Neural Dependence and Sensory–External Incongruence under Naïve Realism

A thesis presented in partial fulfilment of the requirements for the degree of

Master of Arts in Philosophy

Massey University, Manawatū, New Zealand

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2026

Abstract

Naïve realism, the view that sensory appearances are extracorporeal or 'out in the world' and so not supervenient upon neural activity, is confronted with apparent incongruences between sensory appearances and correlated extracorporeal data (Pautz, 2018). Consequently, Pautz (2018) argues that naïve realism is starkly disconnected from results of contemporary science. However, in the present thesis, I demonstrate that sensory–external incongruence need only indicate further investigation is required to identify hidden sensory–external *congruence*. Centrally, through reanalysis of, and expansion upon, the spectral reflectance dataset to which Pautz (2018) appeals, I predict physical correlates of colours through quantitative modelling of the unique–binary hue distinction between colours. Therefore, there is extensive colour sensory–external congruence *underlying* the wider dataset cited in part by Pautz (2018) – demonstrating that sensory–external incongruence can be rendered congruent through further investigation. More generally, I argue that basic tenets of naïve realism permit sensory appearances to be counterfactually dependent upon specific neural activity yet, simultaneously, not upon any determinable physical pattern impinging upon the sensory system. In other words, given basic tenets of naïve realism, neural data can be more illuminating of the 'qualitative character' of sensory experience than associated extracorporeal data. Therefore, I conclude that identifications of sensory–external incongruence most reasonably stand as elicitations for further empirical and theoretical investigation into structures of correlations between sensory consciousness and both neural and extracorporeal data.

Acknowledgements

I am grateful to my thesis supervisor, Professor Bill Fish, and my peer reviewer, Julie Cosson, for their respective illuminating feedback, challenging conversations, and generous support throughout the preparation of this thesis.

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Discovery commences with the awareness of anomaly

– Kuhn, *The Structure of Scientific Revolutions*

Naïve realism, the view that sensory appearances are extracorporeal or 'out in the world' and so not supervenient upon neural activity, is confronted with apparent incongruences between particular sensory appearances and measurable aspects of that which is respectively sensed (Pautz, 2018)[1]. Whereas, Pautz (2018) identifies that these appearances are highly congruent with the measurable aspects of associated neural activity. Consequently, he argues that naïve realism is starkly disconnected from results of empirical science, and is thereby critically undermined, in contradistinction to views that hold sensory appearances are most directly dependent, and potentially therefore supervenient, upon neural activity.

[1] Characterisation varies amongst naïve realists regarding what is sensed, and by extension, what appears in sensory experience. Candidates include a "tract of the environment" (Fish, 2009, p. 52–53) containing "an array of facts" (Fish, 2009, p. 52–53) or "an array of objects and surfaces that possess a vast assortment of properties" (Fish, 2009, p. 52–53); or "causal influence" (Campbell, 2014, p. 98) transmitted by respective objects or perhaps by "a multiplicity of objects" (Campbell, 2002, p. 131); or "sensible profiles - complexes of certain structuring relations and qualities" (Johnston, 2004, p. 136) that are "instantiated there in the scene" (Johnston, 2004, p. 134). Centrally, all such characterizations permit, as Pautz (2018, pp. 2–3) suggests, the sensory appearance of *qualitative properties* that are physically instantiated in, at least in part, *measurable* "objective states of the external world" (Pautz, 2018, p. 3).

However, in the present thesis, I argue that, upon recognising essential data neglected by Pautz (2018; revised in 2021) and his critics, the 'sensory–external' incongruences he identifies are rendered elicitations for further empirical and theoretical investigation, the pursuit of which yields new insight into structures of correlations between physical properties and sensory consciousness with respect to colour sensation. Centrally, I develop counterevidence to Pautz's identified colour sensory–external incongruence. More generally, I demonstrate that a greater observed dependence of sensory appearances on neural activity than on extracorporeal properties can be consistent with basic tenets of naïve realism. Consequently, I thereby counter Pautz's (2018) empirical approach – the evaluation of which is the framework of the present thesis – to determining "whether there is a conflict between naïve realism and science" (p. 1). Importantly, the genesis and significance of this question extends from a debate between naïve realism and its antithesis, internalism. Accordingly, I survey this debate in the following section to define and elucidate important terms whilst situating the corresponding reactive aims of the present thesis, which are motivated in section 1.2 and detailed in section 1.3, before, structurally outlining the thesis argument in section 1.4.

1.1. Naïve Realism and Contemporary Science

Naïve realism and internalism advance contrasting theories about how neural activity contributes to 'qualitative character' – what qualitative properties such as 'pinkness' and 'squareness' are 'like' in experience (Fish, 2009, pp. 6–7, 137–139; Pautz, 2020)[2].

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[2] As Fish (2009, p. 4, n. 5) points out, the term 'qualitative character' is sometimes used interchangeably with 'phenomenal character'. It is reasonable to interpret the terms 'qualitative character' and 'phenomenal character' as used interchangeably by Pautz (2018) because he manifestly does so when first defining the "general diaphaneity assumption" (p. 2) and he does

Implicitly, naïve realists and internalists agree that qualitative character is the *specificity* of a given sensory experience, what the experience is 'like' in terms of what makes it different from other sensory experiences with respect to the differing qualitative properties featuring in the experience – whether or not these differences are for the subject reportable, effable, or recognisable (Fish, 2009, pp. 164, 57, n. 4; Pautz, 2006, p. 205; Pautz, 2021, pp. 4, 192;). Appropriately, then, attempts by naïve realists and internalists alike to account for why a given sensory experience has its qualitative character centre around identifying dependences between differences of qualitative character and differences of physical correlates, and theorising these dependencies as (at least partly) constitutive, or 'grounding', of qualitative character (Pautz, 2021, pp. 49, 184, 192; van Riel & Van Gulick, 2024, pp. 45–51).

Under naïve realism, neural activity is theorised to establish an 'acquaintance' relation that enables the sensory system to *select* mind-independent qualitative properties that are thereby *revealed* to consciousness, constituting externally-presented qualitative character (Fish, 2009, p. 137; Pautz, 2018, pp. 2–5)[3]. For example, what the varying 'pinkness' of an evening sky is like for a subject, that qualitative character of their experience, is literally instantiated in the surrounding atmosphere independent of being observed and is singled-out by the subject's neural activity via sensory receptors (Fish, 2009; Pautz, 2018, p. 2; Pautz, 2021, p. 5). Furthermore, that pinkness is grounded in,

not acknowledge any distinction between these two terms throughout his arguments. Following Pautz, I assume this interchangeability throughout the present thesis.

[3] All naïve realists are at least tacitly committed to the notion of 'acquaintance' because, according to Russell (1912/1990, p. 46; 1903/2010, p. xliii), with whom the term is centrally associated, acquaintance is when items of awareness are present to consciousness in the sense of being unmediated by intermediary items of awareness (Raleigh, 2019, p.1).

though not *reducible* to, how reflective the relevant atmospheric gases are throughout the visible spectrum of light (Pautz, 2018, p. 2). Conversely, under internalism, neural activity is theorised to *generate* mind-dependant qualitative properties, in the sense of such properties *manifesting within or by* consciousness, constituting internally-presented qualitative character (Fish, 2009, p. 137; Pautz, 2018, p. 10; Pautz, 2021, p. 5). For example, the qualitative character of a subject's evening sky experience can be constituted by representations *that it is the case* 'there is pinkness', or by an acquaintance with pink 'sense data' instantiated within consciousness, in either case grounded in neural activity (Pautz, 2018, p. 10; Pautz, 2021, p. 5; Siegel, 2011, pp. 33–34).

This fundamental disconnect between physical properties and qualitative character under internalism entails a "common factor" framework, implied by contemporary empirical investigation into perception, and illuminated by the following notorious thought experiment (Fish, 2021, pp. 13, 126–127). It is conceivable that the postreceptoral processing that results in a perception could occur without causal sensory connection to appropriate objects, as might, in principle, arise spontaneously or by artificial proximal nervous stimulation, such that the processing in either case has the same physiological–cognitive effects – for example, a subject might report the same experience either way (Fish, 2009, pp. 40–42; 2021, pp. 128–130). Accordingly, naïve realists either need to deny that such non-acquaintances could have qualitative character – in which case the subject can be radically mistaken about the nature of their experience – or else posit an additional internalist qualitative character (Fish, 2009, p. 180)[4].

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[4] Alternatively, naïve realists could follow Johnston (2004) and hold that, however the sensory stimulation occurs, the same qualitative properties are experienced but that in the case of artificial proximal nervous stimulation, such properties are not *instantiated* in the world.

Consequently, whatever account naïve realists provide of how neural activity in the 'misperception' case is constitutive of qualitative character will apply also in the perceptual case, given the matching neural activity (Fish, 2009, pp. 84–93; 2021, pp. 16–117). So, that account apparently "screens-off" as explanatorily redundant the contribution of extracorporeal physical properties to the effects of postreceptoral processing, and by extension, to the subject's apparently ostensively acquired perceptual knowledge of their surroundings (Fish, 2009, pp. 84–93; 2021, pp. 16–117). Moreover, evidence of the qualitative nature (or a lack thereof) of an experience is manifestly limited, under current scientific understanding, to observation of perceptual effects, such as instinctive reaction or elicited "introspective repor[t]" (Epstein, 2023, pp. 790–791). Yet, if naïve realists opt austerely for the 'lack of qualitative character' option in the misperception case, then such testimony must be denied with respect to experiences derived from non-acquaintance, thereby undermining claims of qualitative experience more generally. Whereas, internalism need not posit any difference in qualitative character between perceptions and misperceptions, nor deny introspective report, because although perceived objects can stimulate the sensory system, they are not constitutive of qualitative character under internalism (Fish, 2021, p. 57). So, naïve realists must deny, whereas internalists can embrace, a factor constitutive of qualitative character *common* to perceptions and misperception, rendering internalism, as Pautz (2018, p. 15) argues, more scientifically parsimonious than naïve realism.

Further solidifying this internalist advantage, Burge (2011) explains that "[s]cience is committed to the common factor" because neuroscientific and cognitive-psychological evidence indicates there are "quasi-deterministic laws of transition between registration of proximal stimulation and the perceptual states that are formed" (p. 44). Notably, his account of these law-like formations does not require any necessary connection to a *distal* side of nervous stimulation or beyond and so, according to Burge (2011) a ‘perceptual state’ is empirically *exhausted* by the observable condition of the subject’s neural activity and is thus *identified as encompassing*, rather than being merely *correlated with*, their perceptual experience (Fish, 2021, p. 130).

However, Burge (2011) does not prove introspective report infallible in the cases of misperception to which he appeals. Nor does he argue that, in cases of *veridical perception,* there is no causal sensory *modulation* of proximal stimulation by connection to extracorporeal properties – by which I mean he does not argue that, in cases of veridical perception, proximal stimulation is not causally connected to appropriate extracorporeal properties. So, his identification of the comparative lack of such modulating connection in *misperception cases* (of identical proximal stimulation with veridical perception) can mark an empirically observable difference in neural activity, between veridical perception and misperception, that naïve realists can reasonably interpret as a difference in the enabling of qualitative character, thereby grounding a difference in qualitative character. Accordingly, the notion of extracorporeal properties contributing to qualitative character is not strictly in conflict with the relevant science cited by Burge (2011) – instead, that notion is in conflict with Burge’s *interpretation* of the relevant science (McDowell, 2013, p. 275).

Indeed, as McDowell (2013, p. 275) points out, whilst current science identifies causal mechanisms that can render “intelligible” the notion of a ‘perceptual state’ as that which “manifest[s] responsiveness to environmental circumstances”, he says to conflate those elucidating mechanisms with the experiential “content” of the perceptual state “is a disputable philosophical claim, not one that can demand the respect due to results of empirical science” (p. 275). That is, under naïve realism, those mechanisms can coherently enable experience of extracorporeal content to which the perceptual system is connected (McDowell, 2013). Nonetheless, given the relevant empirical science, according to Burge (2011), does not necessitate a connection between distal and proximal nervous stimulation to explain ‘responsiveness manifested’ by the perceptual system, it is indeterminate, at least provisionally, how naïve realism is supposed to be empirically demarcated from internalism. That is, it is provisionally indeterminate whether empirical science can demonstrate how neural activity contributes to qualitative character, as either enabling or generative of qualitative character, given either interpretation of the data is defensible by mutually-opposing respective standards, at least with respect to the data cited by Burge (2011) (Epstein, 2022, p. 785). So, perhaps unless naïve realism or internalism can yield testable mechanistic models, it is unclear that the dispute between naïve realism and internalism over the contribution of neural activity to qualitative character is within the purview of science.[5]

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[5] *Testable* mechanistic models of the contribution of neural activity to qualitative character are at least conceivable. For example, suppose future information theorists are provided with a computational model of how shape qualitative character seems to be generated from neural processing, analogous to (as is widely speculated) how transistors realise computer software. For example, suppose *simultaneously* attending (innately) to all possible logico-mathematical relations between finite points on a represented finite plane is deemed equivalent to the qualitative character of an extended space because all that could possibility be introspectively reported about an extension of space is deemed equivalent to all possible logico-mathematical relations between its points (and vision is not infinitely divisible and is thus finitely experienced). In that case, information theorists could perhaps calculate that, just as software is incapable of running with insufficient memory, the information processing capabilities of neural responses are necessarily inadequate for the level of processing required by the model. Similarly, suppose future evolutionary biologists create a simulation of selective pressures on a primitive sense organ, thereby disconfirming a model of how *connecting to*, rather than *generating*, apparent qualitative properties would have provided a selective advantage, such as if a primitive

This seeming impasse is pragmatically transversed by Pautz (2018; revised in 2021) who, in contrast to Burge (2011), considers extracorporeal data relevant to whether science conflicts with naïve realism. Effectively, Pautz employs organisations of similarities and dissimilarities, or 'similarity spaces', between qualitative properties (as reportedly experienced) to establish a quantitative setting within which it could be determined to what extent similarity spaces between extracorporeal physical patterns, and similarity spaces between neural patterns, are respectively correlated with the qualitative character of associated perceptual experiences[6]. Pautz identifies a respective sensory–external incongruence for each of three sense modalities: Vision, olfaction, and audition. According to Pautz (2018, pp. 6–9; 2021, pp. 66, 151–158, 216–222), empirical data he collates demonstrate that extracorporeal physical properties are badly correlated, whereas neural activity is highly correlated, with qualitative similarity spaces. Consequently, Pautz (2018) argues that naïve realism therefore entails "a swarm of inexplicable, irregular grounding connections in the external world" (p. 9) in contrast to "systematic and regular grounding connections" (p. 15) to neural activity as entailed by "brain-based theor[ies] of sensory consciousness" (p. 1) – including variations of internalism he identifies such as 'internalist representationalism'[7]. Pautz (2018, pp. 9, 15)

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generative model of neural processing does not require, as was mistakenly anticipated, more energy consumption than a corresponding enabling model (Epstein 2023, pp. 806–807, 810).

[6] Note that Pautz does not explicitly utilise quantitative analysis in his identification of sensory–external incongruence, rather he refers to his judgements of how the quantitative data appears qualitatively, as represented pictorially. That is, except for when he deals with audition sensory–external incongruence, in which case he effectively refers to the ordering of data without required reference to how the data appears qualitatively.

