

Jolanta Mazurkiewicz-Sokołowska (ed.)

Studies in Cognitive Linguistics and Multilingualism

Studies in Cognitive Linguistics and Multilingualism

Open Linguistic Debates of the 21st Century

Edited by

Jolanta Mazurkiewicz-Sokołowska
Michał Baran

Editorial Board

Sabine Asmus (*University of Leipzig, Germany*)
Bogusław Bierwiaczonek (*Jan Długosz University in Częstochowa, Poland*)
Reinhard Blutner (*University of Amsterdam, The Netherlands*)
Adam Głaz (*Maria Curie-Skłodowska University, Poland*)
Uwe Junghanns (*Georg-August University of Göttingen, Germany*)
Pia Knoeferle (*Humboldt University Berlin, Germany*)
Katarzyna Kwapisz-Osadnik (*University of Silesia, Poland*)
Javier Valenzuela Manzanares (*University of Murcia, Spain*)
Francisco Ruiz de Mendoza Ibáñez (*University of La Rioja, Spain*)
Günter Radden (*University of Hamburg, Germany*)
Joanna Szczęk (*University of Wrocław, Poland*)
Beatrice Wilke (*University of Salerno, Italy*)

VOLUME 1

The volumes of this series are peer-reviewed.

Studies in Cognitive Linguistics and Multilingualism

Edited by

Jolanta Mazurkiewicz-Sokołowska

V&R unipress

Printed with friendly support of the University of Szczecin.



ISSN 3055-4047

ISSN 3055-4055 (DIGITAL)

ISBN 978-3-8471-2020-9

ISBN 978-3-8470-2020-2 (PDF)

ISBN 978-3-7370-2020-6 (ELIBRARY)

DOI <https://doi.org/10.14220/9783737020206>

Bibliographic information published by the Deutsche Nationalbibliothek

The Deutsche Nationalbibliothek lists this publication in the Deutsche Nationalbibliografie;
detailed bibliographic data are available on the Internet at <https://dnb.dnb.de>.

© 2026 Brill Deutschland GmbH, Robert-Bosch-Breite 10, 37079 Göttingen, Germany

All rights reserved. No part of this publication may be reproduced, translated, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without prior written permission from the publisher. Text and datamining for commercial purposes requires the publisher's permission.

V&R unipress and Brill Deutschland GmbH are part of De Gruyter Brill.
www.degruyterbrill.com

Questions about General Product Safety Regulation: productsafety@degruyterbrill.com

Printing: CP1 books GmbH, Leck

Contents

- 1 Quantum Cognition and the Union of Thinking and Feeling: I. The Failures of Theories that Separate Thinking and Feeling 1
Reinhard Blutner
- 2 Quantum Cognition and the Union of Thinking and Feeling: II. The Qubit Approach to the Integration of Thinking and Feeling 13
Reinhard Blutner
- 3 Artificial Intelligence as a Tool for Cognitive Linguistics: a Critical Examination 28
Javier Valenzuela
- 4 On the Embodied and Social Origins of Concepts and Language 43
Bogusław Bierwiaczonek
- 5 Animal Metaphors Describing Humans in Italian (an Analysis of Dictionary Material) 64
Edyta Bocian
- 6 Colours Associated with HATRED among Spanish-Language Speakers: Survey Findings 80
Barbara Kosik-Szwejkowska
- 7 'Eco' as a Concept on the Spectrum between Environmentally Related and Unrelated 95
Jolanta Mazurkiewicz-Sokołowska
- 8 Perception and the Indefinite Article in French. A Cognitive Analysis 115
Katarzyna Kwapisz-Osadnik
- 9 Epistemic Focus and Intersubjective Grounding in the Lithuanian Verbal Prefix *be-*: a Discourse-Cognitive Perspective 128
Julija Korostenskienė

- 10 The Mapping of *Justice*: Corpora and Digital Tools in 21st-Century Discourse Analysis 153
Michał Szczyszek
- 11 Brown in Polish and Russian: Associations, Prototypical References and Valuation 180
Danuta Stanulewicz and Ewa Komorowska
- 12 Functional Multilingualism in a Romantic Relationship: Building Intimacy and Resolving Conflicts 195
Jakub Przybył, Agnieszka Stępkowska and Pavlo Dytynchenko
- 13 Designing Multilingual Talk Online: Code-Switching and the Uniqueness of Human Language 212
Katarzyna Buczek
- 14 Code-switching in Audio Subtitling: the Case of *Griselda* 232
Verónica Del Valle Cacula
- 15 Exophony and Multilingualism in Contemporary Belarusian Literature: A Review on Language(s) and Identities in Today's Literary Panorama 249
Angela Espinosa Ruiz

Quantum Cognition and the Union of Thinking and Feeling: I. The Failures of Theories that Separate Thinking and Feeling

Reinhard Blutner

Abstract In classical Cartesian theories of the body and mind, thinking and feeling are strictly separated domains. Early models of thinking and decision-making, for instance, are based on the general concept of rationality as developed in logic and decision theory. The classical idea is that rational agents are expected utility maximisers. Emotions and feelings, of course, do not play any role in these Cartesian models. In contrast, early models of feelings are derived from ancient rhetorical theories based on fixed rules. In music, for example, this system associates musical forms with specific emotions (the doctrine of affections). This approach essentially excludes processes of thinking. In this paper, I will outline some puzzles that demonstrate the inadequacy of theories which assume a strict separation between thinking and feeling. In the realm of rational decision-making processes, this relates to the well-known phenomenon of bounded rationality (Tversky and Kahneman). In music, it concerns the emergence of feelings and emotions when the role of thinking (anticipation) is ignored.

