KLIR: Annotated References

Abellán, J. and G. J. Klir, 2005, Additivity of uncertainty measures on credal sets, *Intern. J. of General Systems*, 34, 691-713. [CD]

One of the requisite properties of uncertainty measures is the property of additivity, which is associated with the concept of independence. For credal sets, the concept of independence is not unique. This means that different concepts of independence lead to different definitions of additivity for uncertainty measures. It is shown that the two primary concepts of independence – the mass independence and the strong independence – are indicators that show which of two competing measures nonspecificity is better justifies for each particular class of credal sets.

Abellán, J. and S. Moral, 2005, Difference of entropies as a non-specificity function on creedal sets, *Intern. J. of General Systems*, 34, 203-217. [CD].

Difference of maximum and minimum entropy for credal sets is suggested and investigated as a prospective measure of nonspecificity for the first time.

Abellán, J., G. J. Klir, and S. Moral, 2006, Disaggregated total uncertainty measure for credal sets, *Intern. J. of General Systems*, 35, 29-44. [CD]

A disaggregation of total aggregated uncertainty with respect to minimum entropy measure is introduced and investigated. Nonspecificity under this disaggregation is measured by the difference between the maximum and minimum entropy functionals (Abellán and Moral, 2005), and conflict is measured by the minimum entropy functional.

Andrés, D., 2007, *Infinite Random Sets and Applications in Uncertainty Analysis*, Dissertation (Ph.D.), University of Innsbruck, Austria.

This dissertation contains a proof of uniqueness of the Hartley-like measure of uncertainty.

Aumann, R. J. and L. S. Shapley, 1974, *Values of Non-Atomic Games*. Princeton Univ. Press.

Measures that are more general than monotone measures are used in this book for the study of cooperative games with large numbers of players. See also Wang and Klir (2009).

Bronevich, A. and G. J. Klir, 2010, Measures of uncertainty for imprecise probabilities: An axiomatic approach, *Intern J. of Approximate Reasoning*, 51, 365-390. [CD]

In 2011, this paper contains the latest results regarding the issues of measuring the amount of uncertainty and uncertainty-based information in the various theories of imprecise probabilities. The paper also contains a brief historical overview of research on generalized uncertainty measures.

Chateauneuf, A. and J.-Y. Jaffray, 1989, Some characterizations of lower probabilities and other monotone capacities through the use of Möbius inversion, *Mathematical Social Sciences*, 17, 263-283.

A relationship between Choquet capacities of various orders and their Möbius representations is investigated in this paper. The obtained results make it easier to identify the type of any given Choquet capacity.

Chateauneuf, A., 1996, Decomposable capacities, distorted probabilities and concave capacities, *Mathematical Social Sciences*, 31, 19-37.

A representative paper containing some important results regarding decomposable measures.

Choquet, G., 1953-54, Theory of capacities, *Annales de L'Institut Fourier*, 5, 131-295.

This is a classic paper of great historical significance, in which an organized family of monotone measures of various orders is introduced. These measures play a central role in the area of imprecise probabilities. It is interesting that Choquet worked on the theory of capacities when he was a Visiting Research Professor at University of Kansas at Lawrence during the academic year 1953-54, and this large paper was actually first published as a Technical Report at the University of Kansas.

De Campos, L. M. and M. J. Bolaños, 1989, Representation of fuzzy measures through probabililities, *Fuzzy Sets and Systems*, 31, 23-36.

It is shown in this paper how lower or upper probability measures can be converted to the associated convex polytopes of probability distributions by determining their vertices (extreme points).

De Campos, L. M., J. F. Huete, and S. Moral, 1994, Probability intervals: a tool for uncertainty reasoning, *Intern. J. of Uncertainty, Fuzziness and Knowledge-Based Systems*, 2, 167-196.

An important early paper regarding the uncertainty theory based on reachable probability intervals and its comparison with the Dempster-Shafer theory.

De Cooman, G., 1997, Possibility theory (a set of three papers), *Intern. J. of General Systems*, 25, 291-371. [CD]

This seems to be the most comprehensive mathematical coverage of the theory of graded possibilities. However, the paper does not cover the issues of measuring uncertainty and information.

Dempster, A. P., 1967, Upper and lower probabilities induced by multivalued mapping, *Annals of Mathematical Statistics*, 38, 325-339.

This is the first thorough investigation of imprecise probabilities

Dubois, D. and H. Prade, 1982, A class of fuzzy measures based on triangular norms, *Intern. J. of General Systems*, 8, 43-61. [CD]

This is the first substantial paper on monotone measures based on t-norms, also called decomposable measures.