[7] In section 2.2 of the present thesis, I elaborate upon Pautz's identification of brain-based theories.

concludes from his identified incongruences and congruences that naïve realism should be rejected in favour of a brain-based theory on grounds of stark scientific parsimony[8]. Correspondingly, Pautz (2021) concludes on the same grounds that equivalent incongruences and congruences specifically “support internalist representationalism over basic naïve realism” (p. 217). Although, instead of centring this empirical argument around the *inexplicability* of grounding connections entailed by naïve realism – as Pautz (2018) does – Pautz (2021) instead limits his discussion to “unsystematic and numerous” “external laws” entailed by naïve realism in contrast to “systematic and simple” “internal laws” entailed by internalist representationalism (p. 217). That is, where these external and internal ‘laws’ are, as described by Pautz (2021, p. 218) essentially the ‘grounding connections’ to which Pautz (2018, p. 9) refers.

After the present introduction and literature review section, I primarily address Pautz’s (2018) empirical argument against naïve realism, rather than the revised version by Pautz (2021), or earlier versions by Pautz (2013) and Pautz (2017)[9]. The argument by Pautz (2018) is selected, for wide applicability, as the most up-to-date version that considers naïve realism in contrast to ‘brain-based’ theories *generally*, rather than, as Pautz (2021, p. 217) later does, specifically in contrast to internalist representationalism,

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[8] Pautz (2018) extensively supplements his empirical argument against naïve realism with hypothetical quasi-empirical arguments against naïve realism derived from, and dependent upon, the former *explicit* empirical argument regarding sensory–external incongruence. Throughout the present thesis, I focus exclusively on the latter, more fundamental, ‘incongruence’ argument, and the general form thereof (as implemented in other versions of Pautz’s empirical argument).

[9] Although there are four versions of Pautz (2018), I reference only the first because the differences between the versions are minor and inconsequential to my arguments, and the first is the version recommended to me by my supervisor.

Pautz's (2018, p. 15) preferred brain-based theory[10]. All these versions have a general 'incongruence argument' form: Sensory appearances are incongruent with extracorporeal data, whereas, sensory appearances are congruent with neural data, and so, naïve realism is undermined in contradistinction to at least one view that holds sensory appearances are most directly dependent upon neural activity (Pautz, 2018). The principal conclusions of the present thesis are applicable to this general incongruence argument form, as embodied by Pautz (2018), such that the principal conclusions of the present thesis are applicable to all the above-listed implementations of

[10] The former more general context is useful for illuminating that, under naïve realism, sensory–external incongruence need only evidence a high dependence upon sensory experience by neural responses, as opposed to evidencing unsystematic grounding connections. In particular, comparing naïve realism to brain-based theories reveals that their demarcation is vague and disputable, and this effective 'bridging' between brain-based theories and naïve realism is an efficient way of illuminating a distinction between 'negative' and 'positive' neural contributions to qualitative character that I utilise to, in effect, strengthen naïve realism against Pautz's (2018) version of the empirical argument, and against other versions by extension. Pautz's (2018), version of the empirical argument effectively differs from Pautz's (2021) revised version only by the latter, in addition to contrasting naïve realism more narrowly with internalist representationalism, dropping both the general notion of a brain-based theory and the notion that naïve realism entails "inexplicable" (p. 9) grounding connections. However, such differences are inconsequential to conclusions of the present thesis and so, it would be unnecessarily expansive, and would unnecessarily increase cognitive load, to frequently caveat how conclusions of the present thesis differently apply to differing versions of Pautz's (2018) version of the incongruence argument. Therefore, it is clearer to primarily focus on that particular version.

the incongruence argument; to all those versions of Pautz's (2018) empirical argument against naïve realism.[11]

1.2. Underdevelopments in the Literature

Direct evaluations of the incongruence argument implementations are limited. Fish (2021, p. 132) suggests there is at least one opportunity, in the case of olfactory sensory–external incongruence, for naïve realists to reject Pautz's (2018) identification of incongruence on the grounds that it follows from a misapprehension of the structural complexity of the relevant extracorporeal data. However, Fish (2021) says the approach he considers would clash with general scientific and philosophical consensuses about what kind of items feature in olfactory awareness. Some critical responses to Pautz (2018; 2021), such as those by Cutter (2022), Sethi (2020), and Speaks (2024), do not directly evaluate Pautz's incongruence argument but rather focus on his associated hypothetical quasi-empirical arguments derived from, or dependent upon, or supported by, his explicitly empirical incongruence argument (Pautz, 2024). A partial exception is Sethi (2020, pp. 596–597, 602, n. 18, 28) who, though accepting of Pautz's (2018)

[11] Although I respond to Pautz's (2018) demarcation of naïve realism from brain-based theories in general, rather than Pautz's (2021) revised demarcation of naïve realism from internalist representationalism in particular, the overall conclusions of the present thesis can apply to both demarcations, despite that I criticise the vagueness of the supposed demarcation of naïve realism from brain-based theories. That is, a bridging of naïve realism and brain-based theories is not an argument I ultimately rely upon in the present thesis. Indeed, in section 4.2.1.2 below, through criticism of Pautz's (2018) demarcation of naïve realism from brain-based theories, I identify a negative–positive distinction between contributions to qualitative character that I utilise to propose a way of *defending* that demarcation.

identified incongruences and inexplicabilities, suggests that some sensory–external incongruent phenomena like afterimages – such as seeing yellow in a white surface when one's blue receptors are fatigued – show that incongruent worldly groundings can become systematic and explicable upon recognising concurrent dependencies of the neurological system (dependencies that she argues are co-grounding of qualitative character). Similarly, Cutter (2022, pp. 737–739) is a partial exception because he considers implications of Pautz's (2021) identified incongruences, and corresponding inexplicabilities, for the notion that colours are instantiated external to the mind. However, Cutter uncritically accepts Pautz's identified incongruences.

Contrastingly, Epstein (2022) vigorously and systematically argues that the incongruence argument, as implemented by Pautz (2017) and Pautz (2021), fails to engage appropriately with naïve realism[12]. Generally, Epstein (2022, p. 791) argues that the correlations Pautz (2017; 2021) draws between experience and physical properties depend on the reliability of introspective report, yet the denial of such reliability is a basic tenet of naïve realism given, as detailed in section 1.1 above, the possibility of indistinguishability between perception and misperception. Nonetheless, Epstein (2022, pp. 792–793) recognises that naïve realists can entertain the reliability of introspection in the canonical cases of perception to which Pautz refers – after all, if experiences can have qualitative character, then this is revealed through introspection. However, Epstein (2022, pp. 794–795) argues that Pautz's (2017; revised in 2021) incongruence argument fails in any case, principally, due to ambiguities in Pautz's claim that congruences and incongruences in the data are evident by "any natural measure" (Pautz, 2017, p. 25;

[12] Note that although Epstein (2022) directs his arguments at the versions of the incongruence argument by Pautz (2017) and Pautz (2021), Epstein's arguments are applicable to the version by Pautz (2018) around which the present thesis primarily focuses.

Pautz, 2021, p. 155) – a claim mirrored by Pautz (2018, p. 11). That is, Epstein (2022) points out that Pautz (2017; 2021) does not, with respect to any of his data comparisons, *specify* a standard of measurement by which similarities and dissimilarities are supposed to be identifiable. For example, when discussing reflectance correlates of colour, Pautz (2021) says, “by a natural measure, the blue reflectance-type is more like the *green* reflectance-type than the purple reflectance-type” (p. 162), but he does not detail any natural measure nor define what he takes such a quantification to mean or permit. Epstein (2022) elaborates that nor, by extension, does Pautz specify a “uniform standard” (p. 812) of such measurement between neural and extracorporeal data from which it could be objectively determined whether naïve realism or internalism is ‘more’, or that one is ‘badly’, correlated with sensory experience.

Consequently, Epstein (2022, pp. 794–797) suggests these ambiguities of measurement undermine Pautz’s (2017; 2021) identified incongruences and congruences as *arbitrary*, and perhaps as disproportionally focused on internalist motivations, given the data can potentially be interpreted contradictorily, as both congruent and incongruent, via different standards of measurement[13]. For example, identification of similarities by one measurement need only demonstrate ignorance of dissimilarities by some other measurement, and vice versa. To illustrate by analogy, with respect to linearity, a discontinuous triangle outline and a continuous square outline are more alike than either are to a continuous circle outline. Yet, with respect to continuity, the square outline and circle outline are more alike than either are to the triangle outline.

[13] Epstein (2022) suggests he applies the following “not unique[ly] to Pautz”: “Whether particular scientific studies, or domains of inquiry, are likely to find non-obvious correlations between experience and internal (or external) variables depends in large part on the researchers’ motivations and presuppositions” (p. 796).

Furthermore, these two examples can be undermined by increasing the precision of specification: The circle outline is maximally linear with respect to continuity of curvature, and the triangle outline, if equilateral, can be maximally continuous with respect to repetition of line length and connective angle.

Epstein (2022, pp. 810–811) disputes the implication of Pautz's (2021) arguments that *complex* grounding connections under naïve realism are problematic or indicative of a lack of systematic correlation with sensory experience. As Epstein (2022, pp. 810–811) explains, complex and apparently unsystematic physical groundings of comparatively more simple and systematic phenomena are common and well understood: He points out that basic systems of economics supervene on elaborate physical interactions of matter. He further points out that the systematic neural grounding connections cited by Pautz (2017; 2021) in favour of internalism are highly complex – from which Epstein (2022) conjectures "there is every reason to think" (p. 797) that complex extracorporeal grounding connections would be found to be systematic if the "extremely complex processing of empirical data" (p. 797) utilised to investigate neural correlates of sensory consciousness was likewise utilised to investigate corresponding extracorporeal correlates of sensory consciousness. This conjecture is legitimatised by the fact Pautz (2017; 2021) does not impose any constraints on interpretations of the data, as evidenced by the ambiguities identified by Epstein (2022).

Epstein's (2022) identifications of ambiguities in Pautz's (2017; 2021) analyses, and by extension, Epstein's suggestion of undiscovered complex regularities permitted by those ambiguities, could in either case reasonably impede the cogent development of arguments based on Pautz's identified congruences and incongruences. However, unless such counterevidence is provided, Pautz's incongruence argument can reasonably stand as an evidentially supported pre-scientific theory. That is, standing as not yet replicated but not yet confronted by falsification or failure to predict phenomena and so on. Nonetheless, given the possibility of undiscovered counterevidence conjectured by Epstein (2022, p. 797), it is prudent to interpret Pautz's (2018) analyses of extracorporeal data as showing a conflict between naïve realism and science only *tentatively*. Provided, that is, naïve realists are burdened with acknowledging the reliability of introspective report or a subset thereof, such as in the case of specifically *veridical* perception. Certainly, this burden can be reasonably upheld by theorists sympathetic to the methods of scientific analysis, as is inherently practical when investigating philosophical frameworks within which to identify *physical correlates* of sensory consciousness. However, in the following two sections, 1.2.1 and 1.2.2, I identify underdevelopments in the literature that diminish the tentative scientific appeal of Pautz's (2018; revised in 2021) incongruence argument[14].

1.2.1. The Structure of Colour Similarities

Pautz's (2018; 2021) suggestion that his incongruence argument engages appropriately with science – so as to evidence a "conflict between naïve realism and science" (2018, p. 1) – is undermined by a critical underdevelopment of his analyses, unrecognised by Pautz or his critics. To locate this issue, consider that Pautz's (2018;

[14] Throughout the remaining sections of the present introduction and literature review section, I jointly focus on the similar implementations of the incongruence argument form by both Pautz (2018) and Pautz (2021) – rather than just Pautz (2018) around which sections 2–5 below exclusively focus – to ensure I appropriately engage with the criticisms of the incongruence argument by Epstein (2022) who considers Pautz (2021) but not Pautz (2018). That is, I build upon some of Epstein's criticisms of Pautz (2021), so it is important to demonstrate that those criticisms are equally applicable also to Pautz (2018) – which can be straightforwardly demonstrated by addressing Pautz (2018) and Pautz (2021) simultaneously.

2021) incongruence argument fundamentally depends upon three datasets: Qualitative similarly spaces, associated neural response measurements, and associated extracorporeal measurements. That is, Pautz identifies an ordering structure within the given qualitative similarity space and attempts to match that structure to associated physical measurements. Yet, whilst he collates neural and extracorporeal data, he does not collate any qualitative similarity space data. Perhaps it could be argued that the qualitative ordering structurers to which Pautz refers derive from widespread and shared introspective report and are, therefore, self-evident, or truistic, and so citation of relevant data is not required. For example, Pautz (2018, p. 7; 2021, pp. 40, 157, 161–162) notably refers to the *ubiquitous* view that purple is more similar to blue than (perhaps *either* is) to green, which he determines appropriately matches associated neural response measurements but not associated extracorporeal measurements because, in the latter case, he analyses the respective blue and green correlates to be more similar than either is to the purple correlates.

However, whilst the view that, experientially, purple is more similar to blue than to green, is *ubiquitous* and so, reasonably assumed, Pautz's (2018, pp. 7–8; 2021, pp. 157–158, 217–219) analysis of similarities between these colours is critically incomplete because his corresponding identification of sensory–external incongruence neglects the ubiquitous view that purple is a 'binary hue' conventionally perceived as similar to both blue and red, whereas blue and green, like red and yellow, are 'unique hues' conventionally perceived as maximally dissimilar to one another (Pautz, 2006, pp. 208-209). That is, all else being equal, if the position of purple in a colour similarity space is to be appropriately mapped onto measured physical relations, then those measurements need to be associated with at least blue and red. But Pautz does not mention any relation between red and purple. Instead, the only data he selects that are relevant to correlates of purple are respective correlates of blue and green. Furthermore, even if

Pautz (2018; 2021) is correct that correlates of blue are more similar to correlates of green than either is to correlates of purple, that ordering structure is consistent with blue and green being both unique hues whereas purple is a binary hue, particularly given the conventional identification of purple's position in colour similarity space, with respect to blue, is manifestly incomplete without reference to the relative position of red. The point is that, *whether or not* Pautz is deemed correct in his analysis of similarities between the extracorporeal *correlates* of the respective colours he collates, that dataset is evidently inadequate to map onto the *experiential* similarity relations between two unique hues and one binary hue that he attempts to match to the dataset.

To clarify this point by simplistic analogy, consider the sound of individual words as analogous to the look of individual colours, and the number of letters each word contains as analogous to quantitative correlates of each colour (extracorporeal physical measurements). Manifestly, 'fireman' sounds more similar to 'fire' than to 'water', whereas the reverse holds for corresponding numbers of letters because 'fire' has 4 letters and 'water' has 5 letters, a difference of 1, whereas, 'fireman' has 7 letters, a difference greater than one with respect to either 'fire' or 'water'. Yet, it would be mistaken to therefore conclude that the auditory similarity between 'fireman' and 'fire', and their shared auditory dissimilarity to 'water', does not map onto the corresponding number of letters of each word – due to numerical similarity of letters between 'fire' and 'water' and their shared numerical dissimilarity of letters to 'fireman' – *even though this quantitative analysis is numerically valid*. That is to say, the fundamental phonetic reason 'fireman' is similar to 'fire' is because the former partly *contains* the word 'fire', the other part being the word 'man', which was unacknowledged in the analysis until now. Indeed, upon recognising that 'fireman' is composed of 'fire' and 'man', it becomes clear that the auditory similarities and dissimilarities do, in fact, map onto the corresponding numerical similarities and dissimilarities because 'fireman' is composed of two words, 'fire' and ‘man’ respectively containing 4 and 3 letters and so, the first 4 letters of ‘fireman’ *necessarily* map exactly onto the word ‘fire’. Consequently, given the phonetic similarity between ‘fireman’ and ‘fire’ cannot be adequately captured without recognising that ‘fireman’ is partly composed of ‘fire’, if that similarity were to sensibly map onto number of letters of each word, then that mapping would likewise embody the fact ‘fireman’ is partly composed of ‘fire’.

