

Clustering of Workers Based on The Effect of Downward Social Comparison

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Abstract

Although many companies have applied the social comparison theory to motivate the workers for improving their performance, the reason why social comparison sometimes is successful and other times not, is still not fully understood. Recently, we have built a structural equation model to clarify the psychological mechanism that the workers' personality traits, mediated by their social comparison orientations, affect their response to the downward social comparison, and consequently have a significant influence on the workers' motivation and performance. In this paper, we extend our previous research and conduct a clustering analysis of the workers based on the factor scores of personality traits, social comparison orientations, motivation and efficiency. This paper places our emphasis on offering more detailed insight into the workers' proportion that how many workers respond positively or negatively to the downward social comparison, and providing some key points for practitioners to enhance the effect of downward social comparison.

Keywords

social comparison, comparison orientation, motivation, five factor personality, structural equation model, clustering

1. Introduction

The productivity of a company plays a key role in its profitability and competitiveness. In a variety of manufacturing enterprises, using automated processes within the manufacturing processes can improve their productivity levels and products quality, as well as profits. However, there are still many tasks such as manual assembly that need to be processed by hand, it is as important as ever to improve workers performance. Meanwhile, there are a great number of useful methodologies for achieving increased productivity, such as industrial engineering, the Kaizen method or philosophy. Motivation is also a powerful energy that drives and excites workers, which results in their maximum performance.

In order to improve workers' performance, some factories have applied social comparison theory to prompt workers to compete against each other so as to raise workers' motivation towards assembly tasks. As there is a lack of researches on the effect of social comparison on workers' performance for assembly tasks, we have designed a laboratory experiment of cell production to investigate the effect of social comparison (Dong and Kakehi 2018) and clarified that the workers' performance could be significantly increased by averagely 20% via announcing the performance ranking of each worker in a group to all group members every 15 to 20 minutes. Based on another experiment result from 69 participators (Cao et al. 2020), we further demonstrated that the comparison direction has

significant influence on the workers' performance, and the upward comparison could enhance the productivity by 2% than the downward comparison.

Recently, we have built a structural equation model to clarify the psychological mechanism how the downward social comparison motivates the workers, or how the workers' personality traits, mediated by their social comparison orientations, affect their motivation and performance (Dong et al. 2022). According to this model, it is clear that (i) in the case of downward comparison, the higher the workers' scores on extraversion and playfulness, the higher their motivation and performance; (ii) the downward comparison is not suitable for the workers who score high on the tendency towards to ability-based comparison or emotionality.

1.1 Objectives

This paper intends to extend our previous research (Dong et al. 2022) and conduct a clustering analysis of the workers based on the factor scores of personality traits, social comparison orientations, motivation and efficiency. We aim at offering more detailed insight into how the workers respond to the downward social comparison, and making the following contributions:

- (1) Structural equation modeling (SEM) is currently one of the most discernible analytical strategies in the literature that is being developed across many fields of the social sciences (Tarka 2018), a great number of SEM models have been built to explain many processes and phenomena occurring in society and economy. However, almost all of researches put their emphasis on the explaining of the targeted processes and phenomena through the SEM models, there is a lack of study to consider the factor scores of individuals behind a SEM model. In this paper, we extract the factor scores of personality traits, social comparison orientations and motivation for each worker according to the SEM model, and then conduct a cluster analysis based on the worker's factor scores and their performance.
- (2) Instead of explaining the psychological mechanism that personality traits affect the social comparison process, and consequently influence individual's motivation and job performance, this paper places our emphasis on figuring out the workers' proportion that how many workers respond positively or negatively to the downward social comparison, and how to identify the workers who respond differently to the downward social comparison.
- (3) Although many companies have applied the social comparison theory to motivate the workers for improving their performance, the reason why social comparison sometimes is successful and other times not, is still not fully understood. Almost all of the companies conduct social comparisons according to the supervisors' experiences or intuitions. This paper intends to provide some key points for practitioners to conduct social comparisons more effectively.

