

Relationship between Decision-Making and Executive Function in Conditions of Age, Risk, and Decision-Making Styles

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Abstract: A narrative review of the relationship between decision-making and executive function. Iowa Gambling Task and Cognitive Reflection Test, these two Adult Decision-Making Competence tasks, were used to measure individuals' executive function and decision-making abilities. Age, risk level, and other characteristics all impact the link between decision-making and executive function. These factors, which play an essential variable, were discussed in the review. Research for five decision-making styles correlates with the executive function, including rational, intuitive, dependent, avoidant, and spontaneous. They were also discussed and compared with the age factors. Moreover, the dangers like internet disorder and pathological gambling, which come from the deficit of executive function, have been argued.

Keywords: Executive function, decision-making, working memory

1. Introduction

Executive function (EF) and decision-making (DM) are both crucial concepts in cognitive psychology. The executive function represents the CPU in the human brain, deciding the program's running speed and accuracy. On the other hand, decision-making represents the preferences of an individual and how they judge the situation and make choices. It seems to be randomly distributed, for different people share different favour. However, decision-making is well-regulated. Good decision-making functioning can guide goal-direct decisions, so bright and experienced managers can make correct decisions even if it seems would temporarily lead to negative results.

Scholars' arguments about The relationship between decision-making and executive function are constant. Many researchers believed that individuals' decision-making was associated with their executive function. For example, the executive function could preserve decision-making from stress and pressure [1]. In contrast, others argued that different decision-making bases impact differently on executive functions. The relationship between decision-making and executive function was inconsistent. For instance, executive function is positively linked with spontaneous decision-making in their correlation analyses, according to Fatima et al. [2]. Still, it negatively correlates with age,

dependent decision-making, and avoidant decision-making. As a result, psychology professionals require a study that examines the connection between decision-making and executive function.

2. Method

The academic databases Web of Knowledge and Google Scholar were used to conduct a thorough literature search. The following search terms and their derivatives were entered: executive function, decision-making, under risk, cognitive process, cognitive distortions, and problematic behaviour. Studies were included if they: (i) the topic has to include both executive functions and decision-making and discuss the relationship between executive function and DM; (ii) has to include moderators or specific conditions (ii) published in recent 40 years; (iii) published in English.

3. Literature Review

3.1. Definition

3.1.1. Executive Function (EF)

Executive function can be divided into working memory (WM), inhibition, and shifting. According to an influential taxonomy, working memory is a temporary information storage system helpful in remembering details that will be recalled in minutes. Working memory supports information to be quickly searched and processed, and working memory can protect it from distractions. Inhibition is a self-control ability to resist the temptation of immediate rewards. Shifting is a system that allows processing through different tasks and can turn on specific working memory for the tasks.

3.1.2. Decision-making (DM)

Decision-making refers to a mental process of making a reasonable choice from possible selections. In decision-making, considering every option, valuing the positive and negative of each choice, and predicting the potential consequences of each choice are necessary, according to Reason [3]. The decision-making outcome can be a specific action, a verbal opinion, or an attitude towards the affair.

Decision-making can be classified into ambiguous decision-making and risky decision-making. Decision-making is essential in everyone's daily life, according to Gathmann et al. [1]. However, decisions can be distinguished. Decisions made under normal living conditions are simple, but crucial decisions under high pressure are difficult. Decisions under ambiguity are when no consequences information is provided before the decision, according to Brand et al. [4]. People must decide to depend on their instinct and experience by guessing the possible outcomes [5]. If relevant consequences information is provided, and the information is enough to predict the opportunity cost, it is called decisions under risks [4]. People can decide decisions under risks through valuation.

3.2. Research Paradigm

3.2.1. Adult Decision-Making Competence (A-DMC)

Decision-making competence is prescribed by decision-making theory. It is the ability to judge consistently and decide accurately [6, 7]. Also, it is related to a better life caused by good decisions [6, 8](Bruine de Bruin, Parker, & Fischhoff, 2007; Parker, Bruine de Bruin, Fischhoff, & Weller, 2018).

In DMC, the adult is different from the non-adult, and arguments about them are constant. However, the argument is irrelevant to our topic, so there are no more specific details about their differences

included in this paper. To be mentioned two following tasks were all based Adult-Decision-Making Competence.