So, the initial analysis that ‘fireman’ is similar sounding to ‘fire’ (and dissimilar sounding to ‘water’) was *incomplete* by not acknowledging that ‘fireman’ is part ‘fire’ and part ‘man’, thereby rendering *superficial* the subsequent initial analysis that this auditory similarity does not map onto the numerical dataset of corresponding letters – where ‘fireman’ was considered one word, rather than a phonetic combination of two words. Analogously, given the distinction between unique and binary hues, Pautz’s (2018; 2021) analysis that purple looks similar to blue (but not to green) is incomplete by not acknowledging that, ubiquitously, purple appears part blue and part red, thereby rendering superficial his analysis – *whether or not quantitatively defensible* – that the qualitative similarity space of purple and blue (and green) does not map onto a correlated quantitative dataset of extracorporeal physical properties – where purple is not recognised as appearing part blue and part red[15].

[15] In other words, just as comparing numbers of letters between only ‘single’ words, rather than amongst single words and composite words, inadequately maps onto the phonetic similarities and dissimilarities between the relevant words, so too does Pautz’s (2018) comparison of extracorporeal physical correlates between ‘single’ colours, rather than amongst unique and binary colours, inadequately map onto the ubiquitious qualitative similarities and dissimilarities between the relevant colours to which Pautz implicitly appeals in his identification of colour sensory–external incongruence.

Accordingly, then, it is unsurprising that, as Epstein (2022, pp. 794–795, 812) identifies, Pautz (2018; 2021) fails to specify a measurement standard by which a similarity space is to be identified between physical correlates of colour similarity space. That is, importantly, Pautz does not take into account any specific *way* in which the relevant colours are supposed to relate to one another, such as that purple relates to blue in association with red, or that binary hues are ubiquitously understood as 'combinations', and so he does not have the resources to likewise specify a way in which *correlates* of colours are supposed to relate to one another – this is the first primary point of the present section. Even if the notion of 'ways' in which colours are supposed to relate is left out of Pautz's (2018; 2021) analyses due to be being, say, difficult to quantify as a standard for comparing physical measurements, his requirement that correlates of purple be similar to correlates of blue implicitly *depends* upon such ways of relation – notably that purple is conventionally 'part' blue (with the other 'part', red, being unacknowledged by Pautz).

Consequently, Pautz's (2018; 2021) failure to acknowledge this underlying dependency undermines his identifications of sensory–external incongruence, at least in the case of colour, because the purported "natural measure" (2018, p. 11; 2021, p. 155) by which he privately makes his identification of colour sensory–external incongruence evidently derives from a misapprehension of the structural complexity of the relevant qualitative similarity space. This consequence is similar to Fish's (2021, p. 132) suggestion that Pautz (2018) might misapprehend the structural complexity of relevant *extracorporeal* data in the case of olfaction, but the former consequence (derived from the present thesis) is more general, marking Pautz's misapprehension of the *underlying structural model* in comparison to which he identifies congruences and incongruences between data. Therefore, importantly, Pautz's (2018; revised in 2021) incongruence argument cannot, at least with respect to colour, be reasonably interpreted as demonstrating a "conflict between naïve realism and science" (2018, p. 1) without further investigation confirming his identified congruences and incongruences where correlates of red are taken into account, or what would be more thorough, where a more general ordering structure of colours, and 'ways' of similarities between colours, are each taken into account – this is the second primary point of the present section.

For example, Pautz (2006) suggests that reliable agreement of introspective report can render a "purple experience" quantitatively describable as "60% reddish and 40% bluish" (pp. 208–209). Certainly, the adoption of some such analysis could improve Pautz's (2018; 2021) approach – especially given the ambiguities Epstein (2022) identifies – by establishing, at least as a provisional and approximate model, a quantitative base from which to clearly define congruence and incongruence between experience and physical measurements. Indeed, before determining that quantitative correlates of color experiences "do not exhibit a unitary/binary structure" (Cutter, 2022, p. 738), it would be useful to first establish whether qualitative similarities between unique hues and binary hues are sufficiently modeled, quantitatively, by the notion that each colour occupies an 'ordering position' within similarity space. That is, given there are additional quantitative aspects to the unitary–binary structure, such as the 'additive' notion that binary hues are "combinations" (Pautz, 2006, p. 209), or "composite[s]" (Fish, 2021, p. 169), of unique hues.

So, in the present section, I have identified that the *qualitative* data (a ubiquitously reported similarity space of colour) to which Pautz appeals in his identification of sensory–external incongruence is implicitly more complex (it depends upon a combinatorial similarity between a binary hue and a unique hue) than he attempts to map onto correlated *quantitative* data (extracorporeal correlates of colour). That is, that mapping is incomplete because it does not take account of the implicit complexity of the qualitative data (given the binary–unique hue relation), thereby rendering his conclusions superficial of the underlying similarity relations on which his identification of sensory–external incongruence implicitly depends. Therefore, his analysis or colour cannot be reasonably interpreted as demonstrating a sensory–external incongruence without taking into account the unique–binary distinction by including extracorporeal correlates of red in his quantitative dataset. In which case, if the correlates of purple do not appear to be a combination of the respective correlates of red and blue, then his identification holds, but not otherwise.

Accordingly, in section 3 below, I expand upon Pautz's (2018) dataset of extracorporeal correlates of colour to, more appropriately, include those of red, through which I develop a quantitative model of qualitative similarity between binary hues and unique hues with which to test his claim of colour sensory–external incongruence. The quantitative model predicts extracorporeal correlates of purple from those of blue and red, as well as predicting all other binary hues, thereby demonstrating that there is, contra Pautz, widespread colour sensory–external congruence when taking into account the distinction between binary and unique hues – which I have argued throughout the present section is fundamentally more appropriate than comparing, as Pautz does, a qualitative similarity space, that includes a binary hue and associated unique hue, to extracorporeal correlates without recognising that distinction. Nonetheless, I acknowledge, in section 3.6, that there is scope for Pautz's (2018) identification of colour sensory-incongruence to be problematic for naïve realism if he disregards purple (and perhaps binary hue more generally). That is, if he focuses only on the apparent similarities he identifies between extracorporeal correlates of blue and green, and on apparent similarities and dissimilarities between extracorporeal correlates of unique hues more generally, given unique hues are ubiquitously supposed (being *unique*) to be maximally dissimilar, qualitatively.

1.2.1.2. Other Modalities. Given Pautz (2018; 2021) evidently misapprehends conventional structural complexities of colour similarity space, it might be questioned whether he likewise misapprehends conventional structural complexities of the respective qualitative spaces corresponding to his identifications of olfactory and auditory sensory–external incongruence[16]. However, as Pautz (2021, pp. 162–163) points out, whereas orders of similarities between colours are systematically categorisable by the unique–binary distinction, there is apparently no obvious analogous system available with which to categorise orders of similarities between odours (Mainland, 2018, p. 15). That is, according to Mainland (2018, pp. 15–16), attempts to organise olfactory stimuli for introspective report have been hampered because the "vastness" (p. 15) "of possible odors" (p. 15) makes it "difficult to determine if a given set of materials fairly represents all possible qualities" (p. 16). To illustrate by simplified analogy, without access to binary hues, colour space would be, as reported, totally *unstructured*, there being, in that case, only stimulation of unique hues, which have no obvious relations absent ordering connections through related binary hues. Indeed, according to Mainland (2018, pp. 15–16), "[a] surprising amount of what we know about olfactory coding comes from treating odorants as random inputs with no clear relationships tying one odor to another" (p. 15). Furthermore, according to Epstein (2023, pp. 795–796), although relevant contemporary "machine-learning models" can accurately predict how odour stimulations will be experienced, thus suggesting to him there will inevitably be revealed a "(highly-complex) dimension of similarity along which" olfactory sensory–external congruence can be identified, these models are nonetheless "relatively new and still far from perfect" (p.

[16] To clarify, questioning the structural complexity of such introspectively reported data is distinct from questioning, as Fish (2021, p. 132) effectively does, the structural complexity of the *extracorporeal* data *correlated with* that introspectively reported data.

796). Accordingly, there is no established structural complexity of olfactory qualitative space to misapprehend and so, there are no such grounds to reinvestigate Pautz's (2018; 2021) identified olfactory sensory–external incongruence.

Comparably, Pautz (2018, pp. 8–9; 2021, pp. 216–217) does not obviously misapprehend any conventional structural complexity of an auditory qualitative space in his identification of auditory sensory–external incongruence. That is, the auditory case he discusses revolves around a specific prolonged and increasing auditory stimulation that results in the experienced auditory quality abruptly changing to another auditory quality without an associated change in relevant extracorporeal measurements.[17] In which case, the relevant similarity space is highly simple, involving only two interchanging qualitative properties that are reportedly distinct.

1.2.2. Obscure Neural Dependence

Whether Pautz's (2018; revised in 2021) incongruence argument can hold up against a more extensive analysis of colour similarity structures than he employs, there is a more thoroughly overlooked, though more speculatively problematic, underdevelopment of his analyses. To draw out this fundamental underdevelopment, consider again, as detailed in section 1.1, the apparent indeterminacy of whether empirical science can demonstrate how neural activity contributes to qualitative character, as either enabling or generative of qualitative character. Pautz (2018; revised in 2021) effectively circumnavigates this problem by arguing that if neural grounding connections are, and if extracorporeal

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[17] This is perhaps analogous to either how prolonged exposure to continuous colour results in objective modification in photosensitivity or in subjective modification in beliefs about the content of the experience (Fish, 2021, pp. 169–171).

grounding connections are not, “systematic and regular” (2018, p. 15), or “systematic and simple” (2021, p. 217), then “simplicity considerations strongly support” (2021, p. 217) that qualitative character is “*most directly*” (2018, p. 10), and potentially therefore *constitutively*, dependent upon “neural responses” (2018, p. 10) to proximal nervous stimulation[18]. To this end – that is, to determine whether extracorporeal grounding connections are systematic–regular – Pautz identifies an ordering structure (as detailed in the previous section) within the given qualitative similarity space and attempts to match that structure to associated extracorporeal measurements. Notably, Pautz (2018, pp. 7–8; 2021, pp. 157–158, 217–219) does not attempt to match the qualitative ordering structure to associated extracorporeal measurements in consideration of, nor in conjunction with, the neural response measurements he similarly uses to determine whether neural grounding connections are systematic–regular – nor in consideration of, nor in conjunction with, any other data. Indeed, whereas Pautz does not take *full* account of the colour similarity structures to which he appeals when identifying sensory–external incongruence, he does *not at all* take into account any neural similarity structures when making such identifications, despite that neural activity is the enabling component of the acquaintance relation under naïve realism. Furthermore, Pautz does not explicitly acknowledge, nor does he justify, this exclusive focus on extracorporeal measurements towards identifying potential sensory–external systemisations or regularities.

[18] I caveat that Pautz (2018; 2021) *potentially* argues that qualitative character is *constitutively* dependent upon neural responses because whilst this is clearly the view of Pautz (2021), who contrasts naïve realism with internalist representationalism, Pautz (2018, pp. 10, 16) is unclear, in his identification of the views he contrasts against naïve realism, about whether neural responses have that constitutive role. I elaborate upon this apparent ambiguity in section 2.2 of the present thesis.

However, the justifiability of this exclusive focus is called into question given, as Sethi (2020) implies, sensory–external incongruence can be rendered systematic–regular through additional consideration of contributions to qualitative character by the neurological system. Specifically, Sethi (2020, pp. 596–597, 602, nn. 18, 28) suggests, in her discussion of Pautz (2018), that *afterimages* would seem unsystematic and irregular if investigation into the phenomena were limited to extracorporeal data, whereas afterimages would seem systematic–regular upon additional investigation into concurrent dependencies of the neurological system. To illustrate this implication, consider staring at a large bright blue vase for an uninterrupted and extended period. According to Fish (2021, pp. 169–171; see also Pautz, 2006, p. 211), prolonged exposure to the blue light reflected by the vase can eventually result in diminished sensitivity to that wavelength in the relevant portion of the retina, inversely rendering yellow light – the 'complimentary' wavelength to which the relevant photoreceptors remain sensitive – more visible in the part of one's visual field previously occupied by the vase. Suppose a subject undergoing such an experience turns their attention to the blank white wall behind the vase and accordingly experiences a floating vase-shaped yellow patch superimposed thereon. Without knowledge of the diminished capacity of the relevant photoreceptors, the subject's appropriate claims of seeing a floating vase-shaped yellow patch would rightly seem utterly incongruent with predominant wavelength measurements of their surroundings. Indeed, if the subject experienced and reported many such afterimages, simultaneously or successively, then an empirical investigator focused exclusively on extracorporeal correlates of sensory experience could reasonably consider this type of imagery unsystematic–irregular relative to extracorporeal data. Yet, if the diminished capacity of the relevant photoreceptors is taken into account, then the appearance of afterimagery can be systematically and regularly explained as phenomena concurrently dependent upon both the neurological system and extracorporeal properties (Sethi, 2020, pp. 596–597, 602, n. 18, 28).

Therefore, there is at least one kind of perceptual, though effectively illusory, experience under naïve realism, that is identifiable as systematic–regular only by synthesising observed neural and extracorporeal dependencies on experience. Indeed, the vase-shaped afterimage case illustrates that it is not necessary under naïve realism, at least not universally, that a given perceptual experience *matches* saliently correlated extracorporeal measurements. Accordingly, before determining perceptual experience, more generally, to be unsystematic–irregular, due to particular identified incongruences between experience and the world, it would be prudent to either justify that exclusive focus on extracorporeal measurements or consider whether unrecognised neural dependencies of experience may be behind the respective appearances of sensory–external incongruence identified by Pautz (2018; 2021).

1.2.2.1. Implicit Justification. It could be objected that Pautz (2018; 2021) is not required to justify his exclusive focus on extracorporeal measurement because, under naïve realism, differences in experience are supposed to align to differences in correlated extracorporeal properties and so, a lack of such alignment either undermines naïve realism or else need only indicate a lack of *perceptual* qualitative character, or a lack of qualitative character all together (Fish, 2009, pp. 11–13). That is to say, under naïve realism, *dependences* between differences of qualitative character and differences of physical correlates are theorised to be grounding of qualitative character (Pautz, 2018, p. 3, 184; van Riel & Van Gulick, 2024, pp. 45–51). So, such grounding is undermined, at least provisionally, if differences in qualitative character are not aligned with, and in that sense not observably *dependent upon*, differences in physical correlates.

Yet, this posited implicit justification of Pautz's (2018; 2021) exclusive focus on extracorporeal measurement does not appropriately engage with naïve realism in the afterimage case because it entails either that the qualitative character of the vase-shape experience would not be perceptual, or that there is no such qualitative character. Whereas, naïve realism is consistent with the qualitative character of the vase-shape experience being *perceptual* because, although no contemporaneously distinguishable correlate of the vase shape is instantiated in the subject's surroundings (the blank white wall), that vase shape is constitutively dependent upon those surroundings. That is to say, the set of reflectance's impinging upon the subject's retina, that in aggregate constitute the specific yellow region, are *extracorporeally instantiated* – though abnormally singled-out from surrounding reflected white light – as facilitated by defective sensitivities in the sensory system.