Dubois, D. and H. Prade, 1985, A note on measure of specificity for fuzzy sets, *Intern. J. of General Systems*, 10, 279-283. [CD]

It is shown in this paper that the generalized Hartley measure of uncertainty (nonspecificity), which was introduced (under the name "*U*-uncertainty) for the theory of graded possibilities in (Higashi and Klir, 1983a), can be further generalized to the Dempster-Shafer theory.

Dubois, D. and H. Prade, 2000, *Fundamentals of Fuzzy Sets* (Chapter 7). Kluwer, Dordrecht.

An overview of "state-of-the-art" of fuzzy mathematics in 2000.

Fine, T. L., 1973, *Theories of Probability: An Examination of Foundations*. Academic Press, New York.

This book is one of the most comprehensive studies of foundations of probability.

Geer, J. F. and G. J. Klir, 1991, Discord in possibility theory, *Intern. J. of General Systems*, 19, 119-132. [CD]

Discord, which was introduced as a counterpart of the Shannon entropy in the theory of graded possibilities, in mathematically analyzed in this paper. Since discord violate the essential property of subadditivity, it can be used only as a component in disaggregated total uncertainty.

Geer, J. F. and G. J. Klir, 1992, A mathematical analysis of information-preserving transformations between probabilistic and possibilistic formulations of uncertainty, *Intern. J. of General Systems*, 20, 143-176. [CD]

The transformations are analyzed for interval and log-interval scales. The primary results are: (i) the interval-scale transformation that preserves information always exist and is unique from probabilities to possibilities, but the inverse transformation does not always exist; (ii) the log-interval-scale transformation always exists and is unique in both directions; and (iii) the log-interval-scale transformation always satisfies the probability-possibility consistency requirement.

Harmanec, D., 1995, Toward a characterization of uncertainty measure for the Dempster-Shafer theory, *Proc. of the 1995 Conf. on AI in Montreal*, *Canada*, pp. 255-261. [Reprint]
This paper contains two important contributions to GIT: (1) a sound formulation of axioms for characterizing total aggregated measure of uncertainty in the Dempster-Shafer theory (further developed and generalized by Bronevich and Klir (2010)); and (2) a proof that the total uncertainty based on the maximum Shannon entropy (see Harmanec and Klir, 1994b) is, if not unique, the smallest of all total uncertainty measures satisfying the axioms.

Harmanec, D. and G. J. Klir, 1994a, On modal logic interpretation of Dempster-Shafer theory of evidence, *Intern J. of Intelligent Systems*, 9, 941-951. [Reprint]
The modal logic interpretation of Dempster-Shafer (DST) theory is further developed in this paper. It is shown how to represent the basic probability assignment as well as the commonality function of DST by modal logic. It is also proven that the modal representation of DST is complete for rational-valued functions (belief, plausibility, etc.).

Harmanec, D. and G. J. Klir, 1994b, Measuring total uncertainty in Dempster-Shafer theory: a novel approach, *Intern. J. of General Systems*, 22, 405-419. [CD]
A measure of total uncertainty introduced in this paper for the Dempster-Shafer theory (DST) is proven to satisfy all essential requirements. The measure is an aggregate of the two types of uncertainty that coexist in the Dempster-Shafer theory. It is based on maximizing the Shannon entropy under the constraints of belief and plausibility functions. The significance of this measure is that, contrary to all previously suggested measures, it satisfies the requirement of subadditivity.

Harmanec, D. and G. J. Klir, 1997, On information-preserving transformations, *Intern. J. of General Systems*, 26, 265-290. [CD]
Using the principle of uncertainty invariance based on the total aggregated uncertainty, transformations between the Dempster-Shafer theory, possibility theory and probability theory are investigated in this paper.

Harmanec, D., G. Resconi, G. J. Klir, and Y. Pan, 1996a, On the computation of uncertainty measure in Dempster-Shafer theory, *Intern. J, of General Systems*, 25, 253-263. [CD]
A useful algorithm for computating the total uncertainty in the Dempster-Shafer theory is proposed in this paper and its correctness is proven.

Harmanec, D., G. J. Klir, and Z. Wang, 1996b, Modal logic interpretation of Dempster-Shafer theory: an infinite case, *Intern. J. of Approximate Reasoning*, 14, 81-93. [Reprint]
Generalization of results from (Harmanec and Klir, 1994) and (Klir, G. J. and D. Harmanec, 1994) to infinite sets. It is proven that the modal logic interpretation of the Dempster-Shafer theory is complete in the infinite case as well.