2. Literature Review

Social comparison theory was first proposed by psychologist Leon Festinger (1954). Social comparison refers to a behavior where individuals seek to better understand their status relating to ability, opinion, emotional reaction, and more, by comparing themselves to other people. There are two kinds of social comparison: upward social comparison and downward social comparison (Buunk and Gibbons 2007). When we engage in upward social comparison, we compare ourselves to someone who is (perceived to be or performing) better than we are. In contrast, when we engage in downward social comparison, we compare ourselves to someone who is (perceived to be or performing) worse than we are. Some researchers have argued that the effect of upward or downward social comparisons depends on the individual. The direction of the comparison does not guarantee only positive or negative outcomes.

There is substantial differences in the extent to which, and the frequency with which people compare themselves with others. Gibbons and Buunk (1999) proposed the concept of social comparison orientation (SCO) to refer to the personality disposition of individuals who are strongly oriented to social comparison, particularly sensitive to their own standing relative to others, and interested in information about others' thoughts and behaviors in similar circumstances. Some researchers have showed that those high in SCO seek out more comparisons, spend more time engaging in comparisons, and experience more emotional reactions from comparing themselves with others (Buunk and Gibbons 2006).

Because competition is realized by a comparison of own self with the other members of the group, many researches have argued that social comparison processes fuel the motivation to compete, and social comparison is an important source of competitive behavior (Buunk and Gibbons 2007; Garcia et al. 2013). Numerous management methods

targeting to enhancing the effect of social comparison and consequently workplace performance have been widely applied in various organizations.

Performance feedback is a typical tool to promote social comparison processes for developing employees' behavior performance. Many studies have shown that performance feedback can inspire the intrinsic motivation of employees, and increase the level of technical and behavioral efficiency (Steelman et al. 2004; Fong et al. 2019). Drawing on theoretical insights from research on social comparison processes, Gino and Staats (2011) explored how managers can use performance feedback to sustain employees' motivation and performance in organizations. They showed that direct negative feedback (e.g., employees learn their performance falls in the bottom of their groups) leads to improvements in employees' performance, while direct positive feedback does not significantly impact performance.

Gamification in the workplace is a recent innovation in employee motivation systems, which refers to the use of game techniques in a non-game context. Organizations create internal competitions to engage employees in a healthy "race" and incorporate scores, levels, and prizes, as extra motivation (Hinton et al. 2019). Gamification allows employees to use social comparison information to compare themselves with others. As a consequence, enterprise gamification directly shapes social comparison behavior. Wanick and Bui (2019) conducted a contemporary and inclusive review of initial applications of gamification to various management fields, and they analyzed and mapped the main applications of gamification in management contexts (e.g. human resources, marketing, finance, services, logistics and supply chain and accountability) considering its core features, strategies, motivations and purpose.

Meanwhile, personality is one of the major psychological factors affecting the human behavior, and personality traits have an important role in enhancing the efficiency and effectiveness of employee's job performance. The relationship between personality and job performance has been a frequently studied topic in industrial psychology in the past century (Barrick et al. 2001). The Big Five Model, also known as the Five-Factor Model, is the most widely accepted personality theory held by psychologists today. The theory states that personality can be boiled down to five core factors: openness to experience, conscientiousness, extroversion, agreeableness, and neuroticism. Many studies have been conducted on the Big Five model and behavior, and how these traits can somewhat predict a person's workplace social behavior and performance (Barrick and Mount 1991; Judge and Ilies 2002; Lado and Alonso 2017; Hjalmarsson and Dåderman 2020). Several researches have demonstrated the big five personality dimension that has the biggest influence on job performance is conscientiousness (Dudley et al. 2006; Liu et al. 2022).

