Ontology of Multisensory Unification

1. Research objective

The goal of the project is to construct an ontological model of structural, multisensory unification. This is an empirically-informed philosophical project combining philosophy of mind, results of empirical cognitive sciences, and formal ontology in order to provide a novel solution to the important, and currently unresolved, philosophical question regarding the way in which unimodal structures are unified in the structures of multimodal experiences. Within the project, I will analyze four major dimensions of experiential structures considering three hypotheses: Simple unity, Transformative unity, and Disunity hypothesis (see *Section 3a*).

In everyday situations, we experience the world from a unified, first-person perspective. In particular, our conscious awareness contains elements associated with distinct sensory modalities as we may simultaneously perceive the environment by using distinct senses. For instance, it seems that within a single experience one can see a dog, hear its barking, smell bread from a nearby bakery, and be aware of a pain in the left foot. Furthermore, the elements presented in multimodal experiences are not presented as merely co-occurring but usually seem to be unified within some higher-order structures. For example, we are not only able to experience that something looks dog-like and that something makes a barking sound, but also that there is a single object which has the appearance of a dog and barks (Kubovy and Schutz, 2010; O'Callaghan, 2015). In consequence, it is plausible that elements presented in usual multimodal experiences are arranged according to certain principles, and one of the goals of philosophy of perception is to develop a conceptual framework explicating these principles (Macpherson, 2011; Nudds, 2010; Richardson, 2010; O'Callaghan, 2016).

The above intuitive observations lead to a **unification problem which is *multisensory* and *structural***. It is *multisensory* as it concerns the way in which elements presented in virtue of various senses are unified in multimodal experiences. It is *structural* since addressing it requires specifying the structure of multimodal experiences by, *inter alia*, characterizing dependency relations between presented elements, determining the spatiotemporal framework in which they are presented, and specifying the rules according to which simpler elements compose complex wholes. The question of multisensory, structural unification is particularly difficult due to the fact that each modality may organize the presented elements by using distinct structures. For instance, spatial structures organizing olfactory, auditory, and visual elements may differ significantly from each other and each of various modalities may individuate and track presented entities in accordance to distinct principles (Briscoe, 2016; Matthen, 2010; Richardson, 2010; Smith, 2013; de Vignemont, 2014; Young, 2016). In consequence, it is not obvious how these distinct structures, which may not be compatible, constitute unified structures of multimodal experiences. I propose that the problem of structural, multisensory unification can be addressed by formulating **an empirically-informed, *ontological model*, i.e., a model which by (a) using contemporary ontological frameworks provided by mereotopological theories, individuation theories, and dependency theories, and (b) utilizing current empirical state of the art, characterizes relations between unimodal and multimodal experiential structures.**

It should be noted that my research questions concern the relations between unimodal and multimodal *experiential structures* and not unimodal and multimodal *experiences*. It is so because it is likely that nearly all sensory experiences are multimodal. However, multimodal experiences involve various unimodal structures, i.e. structures which occur due to functioning of mechanisms associated with a single modality, which jointly constitute a multimodal structure. Furthermore, the project does not assume whether the experiential structures correspond to structures in the environment (e.g., whether visual space has the same features as physical space). In addition, it is neutral regarding what metaphysical types of entities are sensory experiences and their structures. Because of that my project can be combined with various epistemic and metaphysical views on perception.

2. Significance of the project

a) State of art and justification for tackling scientific problems by the proposed project

During the last two decades, philosophers of perception became more and more interested both in the topic of multimodality and investigations concerning structural aspects of experiences. First, it has been recognized that a 'visuocentric' approach which treats vision as a model of all perceptual modalities may lead to a distorted image of human sensory perception (Kubovy and Van Vankelburg, 2001; O'Callaghan, 2015). This recognition led to the development of philosophical studies concerning non-visual modalities and multisensory perception (e.g., Briscoe, 2016; Cohen, 2010; Fulkerson, 2011; Keller, 2016; Macpherson, 2011). Furthermore, nowadays it is often recognized that sensory experiences have a certain structure which may be distinct, despite the sameness of represented elements (Matthen, 2004; Richardson, 2011; Soteriou, 2013). For example, while vision and touch may represent the same shape, like a circle, it seems that each of these modalities presents a circle in a structurally distinct way. More specifically, the structural aspects of experiences are those which **(a)**

concern elements which are invariant despite changes in presented entities, like the shape of the visual field which remains the same no matter what is seen (Mac Cumhaill, 2015; Richardson, 2010), and **(b) concern principles according to which the presented entities are experientially organized**, for instance the way perceptual wholes are composed of simpler elements (Casati, 2015; O'Callaghan, 2008).