3.2.2. Iowa Gambling Task (IGT)

IGT measures the learning ability to choose options with a positive expected value [9]. A classic IGT, for instance, ask participants to continually select cards from 4 sets of cards. Among 4 card sets, two are ‘good’ (low risk, small gains, and a positive payoff), and two are ‘bad’ (high risk, big gains, and a negative payoff). This IGT can measure how participants would manage their risks and payoff.

3.2.3. Cognitive Reflection Test (CRT)

CRT measures how participants inhibit their instinct from misleading to find the correct answers to mathematical problems. CRT contains a series of mathematical problems that always lead to incorrect instinct reactions; therefore, participants must resist the instinct and answer correctly [9, 10]. The inhibition abilities are what CRT is measured. In a classic CRT, for example, What is the cost of the ball if both a bat and a ball cost \$1.10, but the bat is \$1 more expensive? The correct response is \$0.05; however, it is simple to give an incorrect answer of \$0.10. Through this CRT, participants’ response time and correction are recorded, representing their abilities on inhibition.

3.2.4. The Comparison between the Two Tests

IGT measures mainly the participants' decision-making, and CRT measures the inhibition abilities, which is a part of the executive function of the participants.

3.3. The Relationship between Decision-making and Executive Function

In general, research has proved that there is a relationship between executive function and decision-making, which tends to be positive. Fabio Del Missier found that the monitoring/inhibition dimension of the executive function was weakly associated with the IGT score, and highly related to performance on two A-DMC tasks (resistance to framing and implementing decision rules). According to past research, executive function and decision-making have a strong relationship, and the connection is affected by moderators.

3.3.1. The Relationship between EF and DM in Different Conditions

It could be found that The relationship between decision-making and executive function varies with specific conditions, such as age and risky situations.

3.3.1.1. Age

A significant moderator that affects executive function in decision-making is age. There is a positive correlation between age and executive function, thus enhancing decision-making. The executive function may have mediated the relationship between age and three types of decision-making for young adults to middle-aged adults, including dependent, avoidant, and spontaneous decision-making, according to a study by Fatima et al. [2]. Results showed that executive function is an important factor in decision-making, particularly during middle adulthood. However, this study is limited as it has a small sample size of only 195 male adults, making the results less reliable and generalizable to the whole population. Moreover, the small sample size threatens the validity of the study as empirical data cannot be established. Despite this flaw, a different study that used a process-tracing approach with two different decision tasks to evaluate behaviours in younger and older persons supports the

idea that older adults are adaptive decision-makers. It was shown that in settings with little self-implications, older persons were more inclined than younger adults to use straightforward solutions. The small sample size is one of this study's limitations, however.

Secondly, does executive function also affect decision-making under risk situations at a younger age where cognitive abilities are less developed? A study suggests that despite knowing the consequences, children and adolescents frequently make risky decisions. This could be due to developing cognitive control brain areas. Age-related variations in risky decision-making may be influenced by executive processes and reasoning, which do not fully develop until adolescence. The study uses The Game of Dice Task, completed by 112 8-19-year-olds, to assess risky decisions (GDT). Executive functioning was assessed using the Modified Card Sorting Test and Ravens Progressive Matrices (categorization, cognitive flexibility, and strategy maintenance). According to the findings, executive functions rather than reasoning were found to have a moderating effect on the effect of ageing on risk-taking in the GDT. Young people with poor executive function make risky choices. Therefore, it would seem that young people's decision-making about risky situations is influenced by the maturation of executive functions linked to the prefrontal cortex. The study's result is supported by another study by Brand and Markowitsch [11, 12], which also emphasizes the importance of age on executive function. The results of the study at hand point toward executive functions as an important component explaining developmental changes in decision-making. On the other hand, there are also other potential factors affecting executive function's effect on decision-making. Finucane and Lees [13] proposed that numerous individual factors, such as a person's cognitive style, experience, or numeracy, could influence decision-making ability. For the current study, there is also a main limitation. The study only used one measure of executive functioning, which does not allow the decomposition of the subcomponents in executive functions that are accountable for the changes in decision-making performance that have occurred over time.