3. Experiment Design and Questionnaires

3.1 Experiment and Downward Comparison

Intending to clarify the psychological mechanism of how downward social comparison motivates workers for manual assembly, we designed a laboratory experiment that uses a toy robot as the virtual good. The toy robot is built up of LEGO Mindstorms and consists of 106 parts. The assembly process is divided into 17 tasks that must be completed according to the given order. The workers record the operation times required to complete every task while doing the assembly operation. The assembly operation and time measurement are repeated five times. We use the assembly time, the operation time required to assemble one toy robot, to measure the workers' performance. The details about this experiment was described in our previous study (Dong and Zhu 2020).

The downward comparison was conducted as the following:

- (1) While the workers are doing the assembly operation, a supervisor checks the assembly times for each of the workers every 15 minutes, and then determine the rank of the workers in ascending order of operation time.
- (2) The supervisor announces the names of the lower half of the workers (the workers with longer time) and their ranks. The announcement is conducted by showing the workers' name on a projection screen or making a statement orally.

3.2 Personality and Comparison Orientation

As the five-factor model (FFM) of personality is the most widely accepted personality theory, this study applies the FFM to measure the workers' personality. The FFM is a hierarchical organization of personality traits in terms of five broad trait dimensions or domains: extraversion, agreeableness, conscientiousness, neuroticism, and openness to experience (Gosling et al. 2003). For the purpose of adapting the FFM to Japanese words and Japanese personality, the Japan Institute of FFPQ has developed a 150-item questionnaire in 1998, named as the five-factor personality questionnaire (FFPQ) (Study Group of the FFPQ 2002). It measures five super traits: introversion vs. extraversion

(EX), separateness vs. attachment (A), naturality vs. conscientiousness (C), unemotionality vs. emotionality (EM), practicality vs. playfulness (P).

Concretely, we use the short version of the FFPQ: FFPQ-50. It is a 50-item questionnaire, which were carefully chosen from 150 items of the FFPQ. Each of the items is rated on a 5-point scale ranging from 1 (disagree strongly) to 5 (agree strongly). The FFPQ-50 has also a hierarchical organization of personality traits. Each super trait consists of five component traits (25 in total). Moreover, each component trait corresponds to two items of the questionnaire.

Furthermore, we use the Iowa-Netherlands Comparison Orientation Measure (INCOM) (Gibbons and Buunk 1999) to measure the social comparison orientation of the workers. This self-report scale has been proven to be valid and reliable based on a wide range of empirical tests. It contains 11 items and differentiates between two dimensions of social comparisons that are distinct in people’s underlying nature: (a) ability-based comparison (Items x1-x6); referring to the question “How am I doing?” and (b) opinion-based comparison (Items x7-x11); referring to the question “What shall I feel/think?”. Each dimension includes one item that is reverse-coded (item x5 and x11). The INCOM scale has previously been transferred to the Japanese version by Toyama (2002), we use this Japanese version.

4. Structural Equation Modelling

We conducted the assembly operation experiment described above during the period from October 2018 to January 2019. As the workers, 81 students of Fukushima University participated in the experiment. As there was one missing value in one worker’s assembly times, and two outliers were detected from the assembly times of another one worker, 79 valid samples were collected.

According to the experiment results, and the answers to the questionnaires of FFPQ-50 and INCOM from the 79 workers, we have built an acceptable SEM model, as shown in Figure 1 (Dong et al. 2022). Here we used the negative