Nevertheless, despite the presence of a significant interest in topics of multimodal experiences and structural aspects of experiences, **contemporary studies face serious limitations in attempts to resolve the multisensory, structural unification problem**. 1) The descriptions of structural aspects of sensory experiences are often provided without specification of the applied ontology, which makes it difficult to assess the relations between structures of various experiences. 2) Studies usually focus only on specific types of experiences, like audio-visual experiences, and do not attempt to provide a structural model of complex experiences which combine various exteroceptive and interoceptive aspects. 3) No answer is provided to the question of how potentially distinct and incompatible unimodal structures constitute structures of multisensory experiences.

I believe that I can solve these problems by applying a precise conceptual framework for describing structures of various experiences and analyzing similarities as well as differences between these structures by using the same notions. In consequence, I will be able to investigate the unimodal structures, how they are related to each other, and how they constitute multisensory structures. Because resources required for constructing such a precise conceptual framework are provided by ontological theories, **the goal of the project is to develop an _ontological model_ of structural, multisensory unification in which experiential structures are analyzed using theories developed on the grounds of formal ontology**. Formal ontological theories are modeling frameworks which describe some domains of reality. In the project, I will apply them in order to model the structural aspects of sensory experiences. A suitable example of such an empirically-informed, ontological modeling approach can be found in my paper concerning part-structure of olfactory experiences (Skrzypulec, 2021a). In this work, I investigated whether the structure of olfactory experiences satisfies the mereological weak supplementation principle which is a part of classic mereology and entails that an entity cannot have merely a single proper part. By analyzing results of empirical studies concerning perception of complex olfactory mixtures, I have argued that this principle is not satisfied in the case of human olfaction, so the olfactory mereology is nonclassical.

b) Innovative character of the proposed project
My approach adopted in the project is novel, since up to this date ontological notions have not been broadly applied to structural aspects of sensory experiences. This lack of application of ontological notions in investigations concerning the problem of structural, multisensory unification is unfortunate, as ontological theories provide precise concepts which are well-suited to describing experiential structures. The novelty of my project is not restricted to its methodological approach. It is also apparent in its scope as it aims to provide a model of complex multimodal experiences in which elements presented by various exteroceptive and interoceptive sensory systems are combined, whereas the usual investigations regarding multimodal experiences are restricted to narrow cases like audio-visual experiences. Furthermore, the novelty of my project lies in identification of the crucial difficulty regarding the problem of multisensory unification: how distinct, potentially incompatible, unimodal structures constitute multimodal structures. This important problem has not attracted sufficient attention in the philosophical literature, which usually discusses either unimodal or multimodal structures separately. In addition, as I address the topic of multimodal experiences primarily from the philosophical perspective, my model is distinct from the usual empirical models which focus not on experiential structures but on characteristics of representational vehicles, or on the ways in which sensory information is processed.

c) The impact of the project's results on the development of the research field and scientific discipline
The project will provide substantial gains for the involved disciplines. From the perspective of the philosophy of mind, my project aims to answer an important philosophical question concerning the unity of multimodal experiences. Answering this question is one of the crucial elements of understanding our sensory first-person perspective through which we experience the world. By combining the philosophical ideas on perception with ontological notions, I will be able to clarify the philosophical conceptions regarding experiential structures and I will develop a common framework for advancing discussions concerning structural aspects of experiences. While the main aim of the project is to answer the philosophical question of multisensory unity, the project will also have an impact on empirical studies concerning multisensory perception. 1) It will serve to identify gaps in the current empirical state of the art regarding structural aspects of sensory experiences by showing the ideas that have clear support in empirical data and those which are not yet determined by the scientific state of the art. 2) My project will explicate relations between philosophical ideas regarding experiential structures

and scientific research concerning perceptual organization by showing in what way, and to what extent, philosophical ideas may be supported, or falsified, by empirical data. 3) The project will provide a precise conceptual framework, for instance regarding the notions of 'part,' 'dependency,' or 'sameness,' which can be used in empirical studies investigating the ways in which sensory experiences are organized.