Hartley, R. V. L., 1928, Transmission of information, *The Bell System Technical Journal*, 7, 535-563.
This is a historically significant paper, in which the notion of uncertainty-based information is introduced for the first time. Hartley derives a measure uncertainty associated with a subset of considered alternatives that contains all possible alternatives, and defines information in terms of uncertainty reduction. His derivation is based on intuitive grounds and is formally reasonable, but he does not prove the uniqueness of his measure.

Higashi, M. and G. J. Klir, 1982, On measures of fuzziness and fuzzy complements, *Intern. J. of General Systems*, 8, 169-180. [CD]
An axiomatic framework for formalizing the most general class of complements of fuzzy sets is introduced in this paper, and it is then employed for a mathematical analysis of a general class of functions for measuring degrees of fuzziness of fuzzy sets that is based on the view that the degree of fuzziness of a fuzzy set should characterize the lack of distinction between the set and its complement.

Higashi, M. and G. J. Klir, 1983a, Measure of uncertainty and information based on possibility distributions, *Intern. J. of General Systems*, 9, 43-58. [CD]

A generalization of the Hartley measure to the theory of graded possibilities was introduced (under the name "*U*-uncertainty") in this paper for the first time. It is proven in the paper that the introduced generalized Hartley measure satisfies all essential requirements, but a proof of uniqueness of this measure is not covered.

Higashi, M. and G. J. Klir, 1983b, On the notion of distance representing information closeness: possibility and probability distributions, *Intern. J. of General Systems*, 9, 103-112. [CD]
A metric information distance based on the generalized Hartley measure (*U*-uncertainty) is introduced in this paper for the theory of graded possibilities. It is applicable to any pair of normalized possibility distributions defined on a finite set of alternatives. It is shown that the measure is either unique or, if not unique, it is the largest information distance.

Jaynes, E. T., 1979, Where we stand on maximum entropy? In: *The Maximum Entropy Formalism*, ed by R. L. Levine and M. Tribus, MIT Press, Cambridge, Mass.
A large and very well-written article explaining the maximum entropy principle.

Joslyn, C., 1997, Measurement of possibilistic histograms from interval data, *Intern. J. of General Systems*, 26, 9-33. [CD]
This paper deals with construction of possibility measures from interval data.

Klir, G. J., 1987. Special Issue of *Fuzzy Sets and Systems* on Measures of Uncertainty, 24, pp. 139-254.
This Special Issue contains major results pertaining to GIT a few years before the name "Generalized Information Theory" was coined. Contributing authors: Dubois, Jumarie, Klir, Lander Mariano, Prade, and Ramer.

Klir, G. J., 1991, Generalized information theory, *Fuzzy Sets and Systems*, 40, 127-142. [Reprint]
In this paper, the notion of generalized information theory (GIT) was for the first time introduced.

Klir, G. J., 1993, Developments in uncertainty-based information, in *Advances in Computers*, ed. by M. C. Yovits, Academic Press, San Diego, 255-332. [Reprint]
An extensive overview of "state-of-the-art" of research in generalized information theory at that time.

Klir, G. J., 1995. Principles of uncertainty: What are they? Why do we need them?, *Fuzzy Sets and Systems*, 74, 15-31.
Three principles of uncertainty are introduced and discusses within the context of GIT: (1) principle of minimum uncertainty; (2) principle of maximum uncertainty; and (3) principle of uncertainty invariance.

Klir, G. J., 1999, On fuzzy-set interpretation of possibility theory, *Fuzzy Sets and Systems*, 108, 263-273.[Reprint]
This paper deals with the problem of fuzzy-set interpretation of possibility theory for subnormal fuzzy sets. The problem is resolved by requiring that: (1) evidence conveyed by a given subnormal fuzzy set is left intact by the interpretation; and (2) possibilistic normalization is satisfied by the interpretation. It is shown that under these requirements, the interpretation is unique and collapses to standard interpretation for normal fuzzy sets.

Klir, G. J., 2002, Uncertainty in economics: the heritage of G. L. S. Shackle, *Fuzzy Economic Review*, VII, 3-21. [CD]
The aim of this paper is to show that the British economist George Shackle developed for his economic theory a formalism that is isomorphic with the theory of graded possibilities.