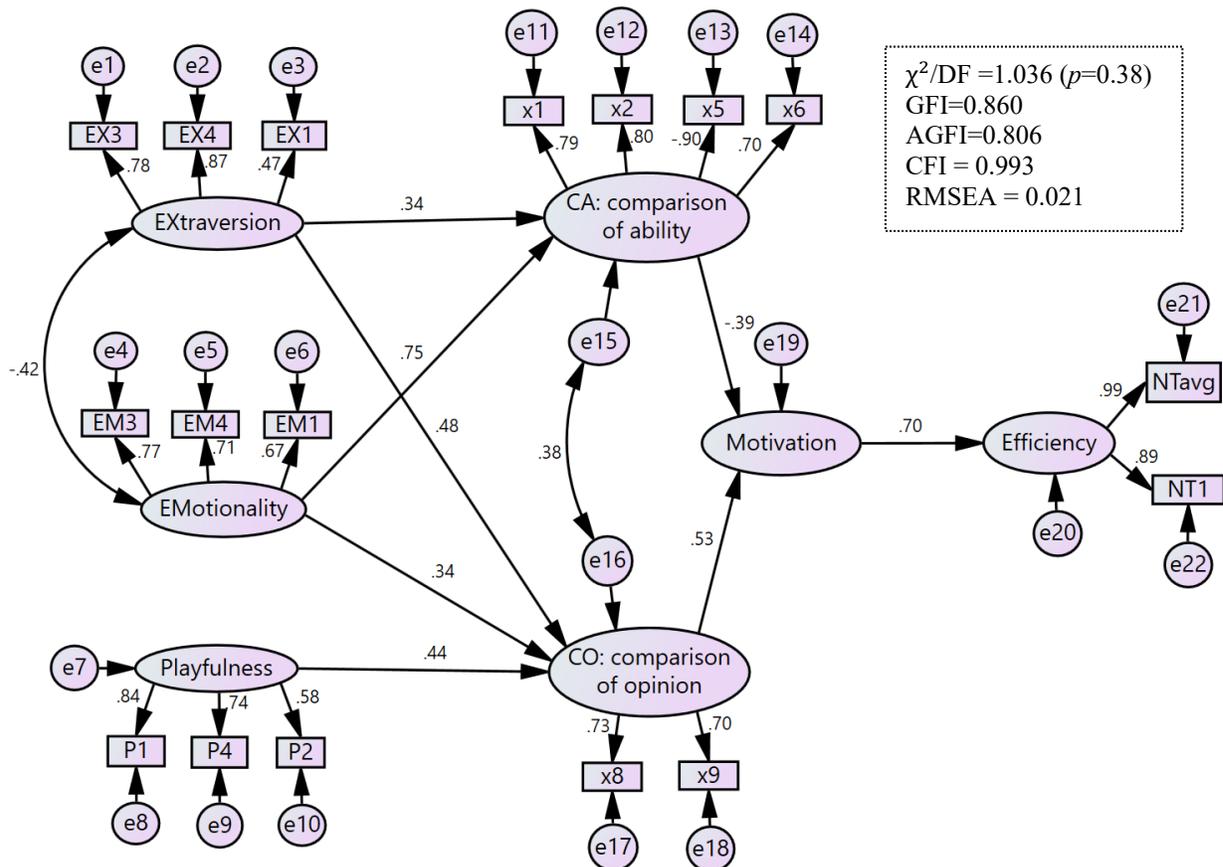


Figure 1. The structural equation model with standardized parameters

values of t_1 (assembly time at the first assembly operation) and t_{avg} (average of the assembly times for five assemblies), denoted as NT1 and NTavg respectively, as the observed variables to characterize efficiency. This SEM model was built using IBM SPSS Amos 20 and specifying the maximum likelihood method to estimate the model parameters.

According to the SEM model of Figure 1, it is clear that: (i) Social comparison process may be more complex than most researchers thought, and among the five personality traits there are only three of them having significant effects on social comparison orientations in the case of downward comparison. The emotionality has a very large positive effects, extraversion and playfulness have medium positive effects on social comparison orientations. (ii) In the case of downward comparison, opinion-based comparison (CO) has a large positive effect on motivation, and ability-based comparison (CA) contributes negatively to motivation because of non-social restraints. This result means that downward comparisons is not suitable for the workers who score high on the tendency toward ability-based comparison. (iii) The higher the workers' scores on extraversion and playfulness, the higher their motivation and efficiency. The downward comparison is suitable to motivate the workers with higher scores on extraversion and playfulness. However, emotionality has negative effect on both motivation and efficiency.