3. Work plan
a) Outline of the work plan and research hypotheses
My investigations will be guided by **three general hypotheses**:
(A) Simple unity hypothesis: According to this hypothesis, the structure of a multimodal experience is unified due to the fact that unimodal structures are compatible with each other, so they can compose a multimodal structure without undergoing modifications.
(B) Transformative unity hypothesis: According to this hypothesis, the structure of a multimodal experience is unified but the unimodal structures are not compatible, so to compose a unified multimodal structure they undergo some transformations.
(C) Disunity hypothesis: According to this hypothesis, the structure of a multimodal experience is not unified. The unimodal structures may co-occur in a multimodal experience, but they do not compose a higher-order, multimodal structure.
I will evaluate these hypotheses in the context of four crucial dimensions of experiential structures: (1) Spatiotemporal frameworks, (2) Compositional principles, (3) Individuation principles, (4) Structural dependencies. The formulated ontological model will allow establishing which general hypotheses, and their specific realizations, are the most plausible in the context of structural dimensions of various types of multimodal experiences. **I have devised the research plan of the project such that it reflects the division of the project in four dimensions.** My project will last five years; during each of the first four years one of the project's dimensions will be analyzed, and during the final year, relying on the previous results, a full ontological model of structural, multisensory unification will be formulated.
(1) Spatiotemporal frameworks: The majority of sensory experiences present entities as localized in time and space. To answer the problem of multisensory, structural unification it is important to identify the unimodal spatiotemporal frameworks and analyze the way they constitute multimodal spatiotemporal frameworks. Spatiotemporal structures associated with different modalities are likely to be distinct (Cheng and Haggard, 2018; Phillips 2014). In consequence, it is important to investigate how these distinct structures are unified. In addition to philosophical works, I will rely on empirical studies concerning spatial and temporal aspects of a variety of sensory systems (e.g., Spence, 2016). Suitable ontological notions are provided by theories of spatial and temporal mereotopology which explicate concepts of parthood and connectedness (e.g., Mazzola, 2019).
(2) Compositional principles: The sensory experiences usually present entities as having some internal structure by being composed of simple elements. For instance, vision presents objects as composed of spatial parts (Casati, 2015; Green, 2017) and audition presents sounds as having temporal parts (Nudds, 2010). By investigating compositional principles, I will analyze how unimodal principles governing presentations of complex wholes are related to principles organizing the multimodal compositional structures. The most relevant empirical works are those which concern principles of perceptual organization in various senses (e.g., Haggard and Giovagnoli, 2011). Compositional principles can be analyzed using mereotopological accounts regarding conditions under which some elements constitute a higher-order whole (e.g., Markosian, 2004).
(3) Individuation principles: Main sensory modalities are able to simultaneously present several distinct elements and re-identify them. For example, vision can identify objects as being the same while they move in a spatiotemporally continuous fashion (Scholl, 2007) and olfaction allows tracking of odor even if its qualities change (Young, 2020). Individuation principles are those which characterize the rules according to which the presented entities are differentiated and identified in sensory experiences. Because such rules may be distinct for elements presented by various modalities, a question arises: How is this diversity of individuation unified in multimodal experiences? To investigate this dimension, I will analyze empirical works concerning the way in which sensory modalities differentiate between synchronically and diachronically presented elements (e.g., Mitroff et al., 2004; Porter et al., 2007). The ontological notions suitable for analyzing individuation principles are provided by ontological individuation theories (e.g., Effingham, 2012).
(4) Structural dependencies: Sensory experiences have lower-level and higher-level aspects which stand in certain dependency relations. For instance, it may be the case that certain complex properties, such as shape, cannot be presented without presenting some lower-level properties such as edges (Green, 2017). My investigations concerning this dimension will reveal how unimodal dependency structures are transformed or preserved in multimodal experiences. A suitable ontological framework is provided by dependency theories (e.g., Bennett, 2004). The relevant empirical works are those which regard relations between higher and lower levels of perceptual processing (e.g., Hummel, 2013).