Keywords thinking – feeling – rational decision – prospect theory – probability theory – programme music – aesthetic feelings – musical expectancy

Introduction

To begin with, I would like to make a methodological remark about the narrative of science, based on the ideas of Adam Becker: “Science is about more than collecting data, applying mathematics and making predictions – it’s about building a picture of the way nature works. ... For any given set of mathematical equations, there’s an infinite number of stories we could tell about what those equations mean. Picking a good story, and then searching for holes in that story, is how science progresses” (Becker 2018).

Reinhard Blutner, ORCID: 0000-0002-4468-4796, University of Amsterdam

In this article, I will share my thoughts on the relationship between thinking and feeling. Classical Cartesian theories of thinking and feelings strictly separate the two domains. For example, early models of thinking and decision-making are based on the general concept of rationality, as developed in logic, probability theory, and decision theory. Cognitive scientists have adopted the concept of rational decision-making from mathematical economics and game theory. The classical idea is that rational agents are expected utility maximisers. Emotions and feelings, of course, play no role in these Cartesian models. In contrast, early models of feelings are derived from ancient theories of rhetoric, such as Plato's art of persuasion. These are described by a system of fixed rules. In music, for example, this system associates certain musical forms with specific emotions (the doctrine of affections). This approach essentially excludes processes of thinking.

Recent research, however, has provided increasing evidence of the failure of there being a strict separation between thinking and feeling. How can this failing be overcome? What is the best alternative narrative that can overcome this flaw? In this context, the recent emergence of a more unified view of the mind and matter has come into focus in the field of science: quantum-like modelling. Without delving into the mathematical specifics of the quantum approach, I will present this innovative method of unifying thought and emotion, as well as the mind and body.

The organisation of the paper is as follows: Section 1 presents earlier approaches to thinking and feeling, demonstrating their shortcomings. Section 2 critically considers the thesis that music is the language of emotion. I will demonstrate that the emergence of musical meaning and emotions cannot be understood by ignoring the role of thinking. In Section 3, a systematic connection between the structural aspects of music and the evocation of emotions and feelings is discussed. The paper ends with some preliminary conclusions.

In the second part of the considerations (Blutner, same volume), I will provide an overview of the quantum information (qubit) approach to thought and emotion, demonstrating why this approach facilitates the integration of thought and feeling. Furthermore, I will demonstrate how the puzzles raised in the first part can be solved using this novel approach. Finally, I will draw some general conclusions about the debate on mind and matter.

1 Earlier Approaches to Thinking and Feeling

In this section, I will outline some puzzles that illustrate the failure of theories that assume a strict separation of thinking and feeling. This concerns the

nature of decision processes when considering the domain of thinking and ignoring the influence of emotions. Furthermore, it is demonstrated that modifications to standard decision theory, such as those in prospect theory, cannot solve deep-seated problems.

Standard decision theory is based on the idea of rational decisions from mathematical economics and game theory (von Neumann and Morgenstern 1944, Savage 1954). In this theory, gambles or prospects f relate to certain (monetary) outcomes x_i which are achieved with probability p_i . The utility $u(x_i)$ is a direct expression of the monetary outcome x_i . The overall utility of a prospect f , denoted by $U(f)$, is the expected utility of its outcomes x_i as shown in formula (1):

$$U(f) = \sum_i p_i \cdot u(x_i) \quad (1)$$

The fundamental premise of classical decision theory is that rational agents select or prefer the prospect with the greatest utility – they are expected to maximise expected utility. A pictorial representation is given in Figure 1.1.

Unfortunately, there are many examples that demonstrate the shortcomings of classical decision theory. Attempts to overcome these issues have led to the development of the bounded rationality project, which was first proposed by Herbert Simon (Simon 1955). Simon claimed that we must replace the “global rationality of the economic man” with a type of behaviour that is compatible with the limitations of human decision-makers and the specific environments in which they operate. Boundedly rational agents experience limitations when it comes to formulating and solving complex problems, as well as processing information (i.e. receiving, storing, retrieving and transmitting that information). There are a number of ways in which “classical” models of ratio-

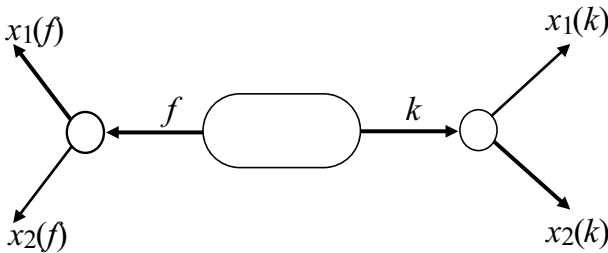


FIGURE 1.1 Typical decision problem. An agent must decide between two prospects, f and k , leading to payoffs $x_1(f)$ and $x_2(f)$ for prospect f and $x_1(k)$ and $x_2(k)$ for prospect k . In classical decision theory, prospect f is chosen over prospect k if the classical utility $U(f)$ is bigger than the classical utility $U(k)$.

nality can be made more realistic without losing rigorous formalisation. A good example is prospect theory (Kahneman and Tversky 1979):

In the classical theory, the utility of an uncertain prospect is the sum of the utilities of the outcomes, each weighted by its probability. The empirical evidence reviewed above suggests two major modifications of this theory: (1) the carriers of value are gains and losses, not final assets; and (2) the value of each outcome is multiplied by a decision weight, not by an additive probability. The weighting scheme used in the original version of prospect theory and in other models is a monotonic transformation of outcome probabilities (Tversky and Kahneman 1992).

Formally, prospect theory is given by the scheme (2):

$$U(f) = \sum_i \gamma(p_i) \cdot v(x_i) \quad (2)$$

The difference between the classical scheme (1) and prospect theory (2) is as follows: In the scheme (2), the outcomes $\gamma(p_i)$ are the stipulated decision weights and the values $v(x_i)$ are the carriers of value. Without further stipulations, Eq. (2) does not make empirical predictions and does not have any explanatory value.