5. Clustering

Because the downward comparison is not a one-size-fits-all solution for increasing motivation and improving performance, it is important to examine the workers' response more detailly to the downward comparison. After building the SEM model of Figure 1, we could obtain the factor scores of personality traits, social comparison orientations, motivation and efficiency. Here, we used the function of AMOS Data Imputation, and chose regression imputation to save the latent variable scores and observed variable values.

As the factor scores of the latent variables and the workers' performance (t_1 and t_{avg}) exhibit a non-normal distribution,

Table 1. One-way ANOVA test across clusters

	Source	Type II Sum of Squares	df	Mean Square	F	Sig.
3 cluster	t_1	10.35	2	5.17	20.83	0.000
	t_{avg}	11.00	2	5.50	34.26	0.000
	emotionality	11.81	2	5.91	15.71	0.000
	extraversion	3.33	2	1.66	6.04	0.004
	playfulness	4.38	2	2.19	6.41	0.003
	CA	10.57	2	5.29	29.98	0.000
	CO	15.22	2	7.61	36.39	0.000
	motivation	11.71	2	5.85	51.73	0.000
	efficiency	10.73	2	5.37	34.37	0.000
4 cluster	t_1	13.00	3	4.33	20.01	0.000
	t_{avg}	13.37	3	4.46	34.01	0.000
	emotionality	17.87	3	5.96	19.85	0.000
	extraversion	4.55	3	1.51	5.76	0.001
	playfulness	4.67	3	1.56	4.56	0.005
	CA	10.72	3	3.57	20.23	0.000
	CO	16.24	3	5.41	27.31	0.000
	motivation	13.52	3	4.51	49.78	0.000
	efficiency	13.05	3	4.35	34.16	0.000
5 cluster	t_1	13.10	4	3.28	15.03	0.000
	t_{avg}	13.77	4	3.44	27.02	0.000
	emotionality	25.63	4	6.41	32.16	0.000
	extraversion	6.86	4	1.72	7.30	0.000
	playfulness	4.81	4	1.20	3.49	0.012
	CA	14.75	4	3.69	29.56	0.000
	CO	16.27	4	4.07	20.29	0.000
	motivation	13.54	4	3.38	36.97	0.000
	efficiency	13.41	4	3.35	27.01	0.000

we conducted the normalization by robust Z score method, according the following equation:

$$\text{robust Z score} = \frac{x - \text{MD}(x)}{\text{NIQR}(x)}$$

where MD(x) is the median, and NIQR(x) is the normalized interquartile range of x.