3.3.1.2. Risk Situation

One could claim that decision-making, particularly in high-risk scenarios, is significantly influenced by executive function. The study conducted by Schiebener and Johannes investigated the effect of the three executive functions: general control (includes inhibiting the initiation of automatically imposing responses), monitoring of behaviour (determining whether the current strategy and the goal are compatible), and concept formation (categorisation of information, detection of task rules) on decision-making under objective risk. The research looked into seven major SEM models with dangerous mediation assumptions. According to the findings of the study, executive control over behavior and cognition can predict decision-making performance. General control is essential in making risky decisions, even though the monitoring and concept formation tests did not directly predict decision-making performance. The study might be constrained because there is no empirical evidence that the tasks involve these domains. Burgess [14] refers to it as task impurity. The results were impacted by individual characteristics, making them less generalizable to society.

3.3.2. Different Decision-making Styles Correlate with Executive Function

The various decision-making styles also impact the relationship between decision-making and executive function, as was already mentioned. In general, five types of decision-making styles were discussed before (General Decision-making Style (GDMS) [15]. They are rational, intuitive, dependent, avoidant, and spontaneous. Each style of decision-making correlates differently with EF, according to Fatima et al. [2]. To access five of those decision-making styles, The GDMS scale is introduced in their research [16]. On the other hand, they used Color-Word Interference Test to access the executive function. It was also accessed by Delis–Kaplan Executive Function System [16] Design

Fluency Test and the Design Fluency Test [17] for a part of research. The correlation between executive function and five decision-making styles is discussed after participants run through all tasks.

As a result, executive function is positively linked with rational decision-making and shares a weak relationship with intuitive decision-making. Three other decision-making styles show a significant relationship with age. In contrast, executive function positively correlates with spontaneous decision-making but is negatively linked with age, dependent decision-making, and avoidant decision-making.

Fatima et al. [2] suggested that the emerging differences among different types of decision-making correlate with executive function because adults with well-developed executive function make decisions without dependence on or avoidance of issues, but with more spontaneous and sensible considerations. When people get a better executive function ability, they can consider different aspects simultaneously and not be influenced by personal emotions in decision-making. Therefore, they did not need to make their choice dependently or evasively, which is the opposite of executive function skills. However, with age growing, executive function skill seems to decline, and people prefer dependent and avoidant decision-making styles. Still, early studies or direct evidence have not supported the argument.

The research written by Fatima et al. [2] provided a whole new horizon for The relationship between decision-making and executive function, but the limitations are many. The researchers tested participants' executive function and decision-making independently, and they found a correlation between the scores of the tasks. This method cannot prove the direct relationship between executive function and decision-making. Secondly, the research mentioned the age relationship with executive function and found that people's executive function declined through age. However, they did not summarise the period of declining age, for every human becomes more mature through age at their first life stage, which contradicts their findings. Thirdly, no inclusion or exclusion criteria were listed in the paper. How they recruited their participants have not been mentioned.

3.3.3. The Dangers of Executive Functioning Deficit

The deficit in executive functioning is evidence of problematic behaviours. For example, a study by Zhou and Zhu [18] tested whether patients with pathological gambling (PG) and those with Internet addiction disorder (IAD) displayed similar traits in terms of working memory, executive function, and impulsivity. Moreover, Individuals with IAD are more impulsive than PG patients, according to research, and both they and PG patients exhibit deficits in working memory, executive dysfunction, and impulsivity. Another research study found that poor impulse control, limited executive function, and abnormalities in reward processing are seen in both chemical and behavioral addictions. For instance, it was found that in pathogenic gambling, there were cognitive distortions. A number of eating disorders, especially those that are linked to eating behaviour, are characterised by abnormalities in risk appraisal and impulsivity. The dorsolateral prefrontal cortex, which is responsible for monitoring executive functions, is also connected with internet addiction disorder's riskier decision-making and increased choice impulsivity.

4. Conclusions

In conclusion, in this literature review, the definition of executive function and decision-making is explored under various circumstances and their relationship. Such as, under risky and addictive situations, participants were shown to have limited executive function and increased impulsivity. Participants with better executive functioning were proven to perform well on decision-making tasks.

However, there are exceptions. Dependent and avoidant decision-making show a negative relationship with executive function, and intuitive decision-making almost shares no connection with

executive function. Therefore, The relationship between decision-making and executive function is conditional. No unified interpretation is made, and more research is needed on this topic.

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