The Nobel Prize winning prospect theory, fortunately, is explicit about the value function $v(x_i)$. This function is typically an exponential function of the outcome, and it takes reference points into account reflecting that losses hurt more than gains feel good – for instance by taking $v(x) = x^{.65}$ for $x \geq 0$ (gains) and $v(x) = -(-x)^{.75}$ for $x \leq 0$ (losses) (see Tversky and Shafir 1992: 308). Taking such stipulations into account, the value function is concave for gains (implying risk aversion), convex for losses (implying risk seeking), and steeper for losses than for gains (loss aversion).

Regarding the decision weights $\gamma(p_i)$, I think the situation is less satisfying than regarding the value function $v(x_i)$. To illustrate the point, let us consider two puzzles called the conjunction and disjunction fallacies.

The conjunction fallacy was described first by Tversky and Kahneman (1983). In one of their experiments, subjects are presented with a story such as the following one:

Linda is 31 years old, single, outspoken and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice, and also participated in anti-nuclear demonstrations. (Tversky and Kahneman 1983: 298).

After the presentation of the story, the subjects are asked to assess the probability of several propositions on a numbered scale. We represent the critical propositions only (together with the average judgements of the probabilities):

(A) Linda is active in the feminist movement (0.61)

(B) Linda is a bank teller (0.38)

(A&B) Linda is a bank teller and is active in the feminist movement (0.51).

Obviously, the results contradict the Kolmogorov axioms of probability theory: The conjunction of two propositions can never assume a higher probability than each of the two conjuncts. Closely related results were obtained when asking for ranking the probabilities of the different events or when asking for frequency judgments (see Busemeyer and Bruza 2012).

Another challenge is related to the disjunction fallacy. This effect is closely connected to violations of the “sure-thing principle”, one of the basic claims made by a (classically) rational theory of decision making. Let us assume that a decision maker prefers option B over option Not B when knowing that event A occurs (i.e., $P(B|A) > \frac{1}{2}$) and likewise when knowing that event A does not occur (i.e., $P(B|\text{Not } A) > \frac{1}{2}$). Then the “sure-thing principle” claims that the decision maker should prefer B over Not B when not knowing whether A occurs or not (i.e., $P(B) > \frac{1}{2}$). If the decision maker refuses B (or prefers Not B), we have a violation of this principle.

In everyday reasoning, human behaviour is not always consistent with the “sure-thing principle”. For example, Tversky and Kahneman (1983) reported that more students would purchase a non-refundable Hawaiian vacation if they were to know that they had passed or failed an important exam, compared to a situation where the exam outcome was unknown. Specifically, $P(B|A) = 0.54$, $P(B|\text{Not } A) = 0.57$, and $P(B) = 0.32$, where B stands for the event of purchasing a Hawaiian vacation, A for the event of passing the exam, Not A for the event of not passing the exam, and P for the averaged judgments of probability. Disjunction fallacies are fairly common in behaviour (Busemeyer et al. 2011, Busemeyer and Bruza 2012). Let's toss a coin. If it lands on heads, you will win €100; if it lands on tails, you will lose €50. After the first toss, people will usually play again if they know the outcome. However, they are not interested in repeating the game if they do not know the outcome. This obviously violates the “sure-thing principle”.

Despite its ingenuity, prospect theory cannot solve the puzzles discussed in the literature. To resolve the conjunction puzzle, for example, the authors introduce the novel concepts of representativeness and availability heuristics, which can make a conjunction appear more probable than one of its constituents

(Tversky and Kahneman 1983). Likewise, the treatment of the disjunction puzzle is considered problematic for prospect theory (Broekaert et al. 2020).

Another issue that cannot be explained by prospect theory is the order-dependence of attitude questions. Consider the study of questions and answers in attitude surveys, which is a key area of applied sociology. Survey researchers have repeatedly demonstrated that the same question often produces different answers depending on the context in which it is asked (Schuman and Presser 1981, Sudman and Bradburn 1982). To cite just one particularly well-documented example, a group of (North-American) subjects were asked whether “the United States should let Communist reporters come in here and send back to their papers the news as they see it?” The other group was asked whether “a Communist country like Russia should let American newspaper reporters come in and send back to their papers the news as they see it?” Support for granting free access to Communist reporters varied significantly depending on whether the question about Communist reporters preceded or followed the question about American reporters. The differences were quite dramatic: in a 1950 study, 36% of respondents accepted Communist reporters when the Communist question came first, compared to 73% when the question came second.

Damasio provides a detailed analysis of Descartes’ error (Damasio 1994, Lenzen 2004). His point is that the Cartesian approach ignores the fact that rational decisions require the guidance of emotions even if the emotions are not conscious. For example, Damasio (1994) draws on research involving patients whose frontal lobes were damaged. These patients became emotionally flat and lost their ability to make quick decisions while retaining their cognitive abilities. Damasio also provides behavioural evidence of his patients’ irrational decision-making. They spend an inordinate amount of time on trivial tasks, such as deciding which window to open. Based on his observations of these patients and his analysis of general neurophysiological data, Damasio concludes that their flawed decision-making ability is due to their lack of emotions.

In this section, we considered theories of thinking (or decision-making) that do not take emotions into account. We also listed several of the shortcomings and failures of such theories. Furthermore, I have argued that conceptions such as Kahneman and Tversky’s prospect theory cannot fundamentally overcome these limitations. In the next section, I will consider some early concepts about the relationship between music and the expression of feelings. I will demonstrate that emotions and feelings cannot arise without thinking and the construction of musical expectations. Therefore, both must coexist – thinking requires emotions, and emotions require thinking.

2 Music and the Emergence of Feelings

Music can have an extrinsic and/or an intrinsic meaning. The former is relevant in the case of programme music; the latter conforms to pure (absolute) music. Taking the intrinsic content of music as basic, we must ask about its nature. Using the term of Immanuel Kant, I propose to identify it with aesthetic feelings.