Nonetheless, it is perhaps ambiguous whether the shape of the afterimage is 'extracorporeal' given it is partly instantiated at the apparent limit of the neurological system, where neural–external confrontation occurs. That is, the shape of the yellow patch is bounded by the region to which the fatigued retinal cells are sensitive, as demarcated from the adjacent region to which the appropriately functioning retinal cells are sensitive. Yet, whilst under naïve realism, there would be no vase-shape experience if one were not acquainted with extended space – and so that shape is necessarily 'extracorporeal' in the sense of being 'in the world rather than the mind' – that shape is arguably constituted also by sensitivities of the neurological system.

1.2.2.2. 'Apparitional' Shape Acquaintance. To explain by contradistinction that neurological contribution, consider veridically perceiving the blue vase for a sufficiently brief period such that no afterimage is induced (at least not noticeably). The shape of the vase, in so far as it is available to the sensory system (it would be unavailable in total darkness), is the physical instantiation of colour contrast between the blueness of the vase and the whiteness of the wall behind. In this sense at least, that colour contrast is constitutive of the vase-shaped qualitative character of the experience. Similarly, consider again the yellow vase-shaped afterimage: The shape of the vase-shaped afterimage, like the shape of the blue vase, is the contrast between physically instantiated colours, in this case yellow and white. However, this yellow–white afterimage visual demarcation is of an 'apparitional' sort compared to the blue–white veridical visual demarcation.

To elucidate by metaphor, consider a subject exploratorily sensing, with their left hand, the shape of the palm side of their right hand with the fingers straightened flat. Suppose the subject subsequently places their right hand – palm side with fingers straightened flat – on a continuously smooth wall. In this 'wall case', the subject can feel the portion of the wall that has the same shape as their right hand. For example, in principle, the subject could logically attend to this extracorporeal shape by consecutively feeling respective sub-regions of the wall extending beneath their fingers and palm[19].

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[19] That is to say, even if, perhaps expectedly, the subject might find it difficult to attend to the global shape of the hand-shaped region of the wall, this could logically be achieved by piecemeal attention to the shape of the respective region each finger is touching and the region extending beneath the palm. This piecemeal attention is plausible as being appropriately analogous to visual saccades building a piecemeal acquaintance with global visual shape under naïve realism. Naïve realists need to hold such a piecemeal view of vision to avoid requiring that visual shape perception is generally illusory, being reduced only to fleeting 'snippets' of typical shapes as isolated by momentary cessations of eye movement. Therefore, the analogous possibility of piecemeal touch shape perception has mechanistic precedence (whether or not that is the way touch perception, in fact, occurs). So, whilst the subject's experience of the hand-shaped region of the wall may be less pronounced, or less simultaneous, than their experience of feeling their right hand with their left hand, the shape is geometrically the same in either case and so, difficulty of attending to the shape in the wall case need only be a contingent limitation of the sensory system.

When the subject exploratorily feels their right hand, the reason their touch experience has its specific qualitative character is primarily due to the specific physical constitution with which they are confronted, the contours of their right hand. Whereas, when the subject feels the same shaped region of the wall via piecemeal attention, the reason their touch experience has its specific qualitative character is at least as much to do with the shape of their right hand as it is with the fact a portion of the wall has that shape. Indeed, the subject could move their right hand about, onto other surfaces, and the shape would remain effectively unchanged – putting aside, for simplicity, significant changes in surface texture or rigidity. So, the fact there is touch experience at all is constituted by the surface of whatever is being touched, whereas the specific global shape of that touch experience is more dependently constituted, *counterfactually*, by the bounds of the sensory system, the shape of the subject's right hand. In other words, the shape experienced in the wall case is overdetermined by the physical constitution of the world. By which I mean the world constitutes an experientially generic phenomenological 'fill' or "rich backdrop" (Fish, 2009, p. 67) only through which there can be experience, but the 'outline' filled is more dependently constituted, counterfactually, by the *limitations* on that touch experience, the specific bounds of the subject's right hand. So, whilst the shape of the subject's right hand and the equivalent shape of the wall are both physical instantiations, the experience of shape in the wall case is more significantly constituted by limitations upon the sensory system, thus constituting an 'apparitional' sensory appearance in the sense that the vase-shaped 'outline' just is the bounds of the sensory system.

1.2.2.3. Obscure Neural Dependence. Correspondingly, the vase shape of the yellow afterimage is constituted in that apparitional sense of being constituted by modulative limitations on the sensory system – by *varying sensitivities of retinal cells*. And as these sensitivities, under naïve realism, *enable* qualitative character rather than *feature* therein as physically instantiated *content*, the vase-shaped afterimage is at least partly constituted by the *functioning* of the neurological system. Furthermore, as neural responses to proximal stimulation – around which Pautz (2018; 2021) focuses his identification of the role of neural activity in sensory experience – can likewise functionally impose modulative limitations upon sensory experience, such as adaptations of visual attention (for example, one can decide where to look), the vase-shaped afterimage case provides mechanistic precedent for neural responses to contribute constitutively to qualitative character. Accordingly, then, before determining perceptual experience, more generally, to be unsystematic–irregular, due to particular identified incongruences between experience and the world, it would be prudent to consider whether unrecognised neural dependencies of experience, and dependencies of *neural responses* in particular, may be behind the respective appearances of sensory–external incongruence identified by Pautz (2018; 2021). In other words, the above explication of the vase-shaped afterimage case calls into question Pautz's (2018) overlooking of neural response measurements in his identification of sensory–external incongruence because, given the mechanistic precedent of afterimagery, there is indication that, under naïve realism, qualitative character could be partly constituted by neural responses in a way that obscures sensory–external congruence.

1.3. Two Central Questions

Two central questions are raised by the above identifications of underdevelopments in Pautz's (2018; 2021) analysis of sensory–external incongruence. In section 1.2.1 above, I showed that Pautz's analysis of colour similarity space is significantly incomplete because he does not appropriately account for the distinction between unique and binary hues. Notably, he attempts to determine whether physical correlates of purple are similar to physical correlates of blue, as purple and blue are conventionally similar in experience. Yet, he does not compare this data to physical correlates of red, despite that purple is conventionally experienced as a “combination” (Pautz, 2006, p. 208) of red and blue. So, Pautz (2018; 2021) does not account for the specific *way* in which purple is similar to blue, as part blue and part red. Consequently, his corresponding identification of colour sensory–external incongruence is not reasonably confirmed without taking into account extracorporeal correlates of red – thus raising the first central question:

1. Does Pautz’s (2018; 2021) identification of colour sensory–external incongruence hold when taking into account that binary hues like purple are, according to Pautz (2006, pp. 208–209), qualitative ‘combinations’ of unique hues like blue and red?

The second central question is raised by the fact Pautz (2018, pp. 6–9; 2021, pp. 155–159, 215–219) does not include neural response measurements in the data set he uses to determine whether extracorporeal dependencies upon sensory experience are generally systematic–regular, which is demonstrated for Pautz by sensory–external congruence. That is, ‘congruence’ between introspective report and associated extracorporeal measurement. Conversely, I pointed out that afterimages are significantly sensory–external incongruent yet rendered systematic–regular when also considering neurological dependencies upon sensory experience (Sethi, 2020, pp. 596–597, 602, nn. 18, 28). In particular, when considering constitutive contributions to qualitative character by *varying* photo sensitives that functionally impose *modulative* limitations upon the sensory system. Consequently, I elaborated that given neural responses can likewise functionally impose modulating limitations upon the sensory system, before determining perceptual experience to be generally unsystematic–irregular due to particular identified incongruences between experience and the world, the mechanistic precedent presented by afterimagery suggests it would be prudent to first consider:

2. Under naïve realism, can sensory–external incongruence be rendered “systematic and regular” (Pautz, 2018, p. 15) through consideration of contributions to qualitative character by neural responses?

A negative answer to the first question would contradict Pautz’s (2018; 2021) identification of colour sensory–external incongruence and undermine such identifications more generally by supporting Epstein’s (2022) postulation that the complex extracorporeal grounding connections Pautz identifies would be found to be systematic upon more “complex processing” (Epstein, 2022, p. 797) of the relevant data. Similarly, a positive answer to the second question would provide reason to doubt whether Pautz (2018; 2021) is justified in identifying unsystematic–irregular extracorporeal groundings of qualitative character because he does not, at least not to that end, consider any associated neural data. Consequently, these answers would undermine his argument that the naïve realist acquaintance relation ‘conflicts with science’ – that is, because sensory–external incongruence demonstrates for Pautz “irregular and unsystematic and grounding connections” (Pautz, 2018, p. 11) under naïve realism. By extension, such answers would undermine the notion that his empirical refutation of naïve realism solves the ‘testability’ problem, which is potentially otherwise intractable (as detailed toward the end of section 1.1 above), of whether it is within the purview of science to determine the role of neural activity in bringing about sensory experience.

Nonetheless, it could be argued that if Pautz’s (2018; 2021) empirical refutation of naïve realism is indeed the only viable solution for transversing that seeming impasse of testability, then even if underdevelopments in his analyses *could* negate that solution, unless relevant negating evidence is provided, provisional acceptance of Pautz’s empirical refutation is most reasonable. Accordingly, to ensure theorists investigating this seeming impasse of testability need not be lead in error by any such acceptance, provisional or otherwise, the present thesis presents theorists with an evaluation of the viability of Pautz's refutation of naïve realism through answering the two central questions identified in the present section.

1.3.1. Answering the Two Central Questions

Focusing now exclusively on the incongruence argument as implemented by Pautz (2018), throughout the present thesis, I demonstrate that sensory–external incongruence need only indicate further scientific investigation is required to identify hidden sensory–external congruence, as Epstein (2022, pp. 794–797) postulates. More speculatively, I show that both neural and extracorporeal measurement can be relevant to the identification of sensory–external congruence. First, through quantitative modelling of binary hues as 'combinations' of, and 'half-way points' between, unique hues, I show that, contra Pautz (2018), systematic correlations between colour similarities and associated extracorporeal measurements are evident, deducible, and predictable, thereby evidencing colour sensory–external congruence. Therefore, I provide a negative answer to the first central question raised above. Second, I demonstrate that sensory–external incongruence, with respect to shape properties, can be rendered systematic through consideration of contributions to qualitative character by neural responses, and I suggest how sensory–external incongruence with respect to colour properties – on which Pautz (2018) focuses his incongruence argument – may be similarly rendered systematic. Therefore, I provide a positive answer to the second central question raised above. Overall, I conclude that Pautz's identification of colour sensory–external incongruence is inadequate, at least provisionally, through recognition of neglected essential data, from which I argue that whilst such incongruences can be accepted more generally, they most reasonably stand as elicitations, from a naïve realist perspective, for further empirical and theoretical investigation into structures of correlations between sensory consciousness and *both* neural and extracorporeal measurements.

1.4. Thesis Outline

In section 2, I clarify respective basic tenets of naïve realism and 'brain-based' theories according to Pautz (2018) and I detail his overall empirical argument against naïve realism in favour of brain-based theories (that implementation of the incongruence argument). Additionally, I determine there is scope for a 'joint-determination' version of naïve realism suggested by Pautz (2020, p. 29, n. 19) to be consistent with his notion of a brain-based theory. In section 3, I expand upon the incomplete dataset of physical correlates of colour that Pautz (2018) considers, which comprises Cartesian 'spectral reflectance' profiles (SRP), and I reanalyse, and expand upon, that dataset through quantitative modelling of binary hues as 'combinations' of, and 'half-way points' between, unique hues. I find that the approximate SRP of each binary hue is deducible from performing basic additive and averaging operations on SRPs of the respective corresponding pairs of unique hues. In section 4, through defence of a joint-determination interpretation of naïve realism, I demonstrate that basic tenets of naïve realism entail that shape perception can be counterfactually dependent upon specific neural activity yet, simultaneously, not upon any determinable physical pattern impinging upon the sensory system. I speculate, via analogous mechanistic precedence, how this possibility could be mirrored in the case of colour perception – in which case naïve realism would be empirically, though not necessarily theoretically, consistent with brain-based theories. Concluding with section 5, I account how the previous sections answer the two central questions identified in section 1.3, from which I conclude that sensory–external incongruence under naïve realism need only indicate further scientific investigation is required to identify either hidden congruence or a constitute role for neural responses in bringing about the relevant sensory experiences.

2. Pautz's (2018) Empirical Argument against Naïve Realism

In this section, to ensure appropriate engagement with Pautz's (2018) empirical argument against naïve realism throughout the present thesis, I clarify his understanding of the theories he counterposes, naïve realism and brain-based theories, and I elaborate upon the premises of his argument and also the overall inferential form of that argument. In section 2.1, I detail basic tenets of naïve realism according to Pautz. In section 2.2, I detail his identification of brain-based theories, and I identify an ambiguity in one of the claims he attributes to brain-based theories from which I determine there is scope for a 'joint-determination' version of naïve realism suggested by Pautz (2020, p. 29, n. 19) to be consistent with his notion of a brain-based theory. Concluding with section 2.3, I provide the implicit inferential form of Pautz's empirical argument.

2.1. Basic Tenets of Naïve Realism

Pautz (2018) pitches his empirical argument against a standardised version of naïve realism that he calls "simple naïve realism about normal experience" (p. 2), which he defines by three basic tenets. First, there is "primitivism about sensible colors" (Pautz, 2018, p. 2) meaning colours are literally instantiated in the physical world grounded in reflectance properties – recall from section 1.1, the pinkness of the evening sky is grounded in the reflectance properties of various atmospheric gases. Pautz (2018) clarifies that, under this colour primitivism, colours are not identical, nor reduceable, to reflectance properties because these intertwined phenomena are of "different essences: the essence of colors is exhausted by how they look, while this is not true of the essence of reflectances" (Pautz, 2018, p. 2).

Second, Pautz details a “general diaphaneity assumption” (Pautz, 2018 p. 2) that the “qualitative character of your visual experience is constituted by your perceptual acquaintance with *objective, mind-independent* states of the external world” (Pautz, 2018 p. 2). By this tenet, perceptual experience is transparent to the external world in the sense of not being supplemented by qualitative manifestations of neural processing, nor of consciousness simpliciter, such as the generation of qualitative properties under internalism. Nonetheless, Pautz (2018) caveats that simple naïve realism permits differences in qualitative character to be constituted by “visual attention and perhaps visual blur” (p. 2) in the sense that these ‘subjective’ factors can modify the ‘way’ in which the ‘objective’ external world is perceived. I elaborate upon these exceptions in section 4.2.1.1 below when defending Pautz’s demarcation of naïve realism from brain-based theories.

Third, Pautz describes a “basic causal theory of perceptual acquaintance” (Pautz, 2018, p. 3) according to which acquaintance with instantiated qualitative properties – like ‘pinkness’ grounded in reflectances, or ‘squareness’ grounded in spatial relations between such reflectances – is secured by “undergo[ing] some or other ‘suitable’ internal subpersonal physical state” that is “caused by” such instantiations “in the biologically normal way” (p. 3). That is, an acquaintance with any given instantiated qualitative property, such as pinkness, requires a secure “causal chain” (Johnston, 2004, p. 116) beginning from appropriate extracorporeal properties (say, a profile of reflectances correlated with pinkness rather than greenness) impinging upon an appropriately functioning sensory system, the “information” (Fish, 2009, p. 61) of which is processed by “a ‘neural correlate of consciousness’ that is ‘poised for cognitive access” (Pautz, 2018, p. 3) as constrained by visual attention (Pautz, 2018, pp. 3–4). As Johnston (2004, p. 139) distils the result of this causal process, “the right causal connection guarantees that the visual channel is open so that direct visual awareness of external things takes place" (Johnston, 2004, p. 139). So, under the causal tenet, the sensory 'channel' of acquaintance is not open to say, pinkness, if a general profile of reflectances correlated with pinkness is only impinging upon photoreceptors that are insensitive (or only minimally sensitive) to red wavelengths (at least when considering pink a light shade of red).