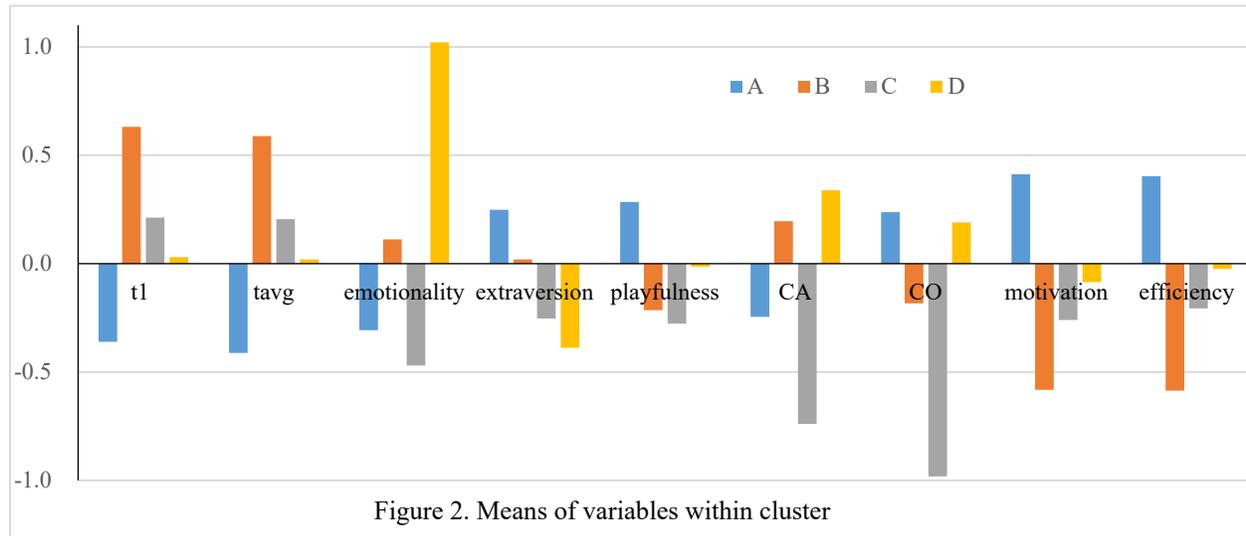
Based on the robust Z scores of the seven factor scores: emotionality, extraversion, playfulness, CA (ability-based comparison), CO (opinion-based comparison), motivation and efficiency, and the assembly time t_1 and t_{avg} , we conducted a hierarchical cluster analysis. Here, we used SPSS Statistics 20, and chose the Ward's method as the cluster method, the square Euclidian distance as the distance measure. Giving cluster number =3, 4, 5 respectively, we could obtain three significant cluster patterns, as shown in Table 1.

6. Results and Discussion

In order to investigate the differences between the clusters, we further conducted the multiple comparison test by Tukey's honestly significant difference (HSD). According to the proportion of variables with significant difference between every two clusters and whether it is easy to explain the clustering pattern, we chose the clustering pattern with cluster number=4 as the final solution. The variable means within each cluster is shown in Table 2 and the bar chart is given in Figure 2.

Table 2. Means of variables within cluster

Cluster	N	t_1	t_{avg}	emotionality	extraversion	playfulness	CA	CO	motivation	efficiency
A	31	-0.361	-0.412	-0.307	0.249	0.284	-0.245	0.237	0.412	0.403
B	22	0.631	0.589	0.112	0.020	-0.214	0.195	-0.183	-0.582	-0.586
C	15	0.213	0.205	-0.470	-0.254	-0.277	-0.739	-0.981	-0.260	-0.206
D	11	0.030	0.020	1.021	-0.388	-0.014	0.338	0.190	-0.085	-0.024



The p -value of the multiple comparison test to perform pairwise comparisons between cluster means for each variable is shown in Table 3.

According to the results of Table 2, Table 3 and Figure 2, we can figure out the characteristics of each cluster.

- (1) Cluster A: The workers of cluster A have positive scores on the opinion-based comparison orientation, and negative scores on the ability-based comparison orientation. As CO (comparison of opinion) has a stronger positive effect on motivation and efficiency, and CA (comparison of ability) gives a negative influence to motivation and efficiency, the workers of cluster A were most strongly motivated through the downward comparison, and they were at the highest level of efficiency among the four clusters. Moreover, this cluster's workers have the highest scores on both extraversion and playfulness, the lower scores on emotionality.

Table 3. Result of the multiple comparison test by Tukey's HSD (*p*-value only)

Cluster		t_1	t_{avg}	emotionality	extraversion	playfulness	CA	CO	motivation	efficiency
A	B	0.00%	0.00%	3.73%	38.42%	1.59%	0.19%	0.61%	0.00%	0.00%
A	C	0.11%	0.00%	78.16%	1.36%	1.62%	0.20%	0.00%	0.00%	0.00%
A	D	8.68%	0.58%	0.00%	0.38%	47.12%	0.10%	99.03%	0.01%	0.57%
B	C	4.34%	1.19%	1.16%	38.83%	98.86%	0.00%	0.00%	1.06%	1.14%
B	D	0.43%	0.03%	0.01%	14.61%	78.89%	79.37%	11.42%	0.02%	0.03%
C	D	75.62%	57.17%	0.00%	91.23%	66.92%	0.00%	0.00%	46.58%	57.32%