Some researchers claim that music is a language of emotion. Music does not just evoke emotions, it communicates emotions. It means music can represent emotions without really realising them. Therefore, is music communicative? Are learned connections between music and emotions essential? Is this the story we must tell about music and emotions?

I think it can clearly be stated that music is not a system of communication in the sense of the American philosopher Paul Grice (Grice 1975, 1989). Bierwisch (1978: 60) expresses this idea as follows: “Language says, music shows what it means” (translation by RB). A similar idea is expressed by Juslin and Sloboda (2013), who stress that the concept of communication requires that there must be an intention to express a particular emotion (and the listener has to recognise this intention). However, it is extremely difficult to find out the real intention of a composer as examples of Shostakovich illustrate (Gojowy 1983). In addition, even when we recognise the intention, then it is not essential for understanding the music of the composer. The music itself shows what it means.¹

But what, precisely, is shown by a piece of music? What precisely is the meaning of music, and how precisely could we model aesthetic feelings? One early idea leads us to the Doctrine of Affects. Johann Mattheson (1681–1764) was a leading proponent of this doctrine. In his book *Der vollkommene Capellmeister* (Mattheson 1739), he proposed a thorough outline of melodic intervals and their affective purposes. And this is Mattheson’s understanding of intervals:

major third → liveliness
 minor third → mourning
 fifth → boldness
 seventh → supplication

¹ However, there are uses of music where communicative intentions play a role. A standard example is Haydn’s “Joke” quartet (Op. 33, no. 2). Without grasping Haydn’s intention to tell a musical joke, we are faced with a passage that can only be regarded as a kind of musical mistake (London, 2008). However, this is not an example of the pure music we are primarily interested in.

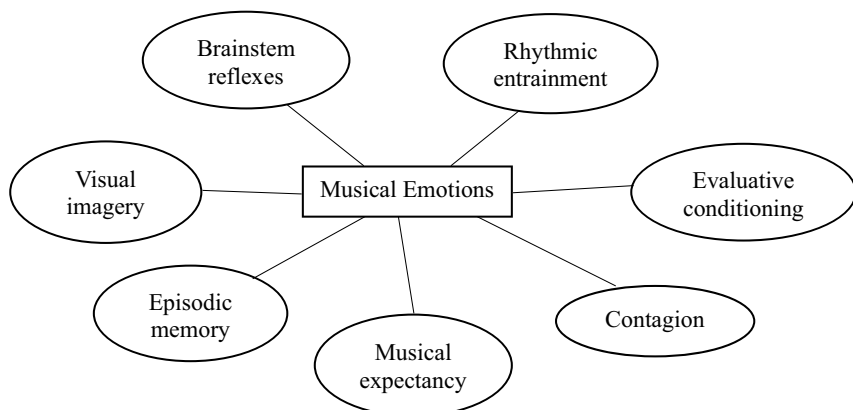


FIGURE 1.2 The generation of emotional states: the BREVCEM model.

In practice, such a doctrine can be extremely helpful for creators of tonal music and songs. Unfortunately, however, the doctrine has several shortcomings, which are listed below:

- (i) Contextual puzzle: Depending on the previous context, chords sound different. A strict mapping thesis as proposed by Mattheson cannot account for this observation.
- (ii) Systematicity failure: A list of associations can describe the situation. However, it cannot explain it.
- (iii) Limited expressibility: Not every emotion can be expressed by music. How to distinguish anger and fear in music?
- (iv) The myth of discrete emotions: Instead of assuming a set of discrete emotions, it is more plausible to assume an infinite set of emotions in an affective space with a defined similarity metric (e.g. Russell 1979, 2003).

Clearly, the current doctrine is based on the hypothesis of discrete mapping, whereby a discrete set of complex musical features is mapped onto a discrete set of affective ideas. Accepting the Doctrine of Affects does not require processes of thinking.

An important issue is to list several different ways how music elicits emotion. Some are listed by the BREVCEM model (Juslin and Sloboda 2013). BREVCEM stands for Brainstem reflexes, Rhythmic entrainment, Evaluative conditioning, Visual imagery, Contagion, Episodic memory, and Musical expectancy. A pictorial representation can be found in Figure 1.2.

“Brainstem reflex” refers to a mechanism inducing emotion because of innate characteristics of a musical pattern signalling possibly critical events. This may include sounds that are unexpected, extremely loud or dissonant. Brainstem reflexes are extremely fast and automatic.

“Rhythmic entrainment” is based on the ability of the Human body to synchronise the heart rate or the breathing to an external rhythm. This can change emotional states in a reflexive, automatic way.

“Evaluative conditioning” is a mechanism that is based on repeatedly pairing musical episodes with other positive or negative stimuli such as visual scenes or dancing episodes. Juslin and Sloboda (2013) refer to Wagner’s Leit-motif strategy as applied “evaluative conditioning”.

“Visual imagery” is a mechanism “whereby an emotion is evoked in the listener because he or she conjures up inner images (e.g. of a beautiful landscape) while listening to the music” (Juslin and Sloboda 2013: 615).

Emotional “contagion” involves an inner imitation of voice characteristics.

“Episodic memory” refers to a mechanism of inducing emotions by certain associations in the listener’s personal memory. Hence, music acquires its emotional meaning by association with significant, personal events (*They are playing our tune, Darling*). However, if this were the only mechanism, then emotional responses to music would vary greatly from individual to individual. This could not explain the typical observation that listeners agree unusually well with one another in labelling musical emotions.