2.1.1. A Principle of Difference

Pautz (2018) explicitly defines simple naïve realism as pertaining only to "'normal' (non-illusory, non-hallucinatory) experience" (p. 2). Accordingly, it could seem reasonable to deny the application of simple naïve realism to afterimagery, which are canonically 'illusory' in the sense of "seeing something to be other than it is" (Fish, 2009, p. 145) – such as perceiving a uniformly white wall to contain a vase-shaped yellow region (upon prolonged visual exposure to a blue vase). However, as elaborated upon in section 4.2.1 below, the demarcation of the vase-shaped region of the white wall is constituted by acquaintance with an existing vase-shaped yellow region – which is the wall *minus* blue in that region. So, in accordance with both the colour primitivism and diaphaneity tenets of simple naïve realism, the yellow and white regions, and their demarcation by extension, are genuinely perceived under simple naïve realism. Furthermore, in accordance with the causal tenet, whilst acquaintance with blueness in the vase-shaped region of the wall is 'blocked' by an insensitivity to blue wavelengths, acquaintances with yellow and white are secured by sufficient respective wavelength sensitivities.

Nonetheless, it could be argued that the vase-shaped yellow region would not *normally* be perceivable with appropriately functioning photoreceptors (unfatigued by overstimulation of blueness) and therefore, afterimagery does not appropriately encapsulate simple naïve realism according to its definition by Pautz (2018), which explicitly applies to "'normal' (non-illusory, non-hallucinatory) experience" (p. 2) "caused . . . in the biologically normal way" (p. 3). However, underperforming photo-sensitivities to various wavelengths from overstimulation is a manifestly persistent visual phenomenon given sustained attention is manifestly required in everyday situations; consider staring to get a glimpse a dangerous spider to be avoided. That is to say, whilst the vase-shaped after imagery case is certainly a visually *pronounced* case of fatigued, and thus underperforming, photo-sensitivities (the afterimage would be perhaps difficult to ignore), it is not reasonably supposed that photo-sensitivities generally perform *perfectly* in light of frequent sustained attention.

Logically, then, there is (all else being equal) a *spectrum* of performance of photo-sensitivities from perfectly functioning to totally insensitive. More simply, there is at least a spectrum of afterimagery from visually indetectable to visually salient. Accordingly, while it could be reasonable to place significant afterimagery outside the scope of simple naïve realism, it is likewise reasonable to permit *some portion* of the spectrum of afterimagery to be within the scope of simple naïve realism. Consequently, under simple naïve realism, differences in qualitative character need not correspond to *empirically detectable* differences in the perceived scene, given afterimagery is by definition detectable (beyond introspective report) only via measurements of the neurological system. This principle, of qualitative difference not universally corresponding to detectable difference in the perceived scene, is here primed for use throughout section 4 of the present thesis.

2.2. A 'Brain-Based' Theory of Sensory Consciousness

Pautz (2018) argues that empirical evidence suggests naïve realism is a "complete non-starter" (p. 1) critically disconnected from science and that, by contradistinction, the notion of a "brain-based theory of sensory consciousness" (p.1) is supported by the relevant empirical evidence and is, therefore, preferrable to naïve realism. Pautz (2018, p. 10) identifies brain-based theories as those committed to two claims, which he respectively terms 'negative' and 'positive'[20]. The 'negative' claim is that qualitative properties are, "contrary to naïve realism, . . . *not* objective, response-independent properties of external items wholly grounded in their objective physical properties" (p. 10)[21]. The 'positive' claim is that qualitative character is, "contrary to simple naïve realism, . . . most directly dependent on our subjective *neural response* to external items" (Pautz, 2018, p. 10). Before detailing Pautz's (2018) empirical argument in section 2.3 below, it is necessary to navigate apparent ambiguities in his identification of brain-based theories that impose constraints upon potential conclusions of the present thesis.

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[20] Although Pautz (2018) identifies brain-based theories specifically in relation to accounting for "the experience of audible qualities" (p. 10), the identified views are applicable to other sense modalities, and Pautz (2018) does not elsewhere define commitments of brain-based views. Therefore, with respect to all the sense modalities Pautz discusses, it is reasonable to interpret his general notion of brain-based theories as reference to the views he identifies in his discussion of audition.

[21] Throughout the present section, for consistency with Pautz (2018, p. 10), I employ the term 'physical properties' to refer to that which grounds qualitative character under naïve realism, whereas until now I referred, in that context, to specifically 'extracorporeal' physical properties.

2.2.1. A Potential 'Brain-Based' Naïve Realism

Pautz's (2018) identification of brain-based theories does not clearly rule out the possibility that naïve realism could be consistent with brain-based theories, in which case his argument against naïve realism in favour of brain-based views would collapse. To see why, consider that Pautz (2018) does not explicitly state whether, in the positive claim, the notion of 'subjective' neural responses being that upon which qualitative character is "most directly dependent" (p. 10) is supposed to be interpreted as dependence that is either generative or enabling of qualitative character, inclusively or exclusively. In other words, whether 'subjective' means 'internal to consciousness', in coordination with the evidently *internalist* negative claim, or alternatively, 'a specific, or unique, to the subject' contribution to qualitative character via the way objects are perceived (perhaps analogous to the way in which visual attention can constitute the difference between experiencing one or many objects) – or whether either meaning is permissible. Moreover, neither does Pautz (2018, p. 10) explicitly state whether a commitment to both negative and positive claims is a necessary condition of brain-based theories (a condition from which an internalist – and so, generative – interpretation of the positive claim could be deductively inferred, if each relevant theory is internally consistent). Consequently, whilst Pautz (2018) explicitly states the positive claim in contradiction to "simple naïve realism" (p. 10) (though I contest this contradiction through section 4 below) it is unclear whether it could be consistent with appropriately modified versions of naïve realism, and by extension, whether any such version could, therefore, be classified a brain-based theory.

For example, consider a "*joint-determination view*" (Pautz, 2018, p. 29, n. 19) according to which "qualitative character "is partly grounded in what is perceived (grounded in causal connections to objects) *as well as* the way in which it is perceived (grounded in the neural response)" (Pautz, p. 29, n. 19). Pautz accounts this view as an adaptation of “extreme ways-based naïve realism” (p. 28) which posits “the qualitative character of your experience is not determined by *what* you perceive; it is determined by the *way* you perceive it, which is partly grounded in your neural response” (p. 28)[22]. By this description all else begin equal, qualitative character can consistently be *directly* dependent upon *both* neural responses and physical properties concurrently (Pautz, 2018, p. 29, n. 19). For example, as ‘side by side’, or potentially ‘merged’, whatever that might entail, provided that the contribution of physical properties is, at least in some ‘portion’, *unmediated* by the contribution of neural responses such that qualitative character is at least partly mind-independent (and so, in that respect consistent with naïve realism) (Pautz, 2018, p. 29, n. 19). In which case, the notion of qualitative character being ‘more’ directly dependent upon neural responses, as required by the positive claim, can be intelligible as neural responses constituting a ‘majority’ of the qualitative character (via grounding the ‘way’ of perceiving). For example, where this relative distribution is determined *empirically* as neural responses having more identifiable correlations, or apparent necessary connections, with qualitative character than do relevant physical properties – a criterion suggested by the empirical approach of Pautz’s (2018) refutation of naïve realism, as detailed in section 2.3 below.

[22] Notably, when defining these two ‘complex’ versions of naïve realism, Pautz (2018) does not predicate ‘neural responses’ of ‘subjective’ as he does when defining his identified positive claim of, perhaps at least some, brain-based theories. This difference could indicate that ‘subjective’ is omitted when explaining these theories due to their assumed status as naïve realist, rather than as internalist. If so, that difference could support an interpretation of ‘subjective’ as included in Pautz’s identified positive claim to signify ‘internal to consciousness’. Nonetheless, as Pautz (2018) does not define what he means by ‘subjective’, his omission of this term in places is, at least provisionally, most reasonably interpreted as inconsequential.

2.2.1.1. An Empirical Interpretation of 'Brain-Based' Theories. It could be argued that there is no ambiguity in Pautz's (2018) identification of brain-based theories because he employs internalist language when concluding arguments in favour of brain-based views, and the revised version of his argument by Pautz (2021) is clearly internalist. For example, Pautz (2018) argues "that the science of sensation … shows decisively that naïve realists … have the matter exactly the wrong way around" because "In many cases, looking for the qualitative character of experience in the properties of the objects experienced is looking for it in the wrong place; we have to be looking rather at the nature of the brain state" (p. 5). While 'nature of the brain state' is not necessarily internalist, because the structure of neural connections can, for example, be grounding of attentional resources, an internalist interpretation is reinforced when he says the following: "The science supports a brain-based view according to which postreceptoral processing can make a contribution to qualitative character above and beyond determining what objective states your sensory systems detect" (Pautz, 2018, p. 20). And "postreceptoral wiring plays a big role in shaping what our experience of the world is like (it is more than a general 'enabling condition')" (Pautz, 2018, p. 21). In which case, the neural grounding of attentional resources and other enabling functions of the brain are apparently not the kind of constitutive neural contributions to qualitative character on which Pautz (2018) focuses his identification of brain-based theories.

However, consider again the vase-shaped afterimage case. Whilst the vase shape is constituted by externally instantiated respective sets of reflected light (one white set and one yellow set) the vase-shaped *visual demarcation* of those sets is clearly modulated by the neurological system rather than a detectable contrast. That is, the fact there is visual experience at all (of extension and colour) is constituted by the reflective surface of the wall, yet the specific *segmentation* of the reflected light into spatially distinct sets of differing colours is more dependently constituted, counterfactually, by the 'bounds' of the sensory system, the contrast between the sensitives of fatigued retinal cells and appropriately functioning retinal cells. Such a *modulating* contribution to the specificity of shape experience – that is, the arrangement of neural cells dictates the shape perceived – can be reasonably considered to have “a big role in shaping” (Pautz, 2018 p. 21) experience of the world despite that it is ultimately the determination “of what objective states your sensory system detects” (Pautz, 2018, p. 20). Furthermore, although varying sensitivities of photoreceptors are not “postreceptoral” (Pautz, 2018, p. 17) responses (the latter on which Pautz implicitly focuses his empirical argument), the point, is that naïve realism can permit the neurological system to make *similarly significant* contributions to differences of qualitative character as can the extracorporeal properties to which a perceiving subject attends. For example, the afterimage can have the same shape as if it were painted in yellow on the white wall. Nonetheless, in section 4 below, I consider whether afterimages being thus partly neurologically constituted is sufficiently analogous to contributions of neural *responses* to warrant speculation about qualitative character that is constitutively dependent upon neural responses under naïve realism.

Either way, Pautz’s (2018) notion of naïve realism entailing that “qualitative character resides in the world and not in the brain” does not necessarily imply that “in the brain” means internally *generated* (p. 22). For example, although the example brain-based theories Pautz (2018, p. 10) details are internalist, there is a potential exception in his consideration, when elaborating upon brain-based theories, of “the peculiar idea” (p. 15) that qualitative properties are “instantiated *in the brain*”, perhaps by which he means in “regions of the brain” (p. 16) – *if* Pautz is thereby referring to an acquaintance, at least in part, with *mind-independent* instantiations, as hesitantly suggested by Alston (1999, p. 191).

Given there is thus evidence for and against Pautz’s (2018) identification of brain-based theories as internalist, it is sensible to remain neutral as to whether brain-based means internalist. Nonetheless, it is consistent with, and sensible considering, Pautz's (2018) *empirical* approach to tentatively consider his negative claim of brain-based theories as, at least, an empirical claim. In which case a variation of naïve realism could be a brain-based theory, at least empirically, if it were demonstrated that, under naïve realism, sensory experience can be more *detectably* correlated with neural responses than with extracorporeal properties. If so, then his *empirical* argument against naïve realism in favour of brain-based views would collapse as contradictory. I revisit this potential significant consequence in section 4 below.

2.3. Irregular Grounding and Parsimony

Turning now to the central empirical premise of Pautz's (2018) refutation of naïve realism, he proposes there is "*bad external correlation* and *good internal correlation*" (p. 6) – by which he refers to there being "a big mismatch between phenomenal structure and the external … structure" (p. 6), whereas, he suggests the relevant phenomenal structures match associated neural structures. That is, he proposes there is sensory–external incongruence under naïve realism and sensory–neural congruence under internalism. Pautz (2018) acknowledges that – apparently due to sensory experience having a "different essenc[e]" (p. 2) to correlated physical properties – it is "coherent" (p. 10) under naïve realism that structures of, and transitions between, experienced qualitative properties may not lineup with correlated structures of, or a lack of transition between, physical properties. Indeed, whilst the diaphaneity tenet of simple naïve realism requires qualitative character to be grounded by "*objective, mind-independent* states of the external world" (Pautz, 2018 p. 2), it does not specify that such grounding connections cannot be highly elaborate or, at least seemingly, arbitrary (Pautz, 2018, p. 2). Nonetheless, Pautz (2018) argues that sensory–external incongruences evidence an “implausible” (pp. 10, 11) requirement of “irregular grounding connections in the external world” (p. 9) under naïve realism that is normatively intolerable given brain-based theories provide a simpler alternative. Accordingly, Pautz (2018) proposes his overall empirical argument against naïve realism in favour of brain-based theories:

1. “[W]e should prefer simple and systematic theories to complex and unsystematic theories" (Pautz, 2018, p. 15).
2. "Given good internal correlation and bad external correlation, naïve realism needs a swarm of inexplicable, irregular grounding connections in the external world" (Pautz, 2018, p. 9).
3. “By contrast, a rival brain-based view of sensible-quality perception only requires regular, simple grounding connections between neural processes and experiences" (Pautz, 2018, p. 9).
4. Therefore, a brain-based view is preferable to naïve realism (Pautz, 2018, p. 9).

Pautz (2018) does not explicitly consider the possibility of counterevidence to any of his premises. Yet, evidently, his premise 2 is vulnerable to Epstein’s (2022) postulation that the irregular extracorporeal grounding connections Pautz identifies would be found to be systematic, and in that sense *simple*, upon more “complex processing” (Epstein, 2022, p. 797) of relevant data.[23] Indeed, in the following section I counter Pautz’s (2018)

[23] Pautz (2021, p. 184) gets close to acknowledging such a possibility, though in hypothetical defense of a variation of internalism, when he says, “maybe there are relatively simple, systematic connections between our intrinsic neural patterns and what perceptible properties (shapes, sensible colors, and the like) we experientially represent, even if we have not yet discovered them.” (p. 184). Whereas, Pautz (2021) does not extend this reasoning to the

identification of colour sensory–external incongruence through expanding upon and reanalysing the relevant data set, upon which I identify simple, systematic, and broadly applicable, correlations between colour similarity spaces and associated quantitative similarity spaces.

possibility of discovering "systematic connections between" (p. 184) sensory experience and correlated extracorporeal patterns.

