in various context, and that sometimes non-mainstream variables can intervene into the well-studied mechanism.

Thus, in design engineering department of a company operating in gas machinery industry, degree centrality can have negative impact on individual creativity due to the specificity of the profession that requires a sufficient amount of time spent in solitude and attracts a particular kind of personality. Consequently, it is not enough to suggest a network mechanism under a novel dressing, but it should be contextualized in terms of such aspects as industry, firm specifics, organization routines, culture and other.

Managerial applications are foreseeable as well. In a way, our findings encourage employers to appreciate and make use of employees' personal predisposition to solitude, acknowledging its role as creativity driver. This issue is very topical considering universal pressure to networking (Casciaro et al., 2016) and design thinking boom. We claim that it is crucial to consider employees' willingness, ability and comfort to network, and therefore to estimate the aftermath of the push to collaborate more. In many cases, networking can trigger individual creativity, but in other cases, it can also suppress it, especially when imposed in administrative manner as in case of collaborative environment.

As a first study to mix PfS and social networks, this study is not free from its limitations. One of the drawbacks is the fact that PfS has not been considered in its interplay with personality traits that are better established in organizational behavour field, such as the Big Five or self-monitoring (Fang et al., 2015). Even though PfS has been tested for possible correlations with aforementioned personality traits (e.g., Burger, 1995), such test has never been run in the setting similar to one of this study, focusing on individuals separately rather than a part of social group. In a way, it is possible that PfS will demonstrate a certain extent of overlap with introversion, and there is not enough evidence to prove or disprove it. However, our attempt here was not to promote the prominence of PfS as personality trait, but rather to address the behavioral predisposition caused by it.

We also acknowledge that some structural elements of the network remained out of focus, including the one that is most commonly referred to creativity or innovativeness, namely, the brokerage. Such restriction rules out additional explanans of PfS — creativity relation.

This article uncorks a bottle of opportunities for interdisciplinary research. Firstly, as degree centrality in intra-firm networks is often associated with managerial position, that, in turn, often appears to constrain individual creativity in a dynamic perspective (e.g., Perry-Smith and Shalley, 2003), it is crucial to make a note on the aspect of PfS, as it can provide an advanced explanation behind complex processes of network evolution in their relation to creative performance. Further, it is worth to test the model in the context another industry, where creative outputs are more social in nature and less thing-oriented (Graziano et al., 2011), and to draw comparisons between the two settings. Here, it is quite likely that advantages of PfS will have different magnitude or direction. Another interesting aspect to consider is the routine of creative people with high PfS. Despite the fact that his question was out of scope of the current piece of research, it is important to understand qualitatively the core difference of high PfS's from low PfS's in organizational context. Thus one of the future directions of research can be a close-up on how high PfS's work, how do they perceive and direct their interactions, how do they react to extrinsic stimuli and what are the levels of their responsiveness. Answering these questions can lead to weighty managerial implications, as it may help to navigate organizational processes in such a way that highly creative people with strong predisposition to solitude are placed in a comfortable environment where they optimize their inner resources.

We fundamentally believe that the dimension of PfS can also compliment those streams of social networks research that do not focus solely on creativity. In this vein, innovation, individual and team performance, cognitive networks and more can take the phenomenon of PfS into consideration.

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Table 1. Descriptive statistics and correlations for High PfS

	Variable	Mean	S.D.	Min.	Max.	1	2	3	4	5	6	7
1	Creative performance	4,20	1,59	1,00	7,00	1						
2	PfS	8,00	1,78	6,00	11,00	0,323*	1					
3	Centrality	15,80	8,27	0,00	36,00	0,183	0,131	1				
4	Collaborative	0,59	0,50	0,00	1,00	-0,320*	-0,042	0,045	1			
5	Overall experience	17,09	12,93	0,70	52,00	0,057	-0,017	0,210	0,215	1		
6	Gender	0,31	0,468	0,00	1,00	-0,351*	-0,085	-0,326*	0,217	0,022	1	
7	Age	38,69	12,87	22,00	72,00	0,053	-0,032	0,227	0,226	0,991**	0,012	1

notes: N=39

*significance: *p < 0.05, **p < 0,01*

Table 2. Descriptive statistics and correlations for Low PfS

	Variable	Mean	S.D.	Min.	Max.	1	2	3	4	5	6	7
1	Creative performance	4,69	1,52	1,00	7,00	1						
2	PfS	3,84	1,31	0,00	5,00	0,079	1					
3	Centrality	18,18	9,94	0,00	42,00	0,175	0,108	1				
4	Collaborative	0,71	0,45	0,00	1,00	-0,323*	-0,168	0,278	1			
5	Overall experience	16,77	12,10	3,00	44,00	0,130	-0,020	-0,078	-0,236	1		
6	Gender	0,39	1,52	0,00	1,00	-0,098	0,057	-0,125	0,159	0,259	1	
7	Age	38,21	11,54	23,00	57,00	0,102	-0,025	-0,039	-0,166	0,986**	0,280	1

notes: N=39

*significance: *p < 0.05, **p < 0,01*

Table 3. Regression results estimating the effects of PfS and degree centrality on individual creative performance

Dependent variable: individual creative performance				
	High PfS		**Low PfS**	
	Model 1	*Model 2*	*Model 3*	*Model 4*
PfS		0,255*		
Centrality				0,342*
PfS x Centrality		0,257*		-0,171
Collaborative		-0,311**		-0,345*
Overall experience	0,404	-0,617*	0,979	0,794
Gender	-0,355**	0,641*	-0,119	-0,006
Age	-0,342		-0,830	-0,725
Constant	5,350	3,747	6,969**	6,603**
R-sq.	**0,129**	**0,344**	**0,055**	**0,216**
F	1,731	2,802**	0,655	1,423

notes: Low PfS, N=38; High PfS, N=39

*significance:*p < 0.1, **p < 0.05*