b) Results of the initial analyzes

To successfully conduct my project, it is important to take into consideration contemporary philosophical discussions regarding experiential structures and multimodality, develop the model by relying on the current empirical state of the art, and investigate the structural aspects of experiences by using precise ontological notions. I have already applied such an empirically-informed approach in investigations concerning the perception of diachronic persistence in vision and audition (Skrzypulec, 2020), the mereology of olfactory experiences (Skrzypulec, 2021a), the structure of audio visual-experiences (Skrzypulec, 2021b), and the perception of high-level properties (Skrzypulec, 2019). These preliminary investigations show that the proposed research framework is likely to be useful in formulating a comprehensive model of multisensory, structural unification.

c) Risk analysis

The main risks of the project concerns that (a) investigating some of the project's dimensions may take longer than assumed, while other dimensions may be less fruitful than initially expected and (b) due to limitation of theoretical argumentation or lack of empirical constraints, it might be difficult to select the best theories of multimodal, structural unification. Nevertheless, my preliminary investigations demonstrate that the project is feasible as the proposed empirically-informed, philosophical approach is able to produce novel results. Furthermore, as the project is composed of modules which can be investigated independently from one another, a failure to investigate one of the project's dimensions does not mean that the project cannot deliver any important results.

4. Methods of research

While the project is divided into five, one-year long modules, each of these modules has an internal structure composed of three stages determined by application of the three main methods: **(a) conceptual analysis, (b) theory evaluation, and (c) structural integration analysis**. The first method consists of analyzing and explicating the ideas regarding the structural aspects of experiences that are present in philosophical and empirical works. It is likely to produce alternative conceptions regarding the unimodal and multimodal experiential structures. However, in order to assess the obtained conceptions to identify the most accurate, a different method—theory evaluation—is needed. This method consists of formulating arguments in order to evaluate which conceptions of experiential structures are the most plausible. I will assess the strength of alternative theories by investigating their plausibility from the perspective of philosophical argumentation and their coherence with the empirical state of the art. By the joint application of conceptual analysis and theory evaluation methods I will be able to select the best conceptions characterizing the unimodal and multimodal structures. However, achieving the final goal of the project requires analyzing the way in which unimodal experiential structures constitute structures of multimodal experiences. This can be achieved by applying the third method: structural integration analysis. This method consists of analyzing the relations between unimodal and multimodal structures in order to determine ways in which they can or cannot be integrated.

5. Literature

Bennett, K. (2004). Global supervenience and dependence. Philosophy and Phenomenological Research, 68(3), 501-529.

Briscoe, R. E. (2016). Multisensory processing and perceptual consciousness: Part I. Philosophy Compass, 11(2), 121–133.

Casati, R. (2015), Object perception. In M. Matthen (Ed.), The Oxford handbook of philosophy of perception (pp. 393-405). Oxford: Oxford University Press.

Cheng, T., & Haggard, P. (2018). The recurrent model of bodily spatial phenomenology. Journal of Consciousness Studies, 25(3–4), 55–70.

Cohen, J. (2010). Sounds and temporality. Oxford Studies in Metaphysics, 5, 303-320.

de Vignemont, F. (2014). A multimodal conception of bodily awareness. Mind, 123(492), 889–1020.

Effingham, N. (2012). Endurantism and perdurantism. In N. A. Manson, & R. W. Barnard (Eds.), The continuum companion to metaphysics (pp. 170-197). London: Continuum.

Fulkerson, M. (2011). The unity of haptic touch. Philosophical Psychology, 24(4), 493–516.