“Musical expectancy” is the last factor we must discuss. It relates to the pioneering work of the musicologist Leonard Meyer. Meyer (1956, 1967) points out that the main emotional impact of music stems from the composer’s arrangement of expectations. Musical meaning and emotion depend on how the actual events in the music play against this background of expectations. Meyer argues that music that is too predictable or too surprising is likely to irritate. The secret to composing a pleasant melody is to balance predictability and surprise.

Several arguments show that musical expectancy is the most important factor to include in the basic semantics of pure music. “Musical expectancy” is the main factor exhibiting systematicity; it does not vary greatly from person to person. Furthermore, it is not influenced by external factors such as personal episodic memories, visual scenes or natural language signals. Very strong emotional responses include chills and tears. These are not evenly distributed throughout musical pieces, but rather occur in certain structural locations (Juslin and Sloboda 2013, Mori and Iwanaga 2017). This again highlights the importance of musical expectancy, which is clearly related to thinking and decision-making processes.

3 Preliminary Conclusions and Outlook

In this article, we have examined two issues that stem from the divide between thought and emotion. The first problem relates to classical decision theory and decision-making. Some crucial problems cannot be solved by approaches such as “prospect theory”, which were originally intended to overcome the limitations of classical decision theory. The second problem arises when we try to establish a systematic connection between the structural aspects of music and the evocation of emotions and feelings. Standard models treat the emergence of musical meaning as a straightforward mapping issue, overlooking the role of thought in generating aesthetic feelings.

In the second part of this thesis, I will demonstrate how a unified solution to both classes of the above mentioned problems can be found by applying the insights of modern quantum cognition. Quantum cognition is a novel approach based on the geometric ideas and concepts of modern quantum theory. Using this conception, problems of bounded rationality can be systematically resolved (e.g. Busemeyer and Bruza 2012). Furthermore, the current quantum-inspired geometric approach enables aesthetic sensations and significant musical structures to be systematically integrated, given that the quantum approach provides an accurate description of the system of tones, melodies, and chords, as well as the realisation of musical expectations (see Blutner 2025).

References

- Becker, Adam (2018): *What is Real? The Unfinished Quest for the Meaning of Quantum Physics*. John Murray Press.
- Bierwisch, Manfred (1978): Musik und Sprache. In: Eberhardt Klemm (ed.): *Jahrbuch Peters 1978. Aufsätze zur Musik*. Leipzig: Edition Peters, 9–100.
- Blutner, Reinhard (2025): *Grundlagen der kognitiven Musiktheorie*. Berlin, Heidelberg: Springer.
- Blutner, Reinhard (2026): Quantum Cognition and the Union of Thinking and Feeling: II. The Qubit approach to the Integration of Thinking and Feeling. In: Jolanta Mazurkiewicz-Sokołowska (ed.): *Studies in Cognitive Linguistics and Multilingualism*. Göttingen: V&R unipress, 13–27.
- Broekaert, Jan B. / Busemeyer, Jerome R. / Pothos, Emmanuel M. (2020): The Disjunction Effect in two-stage simulated gambles. An experimental study and comparison of a heuristic logistic, Markov and quantum-like model. *Cognitive Psychology* 117.
- Busemeyer, Jerome R. / Bruza, Peter D. (2012): *Quantum Cognition and Decision*. Cambridge, UK: Cambridge University Press.

- Bussemeyer, Jerome R. / Pothos, Emmanuel M. / Franco, Riccardo / Trueblood, Jennifer S. (2011): A quantum theoretical explanation for probability judgment errors. *Psychological Review* 118(2), 193–218.
- Damasio, Antonio R. (1994): *Descartes' error: Emotion, Reason, and the Human Brain*. New York: Penguin Putnam.
- Gojowy, Detlef (1983): *Schostakovitsch*. Reinbek bei Hamburg: Rowohlt Taschenbuch Verlag.
- Grice, Paul (1975): Logic and conversation. In: Peter Cole / Jerry L. Morgan (eds.): *Syntax and Semantics, 3: Speech Acts*. New York: Academic Press, 41–58.
- Grice, Paul (1989): *Studies in the way of words*. Cambridge, MA: Harvard University Press.
- Juslin, Patrik N. / Sloboda, John (2013): Music and Emotion. In: Diana Deutsch (ed.): *The psychology of music. Third Edition*. Amsterdam etc.: Elsevier, 583–645.
- Kahneman, Daniel / Tversky, Amos (1979): Prospect theory: An analysis of decision under risk. *Econometrica: Journal of the Econometric Society* 47(2): 263–291.
- Lenzen, Wolfgang (2004): Damasio's Theorie der Emotionen. *Facta Philosophica* 6, 269–309.
- London, Justin (2008): Third Party Uses of Music and Musical Pragmatics. *The Journal of Aesthetics and Art Criticism*, 66(3), 253–264.
- Mattheson, Johann (1739): *Der Vollkommene Capellmeister*. Hamburg: Christian Herold.
- Meyer, Leonard B. (1956): *Emotions and Meaning in Music*. Chicago: The University of Chicago Press.
- Meyer, Leonard B. (1967): *Music, the Arts, and Ideas: Patterns and Predictions in Twentieth-Century Culture*. Chicago: The University of Chicago Press.
- Mori, Kazuma / Iwanaga, Makoto (2017): Two types of peak emotional responses to music: The psychophysiology of chills and tears. *Scientific Reports* 7, 1–13.
- Russell, James A. (1979): Affective space is bipolar. *Journal of Personality and Social Psychology* 37, 345–356.
- Russell, James A. (2003): Core affect and the psychological construction of emotion. *Psychological Review* 110, 145–172.
- Savage, Leonard J. (1954): *The Foundations of Statistics*. New York, NY: Wiley.
- Schuman, Howard / Presser, Stanley (1981): *Questions and answers in attitude surveys: Experiments in question form, wording, and context*. New York: Academic Press.
- Simon, Herbert A. (1955): A behavioral model of rational choice. *The Quarterly Journal of Economics* 69(1), 99–118.
- Sudman, Seymour / Bradburn, Norman M. (1982): *Asking questions*. San Francisco: Jossey-Bass Inc Pub.
- Tversky, Amos / Kahneman, Daniel (1983): Extension versus intuitive reasoning: The conjunction fallacy in probability judgment. *Psychological Review* 90(4), 293–315.