Klir, G. J., 2003a, Uncertainty, in *Encyclopedia of Information Systems*, ed. by H. Bigdoli, Elsevier, 511-521. [Reprint]
A simple, encyclopedic survey of theories of uncertainty.

Klir, G. J., 2003b, Zobecněná teorie informace, in *Umělá inteligence*, edited by V. Mařík et al., Academia, Praha, 21-50.
This is the only overview of generalized information theory in Czech.

Klir, G. J., 2005, Measuring uncertainty associated with convex sets of probability distributions: a new approach, *2005 NAFIPS Meeting*, Ann Arbor, Michigan. [CD]
The important idea of disaggregation of total aggregated uncertainty is presented for the first time in this paper.

Klir, G. J., 2006, *Uncertainty and Information: Foundations of Generalized Information Theory*. John Wiley, Hoboken, NJ.
The book contains a comprehensive coverage of the "state-of-the-art" in GIT in 2006. It is written as a textbook with many solved examples, exercises, historical and bibliographical notes, and a large list of relevant references.

Klir, G. J., 2011, A note on the Hartley-like measure of uncertainty, *Intern. J. of General Systems*, 40, 217-229. [CD]
The paper illustrates how the Hartley-like measure can be used for measuring nonspecificity of standard fuzzy sets, interval-valued fuzzy sets, and fuzzy sets of type 2.

Klir, G. J. and D. Harmanec, 1994, On modal logic interpretation of possibility theory, *Intern. J. of Uncertainty, Fuzziness, and Knowledge-Based Systems*, 2, 237-245. (Reprint)
Application of results obtained by Resconi et al. (1992) to the theory of graded possibilities.

Klir, G. J. and H. W. Lewis, 2008, Remarks on "Measuring Ambiguity in the Evidence Theory", *IEEE Trans. on Systems, Man, and Cybernetics* – Part A, 38, 995-999. [CD]
In this paper, an error in the proof of the principal theorem in a paper published earlier in the same journal (vol. 36, 2006, pp. 890-903) is identified. The earlier paper introduces a functional on belief functions in the Dempster-Shafer theory and claims that it is fully justified as the measure of total uncertainty. Due to the identified error in the proof of subadditivity of this functional, the claim is not valid, which is also illustrated by a class of counterexamples.

Klir, G. J. and M. Mariano, 1987, On the uniqueness of possibilitic measure of uncertainty and information, *Fuzzy Sets and Systems*, 24, 197-219. [Reprint]
Using the requirements of symmetry, expansibility, additivity, monotonicity, branching, and normalization, it is proven in this paper that the generalized Hartley measure introduced (under the name "*U*-uncertainty") for the theory of graded possibilities in (Higashi and Klir, 1983) is unique when uncertainty is measured in bits.

Klir, G. J. and A. Ramer, 1990, Uncertainty in the Dempster-Shafer theory: a critical re-examination, *Intern. J. of General Systems*, 18, 155-166. [CD]
A new version of generalized Shannon entropy in the Dempster-Shafer theory that alleviates some deficiencies of previously suggested versions is introduced in this paper under the name "discord". Discord if further investigated in (Geer and Klir, 1991) and (Ramer and Klir, 1993).

Klir, G. J. and B. Yuan, 1995, On nonspecificity of fuzzy sets with continuous membership functions, *Proc. of the IEEE Conf. on Systems, Man, and Cybernetics*, Vancouver, IEEE Press, 25-29. [Reprint]
This paper is significant from the historical point of view. It contains the first presentation of Hartley-like measure for convex subsets (classical or fuzzy) of *n*-dimensional Euclidean spaces ($n \geq 1$).

Kolmogorov, A. N., 1950, *Foundations of the Theory of Probability*. Chelsea, New York.
This book, published originally in German in 1933, contains the first rigorous formalization of probability theory.

Kolmogorov, A. N., 1965, Three approaches to the quantitative definition of information, *Problems of Information Tramsmission*, 1, 1-7.

Kolmogorov was one of only a few researchers who clearly recognized the fundamental conceptual and mathematical difference between possibilistic information (which he calls in this paper a combinatorial approach) and probabilistic information. Kolmogorov's third approach to information described in this paper, which he calls an algorithmic approach, is not connected with uncertainty.

Martin, O. and G. J. Klir, 2007, Defuzzification as a special way of dealing with retranslation, *Intern. J. of General Systems*, 36, 683-701. [CD]
Defuzzification is viewed in paper as a replacement of fuzzy set with a crisp set that preserves the amount of information the given fuzzy set and, then, replacing the crisp set with the most representative singleton.

