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Optimistic and pessimistic decision making with dissonance reduction using interval-valued fuzzy sets

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ABSTRACT

Interval-valued fuzzy sets have been developed and applied to multiple criteria analysis. However, the influence of optimism and pessimism on subjective judgments and the cognitive dissonance that accompanies the decision making process have not been studied thoroughly. This paper presents a new method to reduce cognitive dissonance and to relate optimism and pessimism in multiple criteria decision analysis in an interval-valued fuzzy decision environment. We utilized optimistic and pessimistic point operators to measure the effects of optimism and pessimism, respectively, and further determined a suitability function through weighted score functions. Considering the two objectives of maximal suitability and dissonance reduction, several optimization models were constructed to obtain the optimal weights for the criteria and to determine the corresponding degree of suitability for alternative rankings. Finally, an empirical study was conducted to validate the feasibility and applicability of the current method. We anticipate that the proposed method can provide insight on the influences of optimism, pessimism, and cognitive dissonance in decision analysis studies.

1. Introduction

The concept of interval-valued fuzzy sets (IVFSs) is defined by an interval-valued membership function [50,80], and the degree of membership of an element to a set is characterized by a closed subinterval of [0, 1]. Many useful methods have been developed to enrich IVFS theory, and IVFSs have been applied in interval-valued logic [61] and preference modeling [62]. Wang and Li [65] defined interval-valued fuzzy numbers and interval-distribution numbers. In addition, they provided a starting point for real-world applications. Deschrijver [18] introduced arithmetic operators in IVFSs. Vlachos and Sergiadis [64] established a unified framework that includes the concepts of subsets, entropy, and cardinality for IVFSs. Wu and Mendel [67] provided definitions of the centroid, cardinality, fuzziness, variance, and skewness of interval type-2 fuzzy sets. Bustince et al. [8] presented a method to construct IVFSs (or interval type 2 fuzzy sets) from a matrix (or image) and analyzed their application to edge detection in grayscale images. Sanz et al. [52] enhanced the performance of fuzzy rule-based classification systems by extending the knowledge base with the application of the concept of IVFSs. Sun et al. [58] defined an interval-valued relation and built an interval-valued fuzzy information system. Yager [78] generalized level sets and provided the basis for the extension of set mapping operations to the case of IVFSs. Zeng and Guo [83] proposed a new axiomatic definition of the IVFS inclusion measure and examined the relationships between the normalized distance, similarity measure, inclusion measure, and entropy of IVFSs. Yager [74] introduced ordered weighted averaging (OWA) operators. Bustince et al. [9] proposed a class of aggregation functions, which include two-dimensional OWA operators. They showed that if we

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apply these aggregation functions to IVFSs, we can obtain an ordered family of fuzzy sets. To aggregate interval-valued intuitionistic fuzzy information, Xu [71] used the Choquet integral to propose correlated averaging and geometric operators for interval-valued intuitionistic fuzzy processes. Built upon the concepts of score and accuracy functions, Xu [72] developed a method based on distance measure for group decision-making with interval-valued intuitionistic fuzzy matrices. Wang et al. [66] found that the score and accuracy functions together still cannot tell the difference between two distinct interval-valued intuitionistic fuzzy numbers in some situations; thus, they introduced a membership uncertainty index function and considered the difference of the uncertainty in the membership and non-membership functions.

Because the decision information given by decision makers is often imprecise or uncertain due to a lack of data, time pressure, or the decision makers' limited attention and information processing capabilities [73], research pertaining to multiple criteria decision analysis (MCDA) problems has most often been performed in a fuzzy environment [12,79,84]. In addition, because it may be difficult for decision makers to exactly quantify their opinions as a number in the interval [0,1], it is more suitable to represent this degree of certainty by the interval [1,69]. IVFSs are suitable for capturing imprecise or uncertain decision information; however, little attention has been given to the effect of dispositional optimism and pessimism on MCDA. Optimism and pessimism, concepts developed by Scheier and Carver [53], are fundamental constructs that reflect how people respond to their perceived environment and how they form subjective judgments. Although theories differ in their specifics, a common idea is that optimists and pessimists diverge in their explanations and predictions of future events [22]. Optimists interpret their lives positively and anticipate desirable outcomes, whereas pessimists view their lives negatively and expect unfavorable outcomes [51]. Previous studies have shown that compared with individuals who are generally pessimistic, optimists report better adjustment to a variety of stressors, including dietary habits and smoking behavior [36]; pregnancy [48]; taking care of seriously ill relatives [23]; the serious health threats involved with undergoing bypass surgery [55]; idiosyncratic personal goal-directed activities [34]; coping strategies and stress reduction [33]; the inevitable pain of failure [51]; economic concerns such as utility adjustment [6] and portfolio and savings choices [49]; and financial intermediation [15].