- Tversky, Amos / Kahneman, Daniel (1992): Advances in prospect theory: Cumulative representation of uncertainty. *Journal of Risk and uncertainty* 5(4), 297–323.
- Tversky, Amos / Shafir, Eldar (1992): The disjunction effect in choice under uncertainty. *Psychological Science* 3(5), 305–309.
- Von Neumann, John / Morgenstern, Oskar (1944): *The theory of games and economic behavior*. Princeton, NJ: Princeton University Press.

Quantum Cognition and the Union of Thinking and Feeling: II. The Qubit Approach to the Integration of Thinking and Feeling

Reinhard Blutner

Abstract In this article, I outline how quantum cognition integrates thinking and feeling into a unified, coherent system. The fundamental concept involves representing information through vectors in a two-dimensional complex vector space. This concept leads to the idea of the qubit, which is fundamentally useful for creating a geometric representation of decision-making and emotion. This geometric representation of decision-making and thinking, and feeling and emotion, connects both sides of the coin, thus illuminating the union of thinking and feeling. In particular, I will demonstrate that the interplay between thinking and feeling is crucial for producing Kant's "aesthetic ideas and feelings".

Keywords thinking – feeling – qubit – quantum approach – quantum information – quantum bits – color space – synesthesia – bounded rationality – conjunction puzzle – attitude questions – aesthetic feelings – chromatic circle – circle of fifth – consonance – dissonance

Introduction

In psychology, there is a long tradition of geometric models of meaning. For example, to understand problem solving, categorisation, memory retrieval, inductive reasoning and other cognitive processes, we must first grasp how humans assess similarity (e.g. Torgerson 1965, Tversky 1977, Gärdenfors 2000, 2014). Further, work by Peter Gärdenfors stresses the geometrical nature of thought and meaning (Gärdenfors 2000, 2014). The mathematical insight of quantum theory is that we must acknowledge the geometric nature of probability, which is determined by projective geometry.

This paper is organised as follows. Section 1 provides an overview of the quantum approach, which is based on the concept of quantum information

Reinhard Blutner, ORCID: 0000-0002-4468-4796, University of Amsterdam

and the geometric idea behind the realisation of quantum bits (qubits). Section 2 presents, in an informal manner, how several conundrums of bounded rationality (discussed in the first part of my study) can be addressed and resolved. Section 3 addresses some issues in cognitive music theory, demonstrating how thinking and feeling interact to produce Kant's aesthetic ideas and feelings. Finally, general conclusions are drawn emphasising the philosophical aspects of the present approach.

1 An Outline of the Quantum Approach

Quantum theory is typically considered a branch of physics dealing with physical phenomena at the microscopic level – the realm of atoms and molecules. It provides a model for studying matter on the finest possible scales. Therefore, it may seem counterintuitive that this theory can be applied to psychology and musicology.

Several researchers have challenged this traditional view of the quantum approach, suggesting that the modern classification of quantum mechanics within the scientific system focuses on the concept of *quantum information* (Vedral 2006). For the last 30 years, Thomas Görnitz and his German colleagues have been exploring the possibility of a physics based on quantum information (Görnitz, 2011, 2014, 2018, Görnitz and Görnitz 2016, Görnitz and Schomäcker, 2018). This millennium project is based on Carl Friedrich von Weizsäcker's idea that matter is information (see Görnitz 2024).

The information-based approach to quantum mechanics has far-reaching consequences for physics, cosmology and philosophy, as well as giving rise to new applications of quantum formalism in fields such as modelling financial systems (Khrennikov 2010) and cognitive research (Busemeyer and Bruza 2012). In short, the underlying thesis is that all spiritual and material things originate from non-local information that exists beyond space and time. The basic building blocks of information are the so-called “abstract quantum bits” described in quantum physics and quantum information theory. The concept of quantum bits requires further explanation.

In order to tell a convincing story, the concept of simplicity plays a significant role. This is true in both the natural and human sciences. There are many ways in which simplicity can be considered a desirable feature of scientific theories. Albert Einstein asserted that “our experience hitherto justifies us in believing that nature is the realisation of the simplest conceivable mathematical ideas” (Einstein 1954: 274). However, it is often unclear what simplicity of a theory really means. In particle physics, I learned 50 years ago that the small-

est particles are the simplest. However, this view is not universally accepted (cf. Görnitz 2014, 2024; Görnitz and Görnitz 2018, C. Mann, 2024):

The third aspect: Physicists try to find all elementary particles, even if these have much shorter wavelength than the ones they already found. And in the end they hope to find a simple formula underlying everything.

But this hope is in vain. The smaller the wavelength, the more energy is needed to generate it. And it will turn its energy in other well-known particles very quickly. The famous Higgs Boson for instance, needed a huge energy to be generated. And there is no reason, why “more energy” should also lead to a simpler formula for everything.

For this reason C.F.V. Weizsäcker in the 1950s postulated that we should not look for the smallest particles, but start at the other end and look for the simplest structure that might exist. And the simplest structure that can exist is the binary alternative of information yes/no, or in numbers: 1 or zero, existing or not existing (C. Mann 2024: 38).

Therefore, an interesting alternative is to look for structures with minimal quantum information. The simplest constructions that conform to this idea are those based on simple qubits. Abstract quantum bits are the simplest structures imaginable. They cannot be divided. However, they can be combined to form more complex units, a process that is governed by the mathematical operation of the tensor product. Numerous extensions and improvements to the theory have been made in recent work (Görnitz 2024).