3. Correlates of Colour: An Empirical Investigation

In the present section, towards answering the first question posed in section 1.3 above, I consider whether the physical correlates of purple to which Pautz (2018) refers are quantitatively similar to physical correlates of blue the same way purple is qualitatively similar to blue, as part blue and part red. In section 3.1, I break down the notion of Spectral Reflectance Profiles (SRP) which are the physical correlates of colour Pautz uses to identify sensory–external incongruence. In section 3.2, I detail that identification. In section 3.3, I develop a model of binary hue to quantitatively capture what it conventionally means for a binary hue to be similar to an associated unique hue, through which I derive an accurate purple SRP from blue and red SRPs, thus contradicting Pautz's (2018) identification of colour sensory–external incongruence. In section 3.4, I consider the potential objection that the model I develop fails to make predictions because it is derived from that which it predicts. However, I offset this objection by deriving an accurate orange SRP from yellow and red SRPs, and by dropping, in section 3.4.3, the aspect of the model that is potentially derivative of what it predicts. Subsequently, I solidify the model in section 3.4.4 by predicting all conventional binary hues by the model. Concluding with sections 3.5 and 3.6, I identify further investigation required to secure my claims, and I argue that Pautz's (2018) identification of colour sensory–external incongruence is more appropriate when applied only to unique hues. In section 3.7 I survey the findings of the present section.

3.1. Spectral Reflectance Profiles

Pautz (2018) identifies colour sensory–external incongruence by comparing respective SRPs of a purple object, a blue object, and a green object, that respectively represent how reflective these objects are throughout the visible spectrum of light (MacAdam, 1985, pp. 4–7) [24]. To unpack SRPs towards explaining Pautz's identification of colour sensory–external incongruence in the following section, see Figure 1, which displays the relevant purple, blue, and green SRPs superimposed for accurate visual comparison[25]. Note, the SRPs in Figure 1 display SRP data provided by MacAdam (1985, pp. 4, 6–7) because that is the source data explicitly cited in the published version of Pautz's (2018) identification of colour sensory–external incongruence by Pautz (2017, p. 25), and the corresponding SRP diagrams appearing in that published version are isomorphic to the SRP diagrams provided unattributed by Pautz (2018, p. 7) and Pautz (2021, pp. 158). The SRP 'wavelength (nm)' axis represents the 'visible' portion of the spectrum of light, measured in nanometres (nm), which transitions from violets beginning at the lowest nm through, "blue[s], green[s], yellow[s], orange[s]" (MacAdam, 1985, p. 2), to reds at the highest nm (MacAdam, 1985, p. 2). Whereas, the 'Reflectance' y axis is a finite spectrum

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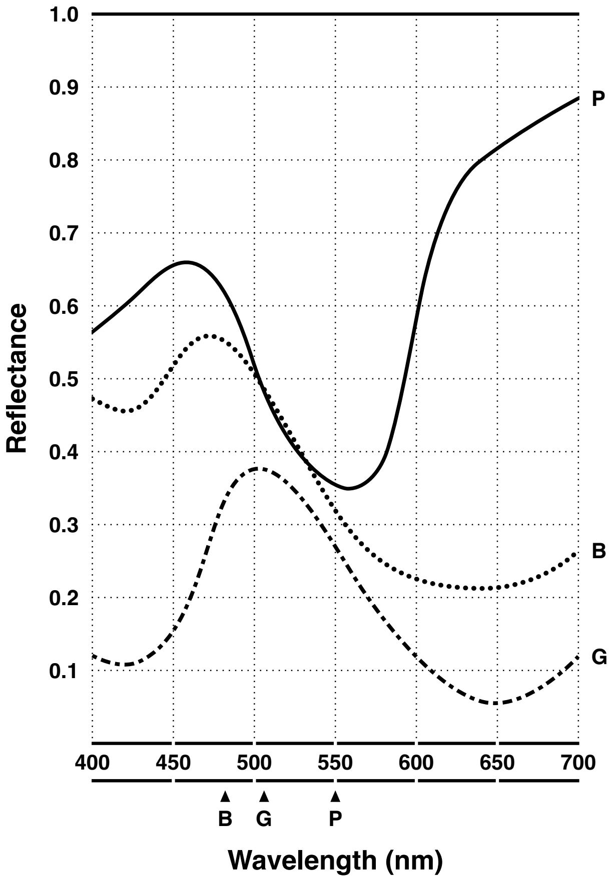
[24] SRPs are Cartesian curves also known as "Spectral reflectance curves" (MacAdam, 1985, p. 4) and more precisely, "spectrophotometric curve[s]" (MacAdam, 1985, p. 3) (MacAdam, 1985). However, in the present thesis, I use the ubiquitous alternative 'profile' over 'curve', becuase Pautz (2018, p. 2) does, but also because SRPs are constructed from finite sets of measurements and so, *specific* curvature interpolated from these measurements can be synthetic and, in that way, more misleading or inaccurate the lower the number of measurements (MacAdam, 1985, p .4). Accordingly, it is more appropriately the *approximate* transitions between peaks and troughs throughout the measurements that are indicative of the underlying reflectance properties, as better captured by the more general term 'profile', which is not obviously a commitment to specific curvature or continuity of measurement.

[25] Placing three SRPs side by side, as Pautz (2018, p. 7) does, unnecessarily increases cognitive load because each Cartesian point is represented three times, thus complicating comparisons of Cartesian distances between SRPs.

Figure 1.

Superimposition of Purple (P), Blue (B) and Green (G) Spectral Reflectance Profiles (SRP) with indicated dominant–complimentary wavelengths



Note: As detailed in the Appendix, each represented function quantitatively approximates the graphed SRP data of the corresponding colour provided by MacAdam (1985, pp. 4, 6–7). The indicated dominant wavelength values for B and G and the complimentary wavelength value for P are provided by MacAdam. Data aspect ratio and assignment of data to axes follow relevant source figures by MacAdam to preserve data scale and facilitate consistent data interpretation.

from 0 (no reflectance) to 1 (total reflectance) indicating what portion of a measuring light beam is reflected from the relevant surface at a given wavelength (x axis value) (MacAdam, 1985, pp. 2–4).

Additionally, the arrows below the x axis indicate the ‘dominant’, or ‘complimentary’ in the case of purple, wavelength values for each SRP, indicating the “purity” (MacAdam, 1985, p. 19) of the measured colour. Effectively, a wavelength value of the visible spectrum (a ‘pure’ colour produced by a single wavelength) that is closest in appearance (this is determined quantitatively) to the colour measured under daylight is the dominant wavelength of the SRP of that colour (MacAdam, 1985, pp. 18–19). So, in Figure 1, the dominant wavelengths of the blue and green SRPs respectively lie before and after 490 nm and thus these SRPs are fairly pure because, according to MacAdam (1985, p. 3), blues occupy “450 – 490 nanometers”, and greens occupy “490 – 560 nanometers”, of the visible spectrum – whereas, a colour with a dominant wavelength of exactly 490 nm would appear neither pure blue nor pure green, but rather a blueish–green (so, teal) (p. 3). However, this ‘purity’ measurement does not apply in the same way to purple, which though similar to violet, cannot be produced by a single wavelength because it is “an additive mixture” (MacAdam, 1985, p. 19) of red and blue (meaning red and blue are simultaneously sensed). Indeed, red and blue do not transition on the visible spectrum to locate purple as a single wavelength thereon (MacAdam, 1985, p. 5). Consequently, the ‘purity’ of purple reflectance is instead determined by the ‘complimentary wavelength’, how closely opposite it is to pure green, the complimentary ‘neutralising’ colour to purple, which means green “would produce a neutral gray in an additive mixture with the purple” (MacAdam, 1985, p. 5).

According to MacAdam (1985, pp. 3–4), the portion of light reflected at each nm for any measured colour is practically invariant to intensity of the measuring light beam and total reflectance throughout the spectrum appears pure white and a total lack of reflectance throughout appears pure black and so, evidently SRPs can encapsulate brightness of colour given increased y values of general Cartesian curvature are closer to pure white, and further from pure black, throughout the visible spectrum – independent of brightness of illumination (MacAdam, 1985, pp. 15–16, 19). However, the colour of illumination is comparatively influential: A given SRP will always be correlated with the same colour under pure daylight, yet under differently coloured illumination (such as when the atmosphere filters daylight into pink), the relevant surface can, perhaps obviously, appear a different colour than under daylight (MacAdam, 1985, pp. 5–7). For example, consider a white wall in an outdoor carpark appearing pink when illuminated by a car's red brake light – this change in colour does not correspond to a change in the SRP of the wall (MacAdam, 1985, pp. 5–7). So, SRPs each constitute a stable physical correlate of measured colour under repeatable conditions, thereby capturing colour quantitatively (MacAdam, 1985).

3.2. Colour Sensory–External Incongruence

Pautz (2018) portrays the purple, blue, and green SRPs in Figure 1 as respectively representing a "purple-looking grape", a "blue-looking ball", and a "green-looking leaf" (p. 7). Correspondingly, he claims that:

> By any natural measure, it is not the case that the reflectance of the blue ball resembles that of the purple grape more than that of the green leaf. If anything, the reflectance of the blue ball resembles that of the green leaf more than that of the purple grape. (Pautz, 2018, p. 11)

Pautz (2018, pp. 7, 11) contrasts this claim to the ubiquitous view that, experientially, purple is more similar to blue than to green. He concludes that this contrast, between *qualitative* similarity and dissimilarity (of sensation) and *quantitative* similarity and dissimilarity (of physical correlates of sensation), constitutes the "implausible" "example of bad correlation" that, under naïve realism, "reflectances ground sensible colors that stand in the very opposite resemblance-order" to the resemblance-order of the corresponding reflectance's (p. 11).

As accounted in section 1.2 above, Pautz (2018) claims his identification of the resemblance order between the purple, blue, and green SRPs is identifiable by "any natural measure" (Pautz, 2018, p. 11), yet as Epstein (pp. 794–797) points out, Pautz (2018) does not detail any such measurements nor relevant standard, thus leaving this identification open to opposing interpretation. Nonetheless, as *Cartesian* curves, SRPs are most fundamentally progressions of co-ordinate location throughout, in this case, the specified x axis domain and finite y axis range. So, such general 'paths' of each SRP, being constituted by a highly simple binary x–y axis relation of change, can be straightforwardly and objectively captured by commonsensical natural language description – such as that a curve 'increases in y value between two x values'. In that setting, the subjectivity of measurement is reduced to determining *which* progressions of location are identified – that is, any portion of a continuous function is infinitely detailed, so not all comparisons of progression can be captured in finite time (consider that there is no logical limit to how finely a continuous function can be divided). So, it is reasonable, as well as neutral towards Pautz' (2018) identified quantitative resemblance-order, to provisionally compare similarities between the relevant SRPs by the fundamental 'natural standard' of reflectance changes throughout the visible spectrum, generalised 'subjectively' (by a lower resolution than is available) as paths approximately characterised by, at least manifestly salient, change.

Implementing this basic descriptive method, and proceeding in the positive direction along the wavelength axis, with respect to the reflectance axis, roughly, the blue and green curves both fall for 25 nm, then rise for 50–75 nm, then fall again until 650 nm, then rise again until 700 nm – whereas purple rises until 458 nm, then falls until 555 nm, then rises until 630 nm at which point the rising tapers off until 700 nm. So, basically, the blue and green curves have a general "'dip-hump-dip' structure" (Epstein, 2022, p. 793), whereas the purple curve has a general 'hump-dip-rise' structure – from the perspective of which Pautz (2018) is correct that the blue SRP is more similar to green than purple. Call such general natural language descriptions, of peaks and troughs as suggested by Epstein (2022, p. 793), 'layperson' modelling of SRP structures.

Evidently, layperson modelling constitutes a sensible and impartial framework within which to articulate Pautz's (2018) identification of colour sensory–external incongruence because it provides a natural standard that captures *fundamental* structure of SRP curvature appropriate to Pautz's claims in a way that is accepted by his major critic (Epstein, 2022). Nonetheless, whilst layperson modelling can objectively capture structures of curvature (albeit via simplified generalisation and so, low-resolution), the more obviously *subjective* comparison of similarities or dissimilarities between such structures is the latent operation that renders Pautz's (2018) relevant claims open to interpretation. Accordingly, towards *objectively* confirming whether Pautz's (2018) identification of colour sensory–external incongruence holds, in the next section, I develop a simplistic model of similarities and dissimilarities between reflectance's that appropriately captures, within the layperson framework, the ubiquitous view to which Pautz appeals; that binary hues like purple are "combinations" (Pautz, 2006, p. 209), or "composite[s]" (Fish, 2021, p. 169), of unique hues.

3.3. Developing a Model of Binary Hue

As qualified in the previous section, Pautz (2018) evidently appeals to the SRPs produced by MacAdam (1985) as appropriately objective physical correlates of colour from which to identify sensory–external incongruence. Accordingly, in order to establish an objective model of binary hue appropriate to Pautz's implementation of ubiquitous introspective report regarding binary hue, it is reasonable to use MacAdam's (1985) general method of colour modelling:

> Color, in the sense in which it is used throughout this volume, may be defined explicitly in terms of a definite set of physical operations. Indeed, every genuine definition of any concept is merely a statement of the operations by which that concept is specified. (p. 2)

As suggested in section 1.2.1 above, the relevant introspectively reported colour concepts of 'combination' and 'composition', when used in a more general quantitative setting, are variations of *additive* operations, such as summing numbers – 3 is 1 and 2 *combined* – or adding geometries – a square can be *composed* of two triangles – and so on. Appropriately, then, given the notion of combination is intrinsically prior to composition (the latter of which being the *result* of combination), the notion of *summing* presents a suitable basic quantitative *operation* through which to model the apparently derivative appearance of binary hues from unique hues, in accordance with MacAdam's (1985, p. 2) method.

Additionally, it could be argued that, qualitatively, binary hues are straightforwardly articulatable also as 'midpoints', or 'halfway', between unique hues – independent of analogous mathematical descriptions pertaining to graphical representations of 'chromaticity' such as are detailed by MacAdam (1985, pp. 9–26). For example, consider a car's red brake lights reflecting off a glossy wall within an undercover carpark. Suppose the wall is blue but when the intense illumination of the brake lights is sufficiently close, the highly reflective wall appears totally red. If the driver observes the wall whilst leaving the carpark, it is reasonable to expect they will initially see bright red that gradually transitions to purple then to blue, due to the influence of the brake lights gradually subsiding. In this case, if indeed purple simultaneously appears partly red and partly blue, then at the point at which the wall appears purple, the part-appearance of red has not fully subsided. By the same token, when approaching the wall when appearing purple, the part-appearance of blue has not fully subsided. Therefore, purple constitutes a qualitative 'midpoint' of transition between red and blue. Accordingly, an alternative, or supplementary, quantitative operation through which to model binary hue is suggested: *mean averaging* of unique hues, thus establishing a midpoint between.

3.3.1. Modelling the Spectral Reflectance Profile of Purple

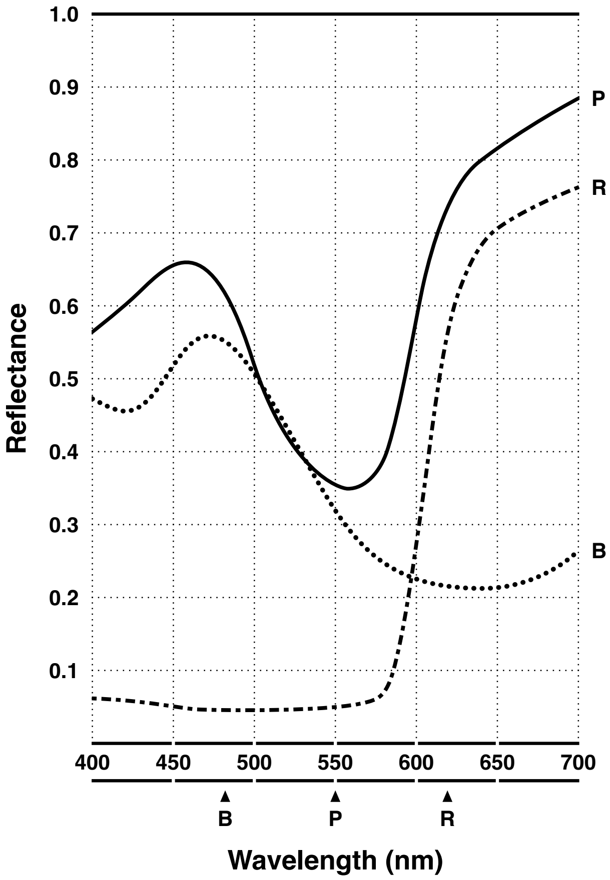
The 'additive' and 'averaging' quantitative models provide an objective setting within which to investigate, as centrally questioned in section 1.3 above, whether Pautz's (2018) identification of colour sensory–external incongruence with respect to purple, blue, and green holds upon comparing the relevant SRPs to the SRP of red. See Figure 2, which shows the purple, blue, and red SRPs from MacAdam (1985) superimposed.