Mesiar, R., 2002, Fuzzy measures and generalized Möbius transform, *Intern. J. of General Systems*, 31, 587-599. [CD]
This paper further elaborates on the generalized Möbius transform that was first introduced by Shafer (1979). This transform is applicable to monotone measures defined on finite as well as infinite measurable spaces.

Molchanov, I., 2005, *Theory of Random Sets*, Springer, New York.
A comprehensive coverage of random set theory, an uncertainty theory closely connected with the Dempster-Shafer theory.

Pan, Y. and G. J. Klir, 1997, Bayesian inference based on interval-valued prior distributions and likelihoods, *J. of Intelligent and Fuzzy Systems*, 5, 193-203. [Reprint]
Employing the tools of interval analysis and the theory of imprecise probabilities, a method is developed in the paper for exact calculation of interval-valued posterior probabilities for given interval-valued prior probabilities and precise or interval-valued likelihoods.

Pan, Y. and B. Yuan, 1997, Bayesian inference of fuzzy probabilities, *Intern. J. of General Systems*, 26, 73-90. [CD]
Results from Pan and Klir (1997) are generalized in this paper, via the α-cut representation of fuzzy sets, from interval-valued probability distributions to fuzzy probability distributions.

Pollack, H. N., 2003, *Uncertain Science … Uncertain World*, Cambridge Univ. Press, Cambridge, UK, and New York.
One of the best conceptual books on uncertainty, especially on uncertainty in science.

Ramer, A., 1987, Uniqueness of information measure in the theory of evidence, *Fuzzy Sets and Systems*, 24, 183-196.
It is proven in this paper that the Hartley measure generalized to the Dempster-Shafer theory (Dubois and Prade, 1895) is unique.

Ramer, A. and G. J. Klir, 1993, Measures of discord in the Dempster-Shafer theory, *Information Sciences*, 67, 35-50. [Reprint]
The concept of discord introduced in Klir and Ramer (1990) is mathematically analyzed.

Ramer, A. and L. Lander, 1987, Classification of possibilistic uncertainty and information functions, *Fuzzy Sets and Systems*, 24, 221-230.
A relationship among axiomatic requirements for possibilistic uncertainty measure is investigated. It is shown that some form of possibilistic branching axiom is essential for proving uniqueness of the Hartley measure generalized to the theory of graded possibilities (Klir and Mariano, 1987).

Ramer, A. and C. Padet, 2001, Nonspecificity in R^n, *Intern. J. of General Systems*, 30, 661-680. [CD]
This paper contains a proof that the Hartley-like measure is additive for any finite n. It is also shown in the paper how the Hartley-like measure can be modified to apply to all bounded subsets of R^n ($n \geq 1$).

Ramer, A., J. Hiller, P. Diamond, and C. Padet, 1997, Total uncertainty revisited, *Intern. J. of General Systems*, 26, 223-237. [CD].
The paper reviews total uncertainty measure conceived as sums of nonspecificity and conflict, none of which satisfies the essential property of subadditivity.

Renyi, A., 1970, *Probability Theory*, North-Holland, Amsterdam (Chapter IX, Introduction to Information Theory, pp. 540-616).
The book contains (in Chapter IX) an elegant proof of uniqueness of the classical Hartley measure of uncertainty.

Resconi, G., G. J. Klir, and U. St. Clair, 1992, Hierarchical metatheory based upon modal logic, *Intern. J. of General Systems*, 21, 23-50. [CD]
It is shown in this paper that belief and plausibility measures of the Dempster-Shafer theory can be represented in terms of formal and semantic structures of modal logic.

Ruspini, H. E., 1991, Approximate reasoning: Past, present, and future, *Information Sciences*, 57-58, 297-317.
This paper includes a discussion of similarity interpretation of graded possibilities.

Shackle, G., 1968, *Uncertainty in Economics and Other Reflections*. Cambridge Univ. Press, Cambridge, UK.
Early observation of the important role of nonadditive measures in economics.

Shackle, G., 1969, *Decision, Order, and Time in Human Affairs*, Cambridge Univ. Press, Cambridge, UK.
Excelent exposure of Shackle's unique approach to economics, in which the theory of graded possibilities plays an an important role.

Shackle, G., 1979, *Imagination and the Nature of Choice*, Edinbugh Univ. Press, Edinburgh, Scotland.
Shackle's last book: a concise summary of his approach to economics with some new results.