To make a long story short, let us represent an ordinary bit as a choice between two arrows: one directed from the origin of a unit circle (a circle with a circumference of 1) to the north and the other directed to the south. Now, let us gradually increase the set of possible arrows. First, consider all the arrows from the origin of the unit circle to any point on its surface (also known as the Bloch circle). The second step considers spheres instead of circles. In the true quantum case, therefore, we have a choice of all the arrows from the origin of the unit sphere to any point on its surface (also known as the Bloch sphere). Just as classical bits can be combined to describe more complex situations, the same is possible for quantum bits. The crucial operation that describes this combination in the quantum case is the aforementioned tensor product.

This is not the place to explain the mathematics of quantum theory. However, I will provide some pointers to help you avoid confusion and create simple visual illustrations. As I mentioned earlier, opposite arrows point in opposite directions. In quantum theory, this situation is described by orthog-

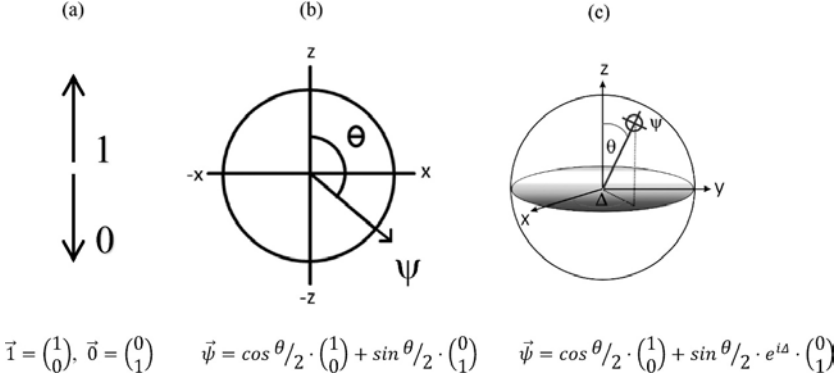


FIGURE 2.1 Bits and Qubits: (a) Bits as a choice between two vectors, (b) Qubits using real numbers (Bloch circle); (c) Qubits using complex numbers (Bloch sphere). The lower line gives a description of the mathematical vector representation. Note that the parameter Δ is a phase parameter.

onal vectors. Therefore, the angles between two vectors are half the angles between the two arrows in the Bloch representation. I will use both the Bloch representation and the vector representation below to describe different possibilities.

Figure 2.1 provides pictorial representations of the three methods of representing information: (a) classical, (b) based on the Bloch circle, and (c) based on the Bloch sphere. Such a vector description is applicable in both the micro world, for example when measuring the polarisation of a photon (up or down), and the psychological world (see examples below).

In an important research paper, Surov (2022) depicted the colour space using the Bloch circle. This is shown in Figure 2.2. Compared with the traditional HSL representation, using the Bloch sphere brings several advantages (cf. Surov 2022, Blutner 2025). For example, it shows that yellow is much lighter than red, green, or blue.

Another advantage is that similar descriptions can be applied to emotions using the Bloch circle. This is shown in Figure 2.3 following the circumplex model of James Russell (Russell 1979, 2003). Interestingly, the emotions are located roughly on the Bloch circle. The inner points of the circle are used to describe mixed states. The points on the Bloch circle represent pure quantum states. It is possible that using the full Bloch sphere could improve the circumplex model of emotions. This would mean that the phase parameter Δ could be different from zero. Unfortunately, this possibility has not yet been investigated.

The space for affective feelings is bipolar. One axis is valence, which represents the dimension ranging from pleasure to displeasure. The other axis is

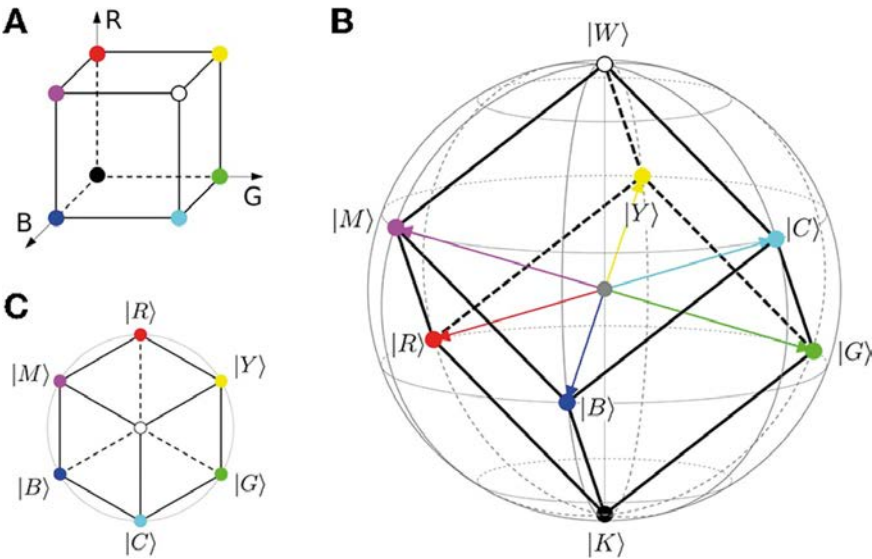


FIGURE 2.2 Qubit representation of the colour space. Part A shows the colour cube which is a structure inside the whole Qubit representation presented in part B. Another structure inside the qubit is the colour circle presented in part C. In this Figure, $|W\rangle$ stands for White, $|K\rangle$ for Black, $|R\rangle$ for Red, $|Y\rangle$ for Yellow, $|G\rangle$ for Green, $|C\rangle$ for Cyan, $|B\rangle$ for Blue, and M for Magenta. I acknowledge Ilya Surov for the granted permission to present his Figure.

activation, ranging from arousal to sleep. In Section 3, I will demonstrate how these dimensions are connected to musical emotions triggered by certain musical events.