- (2) Cluster B: The workers of cluster A have negative scores on the opinion-based comparison orientation, and positive scores on the ability-based comparison orientation. While they have a stronger tendency to engage in ability-based comparison, but have a comparatively weaker tendency to compare opinion with others. According the effect of CO (comparison of opinion) and CA (comparison of ability) on motivation and efficiency, the downward comparison had most strongly negative influence on the motivation of this cluster's workers. That is, the downward comparison decreased significantly the efficiency of cluster B's workers. Noting that the workers of cluster B do not score very high or very low on the three personality traits: emotionality, extraversion and playfulness, they are just inconspicuous or average people.
- (3) Cluster C: This cluster's workers score the lowest on CO (comparison of opinion) and CA (comparison of ability) among the four clusters. This means that these workers have a very weak tendency to engage in social comparison. Because they have little response to social comparison, the downward comparison has almost no effect on these workers. The workers of cluster C can be identified according that they have comparatively lower scores on all of the three personality traits: emotionality, extraversion and playfulness.
- (4) Cluster D: Although the workers of cluster D have positive scores on the opinion-based comparison orientation and this contributes to increase efficiency, they have the highest and positive scores on the ability-based comparison orientation, and this gives a very strong negative effect on efficiency. The positive effect of the opinion-based comparison orientation and the negative effect of the ability-based comparison orientation cancel each other out, as a whole these workers were not strongly motivated and therefore their efficiency is at the average level. This result suggest that it is necessary to improve the procedure of the downward comparison to decrease the negative effect of the ability-based comparison orientation. It's easy to identify the workers of cluster D according to the fact that they have the strongest scores on emotionality.

7. Conclusion

According to the results of section 6, we can give the following evidences on how the workers respond the downward social comparison.

- (1) Thirty-one (39.2%) workers of 79 (cluster A) responded significantly and positively to the downward comparison. These workers have the highest scores on both extraversion and playfulness.
- (2) There were 22 (27.8%) workers of 79 (cluster B) who are negatively motivated through the downward comparison, and their efficiency was decreased significantly. These workers don't have very high or very low score on the three personality traits (emotionality, extraversion and playfulness).
- (3) Fifteen (19.0%) workers of 79 (cluster C) have a very weak tendency to engage in social comparison. These workers almost mode no response to the downward comparison. These workers are characterized by low scores on all of the three personality traits: emotionality, extraversion and playfulness.
- (4) The downward comparison has both positive and negative effect on the efficiency for a small number (14.0%) of the workers (11 out of 79 workers, cluster D). They have the highest scores on emotionality.

From these evidences, we can provide the following key points for practitioners to conduct social comparisons more effectively

- (1) The downward comparison described in section 3.1 is suitable to motivate the workers who have the higher scores on both extraversion and playfulness.
- (2) There are 27.8% of the workers who respond negatively to the downward comparison. Therefore, the downward comparison described in section 3.1 is not appropriate to motivate these workers. However, these workers have average scores on the three personality traits (emotionality, extraversion and playfulness), it may be not easy to identify them.

- (3) There are 19.0% of the workers who barely respond to the downward comparison. These workers can be easily identified through the fact that they have comparatively lower scores on all of the three personality traits: emotionality, extraversion and playfulness.
- (4) A small number (14.0%) of the workers with the strongest emotionality respond contradictorily to the downward comparison. The procedure of the downward comparison should be improved to decrease the negative influence of the ability-based comparison orientation. For example, we can announce the assembly times and the ranks for the half of the workers with longer assembly times, while not announcing the workers' name.

Because the above results were obtained based on the small sample size ($n=79$), the workers' proportion in the four clusters may change if the sample size is increased. It is necessary to increase sample size to confirm the above results. Moreover, we are going to improve the procedure of the downward comparison and conduct some new experiments.

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