Shafer, G., 1976, *A Mathematical Theory of Evidence*, Princeton University Press, Princeton, NJ.
An important special theory of imprecise probabilities, which is based on totally monotone measures is introduced in this book. The theory, which was inspired by the work of Dempster (1967), is now usually referred to in the literature as the Dempster-Shafer theory.

Shafer, G., 1979, Allocation of probability. *The Annals of Probability*, 7, 827-839.
In this paper, the author extends the Dempster-Shafer theory, which has largely been developed for fine sets of alternatives, to infinite sets.

Shannon, C. E., 1948, The mathematical theory of communication, *The Bell System Technical Journal*, 27, 349-424, 623-656.
This is a classic series of papers introduced a justified way of measuring uncertainty and uncertainty-based information for probability distributions on finite sets. The introduced measure, which is unique for each particular choice of a measurement unit (a particular normalization), is usually referred to as the Shannon entropy.

Shore, J. E. and R. W. Johnson, 1980, Axiomatic derivation of the principle of maximum entropy and the principle of minimum cross-entropy, *IEEE Trans. on Information Theory*, 26, 26-37.
It is shown in this paper how the principles of maximum entropy and minimum cross-entropy can be mathematically derived from four consistency axioms for inductive (or ampliative) reasoning.

Struck, P. and A. Stupňanová, 2006, *S*-measures, *T*-measures and distinguished classes of fuzzy measures, *Kybernetika*, 42, 367-376.
An important paper for prospective research on uncertainty theories based on decomposable measures.

Tanaka, H., K. Sugihara, and Y. Maeda, 2004, Non-additive measures by interval probability functions, *Information Sciences*, 164, 209-227.
A comprehensive mathematical treatment of the uncertainty theory based on reachable probability intervals.

Troffaes, M. and S. Destercke, 2011, Probability boxes on totally preordered spaces for multivariate modelling, *Intern. J. of Approximate Reasoning*, 52, 767-791. [CD]
Pairs of lower and upper cumulative distribution functions, usually called probability boxes or p-boxes, are formalized in terms of Walley's behavioral theory of imprecise probabilities. In particular, issues of constructing probability boxes and drawing infereces from them are investigated.

Vejnarová, J. and G. J. Klir, 1993, Measure of strife in Dempster-Shafer theory, *Intern. J. of General Systems*, 22, 25-42. [CD]
Strife is a functional that was introduced in the Dempster-Shafer theory as a prospective generalization of the Shannon entropy. It is shown in this paper that strife violate the essential property of subadditivity not only alone, but also when added with the well justified generalized Hartley measure. It can thus be used only as a component in a disaggregated total uncertainty.

Walley, P., 1991, *Statistical Reasoning with Imprecise Probabilities*. Chapman and Hall, London.
This is an important, classic book on imprecise probabilities. It focuses on the behavioral (betting) interpretation of probability theory and, as a consequence, mathematical treatment is primarily based on lower and upper previsions (expectations) rather than lower and upper probabilities.

Wang, Z. and G. J. Klir, 2009, *Generalized Measure Theory*, Springer, New York.
This book covers the relatively new mathematical theory of generalized measure theory quite comprehensibly. The primary focus is on monotone measures, which have often been referred to in the literature as fuzzy measures even though they do not involve any fuzziness. Several chapters in the book are devoted to the theory of integration associated with various types of monotone fuzzy measures. The book investigates Sugeno integrals, Choquet integrals, pan-integrals, and upper and lower integrals. Also included in the book is the subject of fuzzification of generalized measures.

Weichselberger, K. and S. Pöhlman, 1990, *A Methodology for Uncertainty in Knowledge-Based Systems*, Springer-Verlag, Berlin.
The focus of this book is on the theory of reachable (or reasonable) interval-valued probability distributions.

Zadeh, L. A., 1978, Fuzzy sets as a basis for a theory of possibility, *Fuzzy Sets and Systems*, 1, 3-28.
Using fuzzy-set interpretation, the theory of graded possibilities is introduced in this paper for the first time.

Zadeh, L. A., 2005, Toward a generalized theory of uncertainty (GTU) – an outline, *Information Sciences*, 172, 1- 40. [CD]
An outline of a research program that is complementary to GIT. The aims of GIT and GTU are similar, but they use very different approaches to achieve these aims. The GIT follows a bottom-up approach: starting from classical theories of uncertainty and developing their various generalizations. The GTU follows a top-down approach: starting with the most general conception of uncertainty and developing its various specializations. Thus far (in 2011), not much has actually been developed in the GTU program beyond the ideas presented in this paper.