As a commonsensical 'first-pass' layperson modelling of the similarities and dissimilarities between the respective SRP curves in Figure 2, the purple curve *contours neatly* around, and above, the top of the blue and red curves, following the 'hump-dip-rise' shape constituted by the superimposition of the red and blue curves. Furthermore, the complimentary wavelength value of purple lies exactly in-between the blue and red dominant wavelength values[26]. This middle position of the purple value is the mean average of the blue and red values, thus according with the averaging model. Similarly, the curvature of purple accords with the additive model because if the blue and red curves were summed on the reflectance axis, then the resulting curve would necessarily sit above the blue and red curves, fitting the contour of the superimposition of these blue

[26] Whereas in Figure 1, the blue and green dominant wavelength values are close together, deviating significantly from the purple value.

Figure 2.

Superimposition of Purple (P), Red (R), and Blue (B) Spectral Reflectance Profiles (SRP) with indicated dominant–complimentary wavelengths



Note: As detailed in the Appendix, each represented function quantitatively approximates the graphed SRP data of the corresponding colour provided by MacAdam (1985, pp. 6–7). The indicated dominant wavelength values for B and R and the complimentary wavelength value for P are provided by MacAdam. Data aspect ratio and assignment of data to axes follow relevant source figures by MacAdam to preserve data scale and facilitate consistent data interpretation.

and red curves. To confirm this interpretation of the data, the quantitative models can be utilised to determine whether the purple SRP can be mathematically derived from the blue and red SRPs.

However, with respect to the additive model, it could be objected that, as the reflectance axis constitutes a *finite* domain, it does not seem coherent to add values within that domain. For example, adding 0.5 and 0.51 would breach the upper bound of the spectrum, constituting more than 100% reflectance, which is manifestly physically incoherent, at least by the conventional definition of what it is for photons to be reflected. Nonetheless, due to special relativity, effective combination of quantities in a finite domain is widespread in nature, intrinsically occurring in every causal event due to viewer-relative combination of velocities taking place within a finite domain with the speed of light as the upper bound (Arfken et al., 1984, pp. 363–373; Russell, 1925/2009, pp. 45-58). Therefore, Einstein's' velocity addition formula, from which such effective 'combined' velocities can be derived, is a congenial model through which to test the addition of the blue and red SRPs: Arfken et al. (1984, pp. 367) define the formula as:

$$u = \frac{u' + v}{1 + \frac{u'v}{c^2}} \tag{1}$$

Although the variables of equation 1 *dynamically* depend upon the special relatively notion of 'frame of reference', an appropriate dynamic analog of SRPs is not required for use of equation 1 because it is rather the *superficial* form of equation 1 that is desirable for the present *provisional* modeling task; two variables, u' and v, are effectively summed as constrained by a limit, c^2, to produce u that cannot exceed c^2 (Arfken et al., 1984, pp. 363–373). Given that, in equation 1, c^2, the speed of light, is the upper bound of the finite domain, yet the upper bound of the SRP reflectance axis is 1, the model becomes the following where c_1 and c_2 are the blue and red reflectance values throughout the visible spectrum, respectively, and c_3 is thus the 'derived' purple reflectance values throughout the visible spectrum:

$$c_3 = \frac{c_1 + c_2}{1 + c_1 c_2} \tag{2}$$

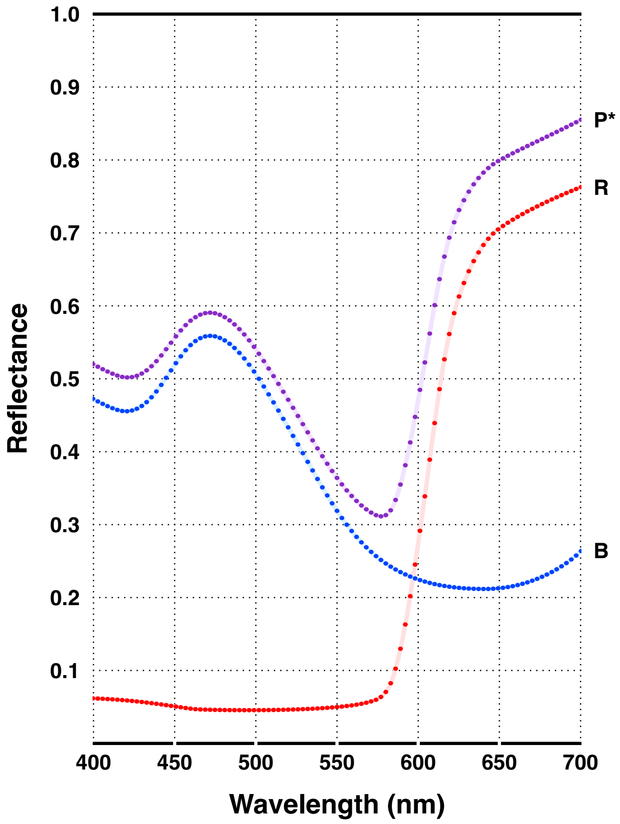
Given the SRP data provided by MacAdam (1985) – which is the most appropriate data for present analyses to avoid deviations in the data due to differing methods of reflectance testing – is provided only via visual representations, the data must be first approximated quantitatively in order to perform accurately reproducible mathematical operations on the blue and red curves. I carry out these approximations in the Appendix of the present thesis, resulting in encoded (for straightforward reference) piecewise parametric functions. I use the explicit mathematical form of these functions, detailed in section A.2 of the Appendix exampled by equation A3, to derive finely and uniformly spaced sample points of the blue and red curves. Then, I add the respective sample points of the red and blue curves by equation 2, resulting in the derived purple in Figure 3.

As Figure 4 demonstrates, the derived purple closely approximates the purple SRP. Although there is separation between the derived purple and purple, notably between 400 nm–475 nm, this is less significant, at least with respect to Cartesian distance, than the blue and green curves are generally separated, the latter comparison of which Pautz (2018) implicitly considers desirably similar. Furthermore, as MacAdam (1985, pp. 4, 7, 6) considers his SRPs as corresponding to 'typical' instances of the relevant colours, rather than 'perfectly average' relevant colours (should such 'pure' SRPs exist), the fact the derived purple matches so closely to 'typical' purple despite the former being derived from 'typical' unique hues – thereby constituting an approximation of purple that would perhaps be expectedly *compounding* in its roughness – reasonably offsets the proposed significance of separation between derived purple and purple.

Consequently, given the purple SRP evidently has the *appearance* reasonably expected of a combination of blue and red SRPs (it 'fits' their superimposed contours),

Figure 3.

Synthesis of Derived Purple (P) Spectral Reflectance Profile (SRP) from Red (R) and Blue (B) SRPs*

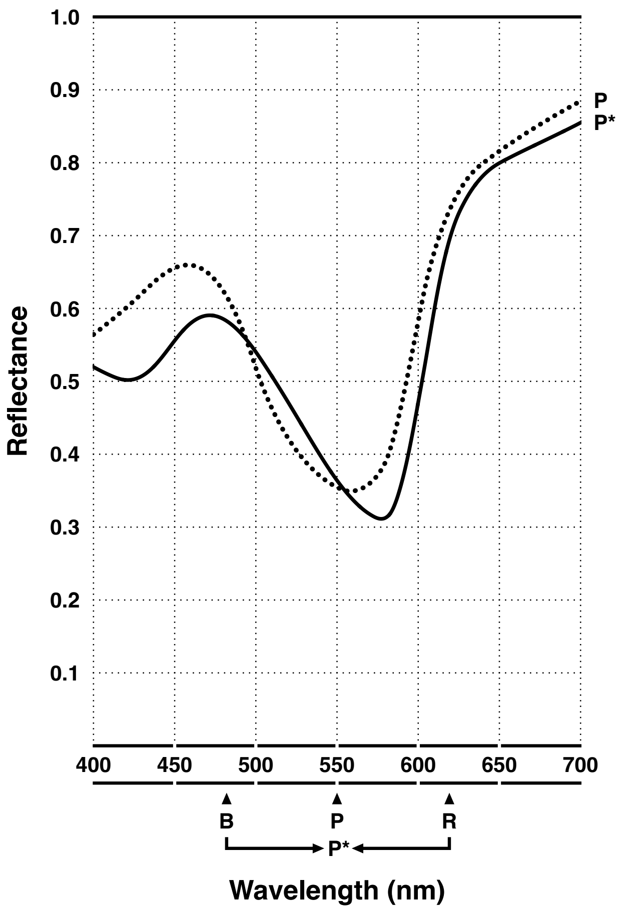


Note: As detailed in the Appendix, the represented functions R and B each quantitatively approximate the graphed SRP data of their respective colours provided by MacAdam (1985, pp. 6–7). Indicated on R and B are function sample points at uniform 3-nm increments, including endpoints. P* is a piecewise quadratic function interpolated through points that are each the sum, via Einstein's non-linear Velocity Addition Formula, of the respective y-values from R and B at each sampled x-value. Data aspect ratio and assignment of data to axes follow relevant source figures by MacAdam (1985, pp. 6–7) to preserve data scale and facilitate consistent data interpretation.

and that indeed such a purple SRP can be mathematically derived, and in that sense *predicted*, from the SRPs of blue and red, this additive analysis of physical correlates of purple, with respect to the position of the purple SRP in qualitative similarity space,

Figure 4.

Superimposition of Purple (P) and Derived Purple (P) Spectral Reflectance Profiles (SRP) with indicated dominant–complimentary wavelengths for P, P*, and Blue (B) and Red (R) SRPs*



Note: As detailed in the Appendix, the represented function P quantitatively approximates the “typical purple material” (p. 7) graphed SRP data provided by MacAdam (1985). The indicated dominant wavelength values for B and R and the complimentary wavelength value for P are each provided by MacAdam (1985, pp. 6–7), and the value for P* is modelled as the midpoint between the B and R values. P* is an interpolation through points that are each the sum, via Einstein’s non-linear Velocity Addition Formula, of respective y-values from R and B SRP data functions – approximated from graphed data by MacAdam (1985) as detailed in the Appendix – at sampled x-values, taken at 3-nm increments, including endpoints. Data aspect ratio and assignment of data to axes follow the relevant source figure by

MacAdam (1985, p. 7) to preserve data scale and facilitate consistent data interpretation.

contradicts Pautz's identification of sensory–external incongruence. More simply, the quantitative models developed thus far demonstrate that, contra Pautz (2018), the purple SRP is quantitatively similar to the blue SRP in the same way purple is qualitatively similar to blue, as part blue and part red. Therefore, Pautz's second premise of his empirical argument against naïve realism from section 2.3 above – that *there is* sensory–external incongruence under naive realism that entails "irregular grounding connections in the external world" (2018, p. 9) – is undermined in the case of his proposed colour sensory–external incongruence. That is, the dataset of physical correlates of colour to which Pautz appeals can be considered evidence of sensory–external *congruence* when expanding the dataset to more appropriately (as argued in section 1.2.1 above) include the red SRP.

3.4. Generalising the Model

In this section, I test the modelling against similarities between unique and binary hues more generally to substantiate derived purple as a plausible manifestation of, rather than being merely coincidental to, the *general* unique–binary hue relation. To illustrate the importance of this generalised testing for determining whether Pautz's (2018) identification of sensory–external incongruence holds, consider the following potential objection: The close match between derived purple and purple need only be considered a coincidence given it could be reasonably argued that upon implicitly positing that purple should be derivable by blue and red, I have therefore proceeded to fit the facts to the model. That is, it could be objected that the fact I establish a 'prediction' of the purple SRP is because the derived purple SRP has been effectively *reverse engineered* from the superposition of the purple, blue, and red curves – as opposed to if the model had been derived without utilising knowledge of the purple SRP. In other words, the model is not obviously *predictive* of the purple SRP because it is effectively derived from that SRP.

Being enabled to meet such an objection is required for appropriate investigation into Pautz's (2018) identification of colour sensory–external incongruence with respect to my relevant criticisms, from section 1.2.1 above. That is, in section 1.2.1 above, I claimed that his identification of sensory–external incongruence effectively fails due to an insensitivity to the distinction between binary and unique hues, *which is a general phenomenon not peculiar to* only purple, blue, and red. Indeed, the derivation of a purple SRP from blue and red SRPs does not necessarily, all else being equal, constitute a *general* model of similarities between binary and unique hues and so, the objection that the model is derivative of the purple SRP rather than predictive of that SRP needs to be addressed. That is to say, if other binary hues are not similarly derivable, then my claim, that Pautz's (2018) neglect of the unique–binary hue distinction renders his analyses of colour superficial, would be undermined given that distinction would be, in the presently assumed scenario, inapplicable to extracorporeal correlates of binary hues *other than purple*.

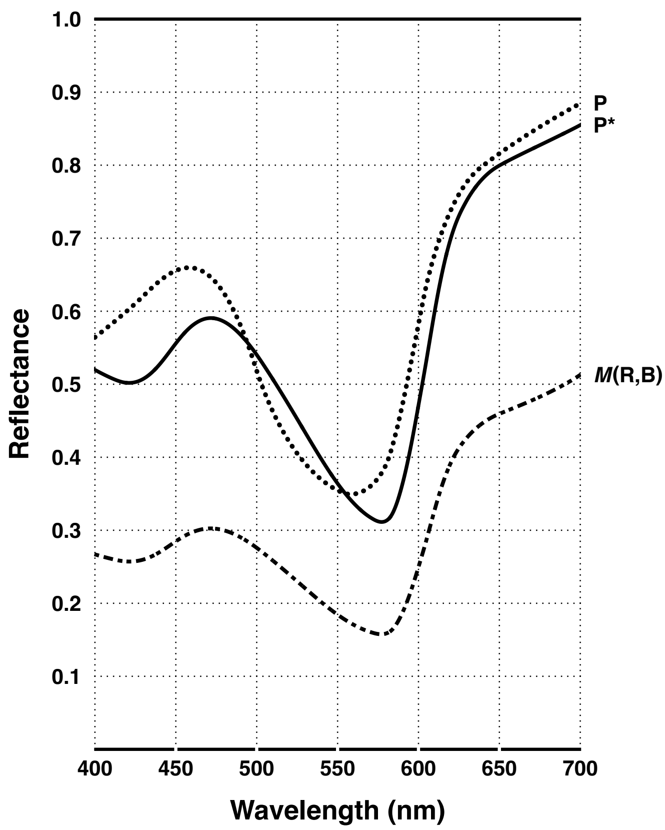
Nonetheless, even in that scenario, it could be argued that so long as my identification of sensory–external congruence holds, then Pautz's *generalisation* of colour sensory–external incongruence from the *particular* case he identifies, would be countervailed by the counterevidence of sensory–external congruence embodied by derived purple. However, the present thesis need not depend upon any such countervailing of Pautz's generalisation from a particular case because, throughout the present section, I demonstrate that the unique–binary hue distinction is applicable to a quantitative dataset of extracorporeal correlates of *all hues*. Thereby supporting the *more fundamental* criticism of Pautz (2018), from section 1.2.1 above, that his analyses of colour are incomplete, and therefore his conclusions are superficial and need to be supplanted by a more thorough investigation, because he does not take into account the unique–binary hue distinction, despite that he appeals to similarity between purple and blue.