Green, E. J. (2017). On the perception of structure. Nous, 53(3), 564-592.

Haggard, P., & Giovagnoli, G. (2011). Spatial patterns in tactile perception: Is there a tactile field?. Acta Psychologica, 137, 65–75.

Hummel, J. E. (2013). Object recognition. In D. Reisburg (Ed.) Oxford handbook of cognitive psychology. Oxford: Oxford University Press, pp. 32–46.

Keller, A. (2016). Philosophy of olfactory perception. New York: Palgrave Macmillian.

Kubovy, M., & Schutz, M. (2010). Audio-visual objects. Review of Philosophy and Psychology, 1, 41–61.

Kubovy, M., & von Valkenburg, D. (2001). Auditory and visual objects. Cognition, 80, 97–126.

Mac Cumhaill, C. (2015). Perceiving immaterial paths. Philosophy and Phenomenological Research, 90(3), 687–715.

Macpherson, F. (2011). Cross-modal experiences. Proceedings of the Aristotelian Society, 111, 429–468.

Markosian, N. (2014). A spatial approach to mereology. In S. Kleinschmidt (Ed.), Mereology and location (pp. 69-90). Oxford: Oxford University Press.

Matthen, M. (2004). Features, places, and things: Reflections on Austen Clarks's theory of sentience. Philosophical Psychology, 17(4), 497–518.

Matthen, M. (2010). On the diversity of auditory objects. Review of Philosophy and Psychology, 1, 63–89.

Mazzola, C. (2019). The mereotopology of time. Notre Dame Journal of Formal Logic, 60(2), 215-252.

Mitroff, S. R., Scholl, B. J. & Wynn, K. (2005) The relationship between object files and conscious perception. Cognition, 96, 67–92.

Nudds, M. (2010). What are auditory objects?. Review of Philosophy and Psychology, 1, 105-122.

O'Callaghan, C. (2008). Object perception: Vision and audition. Philosophy Compass, 3/4, 803-829.

O'Callaghan, C. (2015). The multisensory character of perception. Journal of Philosophy, 112(10), 551–569.

O'Callaghan, C. (2016). Objects for multisensory perception. Philosophical Studies, 173, 1269–1289.

Phillips, I. (2014). The temporal structure of experience. In V. Arstila, & D. Lloyd (Eds.), Subjective time (pp. 139-158). Cambridge, MA: The MIT Press.

Porter, J., Craven, B., Khan, R. M., Chang, S.-J., Kang, I., Judkewitz, B., Volpe, J., Settles, G., & Sobel, N. (2007). Mechanisms of scent-tracking in humans. Nature Neuroscience, 10(1), 27–29.

Richardson, L. (2010). Seeing empty space. European Journal of Philosophy, 18(2), 227–243.

Richardson, L. (2011). Bodily sensation and tactile perception. Philosophy and Phenomenological Research, 86(1), 134-154.

Scholl B. J. (2007) Object persistence in philosophy and psychology. Mind and Language, 22(5), 563–591.

Skrzypulec, B. (2019). Perceptual kinds as supervening sortals. Pacific Philosophical Quarterly, 100(1), 174-201.

Skrzypulec, B. (2020). Visual endurance and auditory perdurance. Erkenntnis, 85, 467-488.

Skrzypulec, B. (2021a). The nonclassical mereology of olfactory experiences. Synthese, 198, 867–886.

Skrzypulec, B. (2021b). The structure of audio–visual consciousness. Synthese, 198, 2101-2127.

Smith, B. C. (2013). The nature of sensory experience: the case of taste and tasting. Phenomenology and Mind, 4, 212–227.

Soteriou, M. (2013). The mind's construction. The ontology of mind and mental action. Oxford: Oxford University Press.

Spence, C. (2016). Oral referral: On the mislocalization of odours to the mouth. Food Quality & Preference, 50, 117–128.

Young, B. D. (2016). Smelling matter. Philosophical Psychology, 29(4), 520–534.

Young, B. D. (2020). Perceiving smellscapes. Pacific Philosophical Quarterly, 101(2), 203-223.