Interestingly, colours and emotions can both be described by qubits. The advantage of this similar description for colours and emotions is that it explains the phenomenon of synesthesia, whereby colours and emotions are perceived as being connected. People therefore claim that red refers to warm emotions, blue to cool ones, yellow to light and optimism, and black to darkness and unhappiness (cf. Surov 2022, Blutner 2025).

The qubit model, and vector models in general, are useful tools for representing graded probabilities. The basic idea is depicted in Figure 2.4 for a three-dimensional vector space. This vector space is spanned by the three axes vectors u_1 , u_2 , and u_3 . Each axis vector can be interpreted as a proposition. Orthogonal axes represent propositions that exclude each other. It is not only the axes (i.e. one-dimensional subspaces) that represent propositions. In principle, each subspace can represent a proposition. Figure 2.4 shows this by using a two-dimensional subspace, represented by plane A.

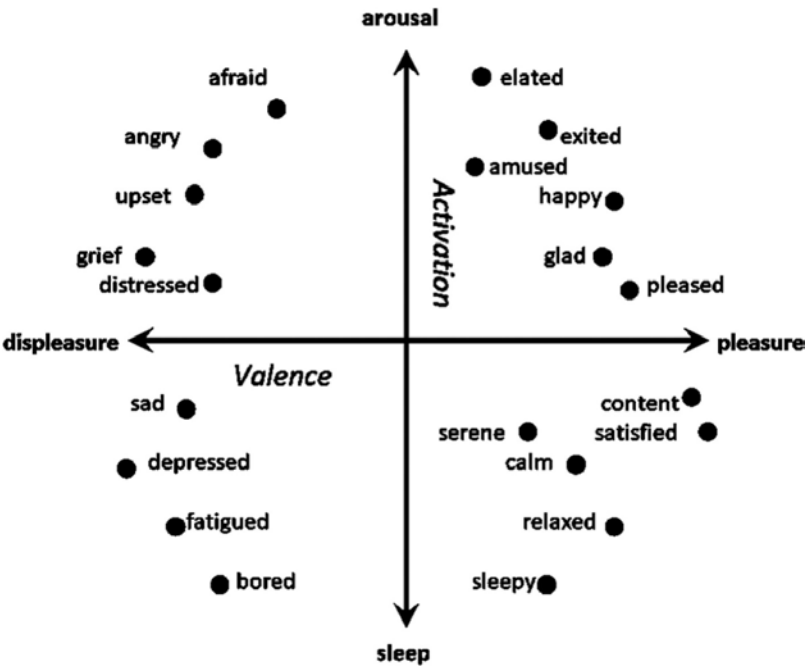


FIGURE 2.3 Pleasure-arousal judgement space for affective feelings according to James Russell (2003). This model of core emotions has two dimensions: valence (pleasure–displeasure) and activation (arousal–sleep).

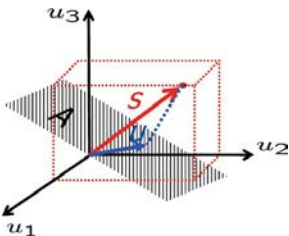


FIGURE 2.4 Projections and probabilities. The squared length of any projection onto a subspace can be seen as realising a probability measure.

Projecting state s onto plane A results in the vector $u = A(s)$. Importantly, the square of the length of this vector counts as the probability of the corresponding proposition (indicated by a subspace). The probabilities are obviously defined by the state vector s , and if s has unit length, the Pythagoras theorem tells us that the probabilities of a complete set of orthogonal subspaces of our vector space add up to 1. Another interesting property relates to subspaces. If A' is a subspace of vector space A , then it can be shown that the probability of A' is less than or equal to the probability of A .

2 How the Quantum Approach Can Solve Some of the Puzzles of Bounded Rationality

In this section, I will demonstrate how the quantum approach explained in Section 1 can be used to solve several puzzles discussed in the first part (Blutner, same volume).

Let us apply the idea of projections and probabilities, as previously explained, to the conjunction fallacy, as described in the first part (Blutner, same volume). It is repeated here:

- (A) Linda is active in the feminist movement (0.61)
- (B) Linda is a bank teller. (0.38)
- (A&B) Linda is a bank teller and is active in the feminist movement (0.51)

In classical set-theoretic semantics, propositions refer to subsets of a given set of possible worlds. In the geometric model, propositions correspond to subspaces of a given vector space. Opposing propositions correspond to orthogonal subspaces, while complementary propositions correspond to non-orthogonal subspaces. The projection postulate describes how projections onto subspaces relate to probabilities.

Figure 2.5 shows a two-dimensional vector space with orthogonal axes A and $\bar{A}$, as well as B and $\bar{B}$.¹

It is based on the work of Pothos and Busemeyer (2011). Note that the axes A and B are not orthogonal. Such axes are called complementary. They represent complementary propositions. (cf. Blutner, 2024a). In my example, the state-vector s is chosen in a way that results in the approximate probabilities

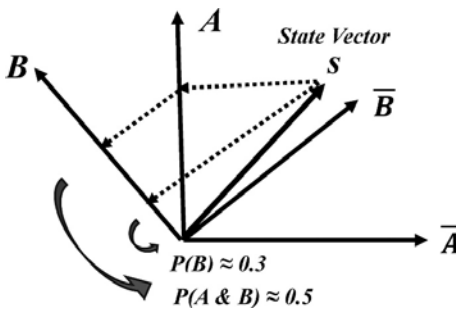


FIGURE 2.5
Conjunction puzzle using a two-dimensional vector space. Inspired by the modelling of Pothos and Busemeyer (2011). The lengths of the represented projections are listed in the Figure and are approximately in line with the experimental findings.

¹ Note that $\bar{A}$ refers to the negation of A , i.e. Not A .