Although the effects of optimism and pessimism on mental and physical health have been thoroughly investigated, only a few attempts have been made to determine how optimists and pessimists organize their thinking and conceptualize MCDA. Hey [30] demonstrated that the Hurwicz procedure can handle a decision problem optimistically or pessimistically. The Hurwicz procedure is an amalgamation of the maximin and maximax methods and employs a pessimism-optimism index because it takes both the worst and the best outcomes into account. However, this method is inadequate when considering an entire multiple criteria problem because of the noncompensatory nature of the selection process [32]. Yager [75] suggested a pseudo probability distribution to reflect the decision maker's attitude by applying OWA operators, and demonstrated that the Hurwicz approach is a special case of his method. Using a similar idea, Yager [76] proposed that the orness measure with an OWA operator can be interpreted as a measure of optimism in decision making, while andness measures pessimism. Furthermore, Yager [77] developed an attitudinal fuzzy measure that is generated with a cardinality index to characterize attitudes, including optimistic, neutral, and pessimistic characteristics. The risk attitude of a decision maker as proposed by Yager is defined in one dimension with optimism and pessimism as two opposing extremes, where people are categorized as optimists, neutralists, or pessimists. However, most psychological studies have indicated that optimism and pessimism belong to divergent dimensions [10,11,14,29,54]. That is, human beings might have both optimistic and pessimistic tendencies at the same time. Therefore, a more precise method is needed to handle optimism and pessimism in decision-making. This study addresses the effects of optimism and pessimism separately; moreover, the degree of determinacy associated with the membership of the element is taken into account to capture hesitation that is influenced by optimism and pessimism. The proposed methods can be adapted to real-world problems by adjusting the parameter values based on the role of optimism and pessimism in the particular application.

Very few studies have been conducted on the concept of dissonance in decision analysis based on IVFSs. The concept of dissonance has been discussed widely in the field of social psychology [26]. Festinger [19] described cognition dissonance as a psychologically uncomfortable state that motivates an individual to reduce that dissonance. Festinger [19] and Straits [57] showed that whenever people make a decision, they often have some degree of cognitive dissonance. Faced with the necessity of choosing among noninferior/nondominant alternatives, the decision maker collects and evaluates available information on the alternatives and eventually establishes a preference order. When a person makes a decision based on available alternatives, each of which has certain advantages and disadvantages over the others, varying levels of post-decision dissonance result [5,44]. More specifically, decision makers have doubts and anxieties about the choices they have made because the rejected alternatives had certain desirable traits and the selected option has undesirable characteristics that they must now accept or tolerate. The magnitude of post-decision dissonance has been shown to increase in important (high involvement) decisions [43,44]. On the other hand, Festinger [20] and Mittelstaedt [45] suggested that dissonance increases with the number of rejected alternatives.

If the post-decision dissonance experienced by the decision maker is great enough, it could cause that individual to withdraw the choice or exchange one alternative for another. In other words, a high level of dissonance may cause decision makers to reduce dissonance by switching their choice [45] or by justifying their decision post hoc [38]. The preference order does not stabilize because dissonance exists, and so the decision maker has to adjust the decision situation and make a new choice. Thus, dissonance may increase decision effort and increase overall cost. Therefore, to achieve effective decisions, it is crucial to minimize post-decision dissonance. Because the decision maker's cognitive dissonance may negatively influence the stability of the decision results, it is important to discuss methods to decrease cognitive dissonance. A literature