3.4.1. Isomorphism Between the Operations

Before generalising the modelling, in the present section I identify an isomorphism between the additive and averaging aspects of the model in anticipation of potential peculiarities in the relevant SRP data provided by MacAdam (1985) that I address in section 3.4.3 below. Consider the potential auxiliary objection that Einstein's velocity addition formula has been conveniently selected for the model to ensure the additive aspect of the notion is not undermined by the finitism of the reflectance axis. However, as a mean average of two values is equivalent to *those two values added* then divided in half, and as a mean average can be likewise obtained without addition by negating the smaller value from the larger value and negating half the result from the larger value, the general shape of the purple curve is derivable from the *mean average* of the blue and red curves *also*. In other words, even if the additive aspect of the modelling is removed, the averaging aspect isomorphically captures the general 'dip-hump-dip-rise' shape of the derived purple, evidencing that reflectance differences between the blue and red curves are *intrinsically* approximate of the purple curve – as opposed to such an approximation being effectively 'manufactured' by reverse engineering. See Figure 5 for the mean average between blue and red, function *M*(R,B), which is necessarily isomorphic to the derived purple function.

Figure 5.

Superimposition of Purple (P) and Derived Purple (P) Spectral Reflectance Profiles (SRP) and function M(R,B)*



Note: As detailed in the Appendix, the represented function P quantitatively approximates the “typical purple material” (p. 7) graphed SRP data provided by MacAdam (1985). P* is an interpolation through points that are each the sum, via Einstein’s non-linear Velocity Addition Formula, of respective y-values from the red (R) and blue (B) SRP data functions – approximated from graphed data by MacAdam as detailed in the Appendix – at sampled x-values, taken at 3-nm increments, including endpoints. Reutilising these sampled x-values, *M*(R,B) is a quadratic function interpolated through points that are each the midpoint between the respective y-values of the R and B SRP functions at each sampled x-value. Data aspect ratio and assignment of data to axes follow the relevant source figure by MacAdam (1985, p. 7) to preserve data scale and facilitate consistent data interpretation.

3.4.2. Modelling the Spectral Reflectance Profile of Orange

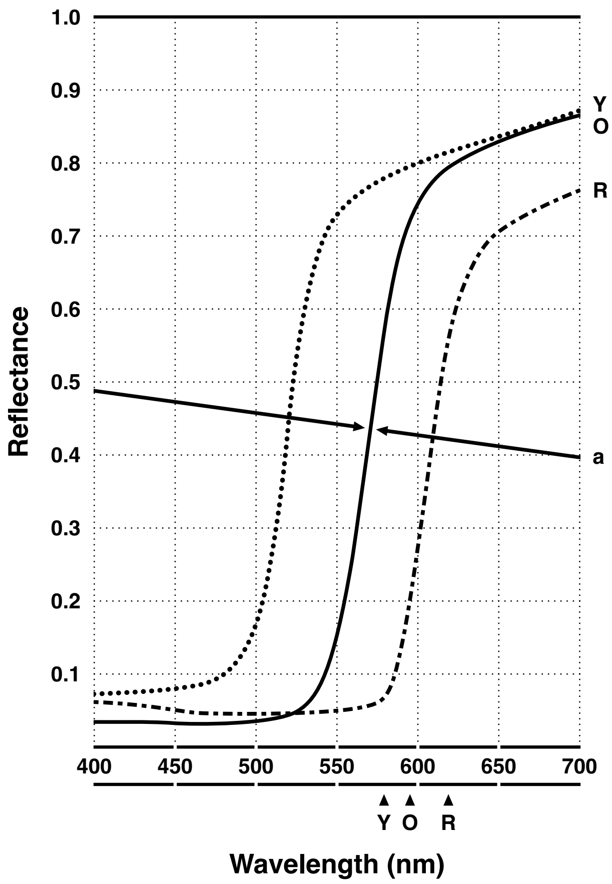
The objection that the aggregate model (the additive and averaging models combined) is derivative of the purple SRP rather than predictive of that SRP would be substantiated if the other binary hue SRP MacAdam (1985) provides, orange, is not similarly derivable by the model. Yet, as displayed in Figure 6, in accordance with the averaging model, the orange SRP visually (and mathematically) approximates the midpoint between the red and yellow SRPs, at least with respect to angle a, and the dominant wavelength of orange is close to the midpoint between the respective dominant wavelength values of yellow and red.

However, in the positive direction of wavelength, the orange curve initially extends lower in reflectance, and eventually extends greater in reflectance, than perhaps reasonably required by the averaging model with respect to angle a. Nonetheless, it could be argued that such discrepancies are within the tolerance earlier afforded to the initial separation of the purple and derived purple SRPs. Moreover, the fact the dominant wavelength of the 'typical' orange sits slightly towards the corresponding 'typical' yellow value than to the corresponding 'typical' red value could reasonably suggest the orange measured is not typical in the sense of being 'near-perfectly average' between yellow and red, but is rather 'more' yellow than red, thereby reducing the identified discrepancies to the subtle lower initial reflectance of orange compared to both yellow and red.

Yet, it could be objected that by introducing the notion of an arbitrary angle at which the orange SRP can be considered approximate of both the yellow and red SRPs (or perhaps as a 'shifting' of a particular 'S' curve shape that is shared by yellow and red), I have again reversed engineered the orange SRP from superimposing the orange,

Figure 6.

Superimposition of Yellow (Y), Orange (O), and Red (R) Spectral Reflectance Profiles (SRP) with indicated dominant wavelengths, and an angle at which O approximates the midpoint of (Y,R), (a)



Note: As detailed in the Appendix, each represented function quantitatively approximates the graphed SRP data of the corresponding colour provided by MacAdam (1985, pp. 6–7). The indicated dominant wavelength value for each colour is provided by MacAdam. Data aspect ratio and assignment of data to axes follow relevant source figures by MacAdam to preserve data scale and facilitate consistent data interpretation. Angle a is 172.215°.

yellow, and red SRPs, yet without reference to the additive aspect of the model – which does not obviously support the previous primarily-additive results of the model.

Whilst such an objection is reasonable, the orange SRP does not significantly deviate from the reflectance midpoint of the yellow and red SRPs, function *M*(Y,R), displayed in Figure 7. Notably, the *steep* change of the orange SRP reflectance between approximately 550 nm to 580 nm is saliently contrasted against a relative *plateau* of *M*(Y,R) reflectance change throughout that nm range. However, this discrepancy could be reasonably interpreted as peculiar to MacAdam's (1985) measurements (say, if his sampling of orange reflectances were course-grained, his unspecified method of interpolation could 'skip' the plateau region). Indeed, the SRP of 'Munsell 5YR 7/12' in Figure 7, a manifestly canonical standardised orange sampled at 10 nm increments provided by Centore (n.d.), has a subtle plateau of reflectance change between approximately 575 nm and 565 nm in contrast to the steep change of the orange SRP by MacAdam (1985) – therefore empirically supporting the interpretation of the lack of plateau in MacAdam's orange SRP being peculiar to his measurements, or to his selection of orange surfaces[27]. Even if not, Figure 7 demonstrates that the 'standard' averaging model of orange (with no arbitrary angle of operation), *M*(Y,R), approximates both empirically derived SRPs of orange, thus supporting the averaging quantitative model.

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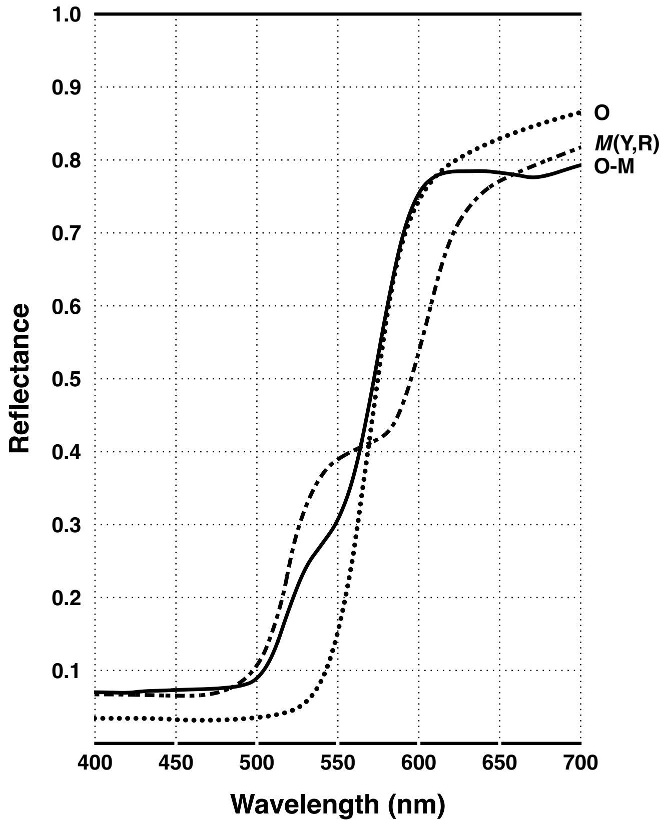
[27] Limited data is available regarding dominant wavelengths of alternative SRP data to MacAdam (1985). So, from this point onwards, I exclude that aspect of SRP modeling. For an elaboration of Centore's (n.d.) method of colour measurement, and its advantages over other methods, see Centore (2013).

Figure 7.

Superimposition of Orange (O) and Orange ‘Munsell 5YR 7/12’ (O-M) Spectral Reflectance Profiles (SRP) and function M(Y,R)



Note: As detailed in the Appendix, the represented function O quantitatively approximates the “typical orange material” (p. 6) graphed SRP data provided by MacAdam (1985). *M*(Y,R) is a quadratic function interpolated through points that are each the midpoint between respective y-values from Yellow and Red SRP functions – approximated from graphed data by MacAdam (1985) as detailed in the Appendix – at sampled x-values, taken at 3-nm increments, including endpoints. O-M is a quadratic function interpolated through 10-nm increment points that constitute the SRP of ‘Munsell 5YR 7/12’ provided by Centore (n.d.). Data aspect ratio and assignment of data to axes follow the relevant source figures by MacAdam (1985, pp. 6–7) to preserve data scale and facilitate consistent data interpretation.

3.4.3. Distilling the Model

The two quantitative models comprising the modelling developed thus far asymmetrically establish *two* methods of binary hue synthesis from unique hues. That is, a purple SRP is derived by the additive model with its dominant wavelength derived by the averaging model, whereas *both* an orange SRP and its dominant wavelength are derived by the averaging model. However, in the present section I demonstrate that the additive model should be provisionally set aside towards confirming the quantitative modelling of the unique–binary distinction.

Given MacAdam (1985, pp. 15–16, 19) implies the higher in reflectance the *general* SRP of a colour is, the closer it is to white and the further it is from black, and thus the *brighter* it is (at least with respect to other shades of that particular colour), it could be reasonably argued that the additive model is only relevant to deriving *generally brighter* versions of binary hues relative to the corresponding unique hues. Yet, MacAdam (1985) does not specify that the 'typical' purple SRP is supposed to be generally brighter than the typical respective blue and red SRPs, so it would be prudent to consider whether the brightness of the purple SRP is peculiar to MacAdam's identification of 'typical' purple. Indeed, if it were shown that the averaging model results in a canonical purple (perhaps unless excessively dull, or 'non-bright'), then given the alternative additive model is pursued *in response* to the purple SRP appearing generally higher than the blue and red SRPs, the objection that derived purple is a reverse-engineering, rather than being predictive, of a purple SRP would be supported. In that case, the averaging model would be preferable, with the additive model provisionally set aside. In fact, the reflectance midpoint of the blue and red SRPs closely approximates the manifestly canonical, though perhaps slightly dull, purple, 'Munsell 5P 4/10', as displayed in Figure 8. Consequently, the averaging model is preferred, with the additive model being relegated to a supplementary aspect to the model on standby[28].

3.4.4. Testing the Model

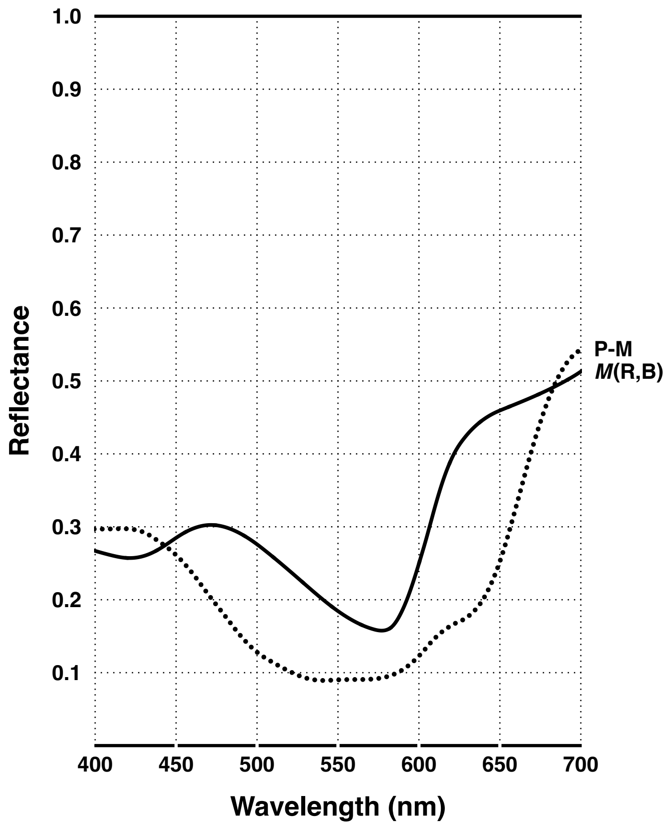
The fact MacAdams (1985) does not provide SRPs of binary hues other than purple and orange, whilst providing SRPs of all the unique hues, presents an opportunity to test the model, thus demonstrating a *general* model of similarities between binary and unique hues. That is, if the model can *predict* the SRPs of the remaining binary hues, teal (bluish-green) and lime (yellowish-green), by the respective SRPs of relevant unique hues, then this predictive theoretical–empirical confirmation would significantly, if not outright, undermine the objection that the model produces coincidental, rather than predictive, results. Furthermore, such predictions exhaustive of binary hue would establish a generalisation of the notion of binary hue sensory–external *congruence* evidenced by Figures 7 and 8. More particularly, such predictions would validate the quantification of similarities and dissimilarities between binary and unique hues proposed in the present thesis, the averaging model, thereby securing an *objective* alternative to Pautz's (2018) apparent *subjective* similarity and dissimilarly comparisons. Thus validating my counterevidence to Pautz's identified colour sensory–external incongruence.

Indeed, the model approximately predicts the respective SRPs of manifestly canonical teal, 'Munsell 5BG 6/6', and lime, 'Munsell 5GY 8/10', as respectively demonstrated in Figures 9 and 10. The teal match is strikingly accurate throughout the visible spectrum,

[28] By 'aspect' I refer to addition and mean averaging by the reflectance axis being isomorphic with respect to SRPs.

Figure 8.

Superimposition of Purple 'Munsell 5P 4/10' (P-M) Spectral Reflectance Profile (SRP) and function M(R,B)

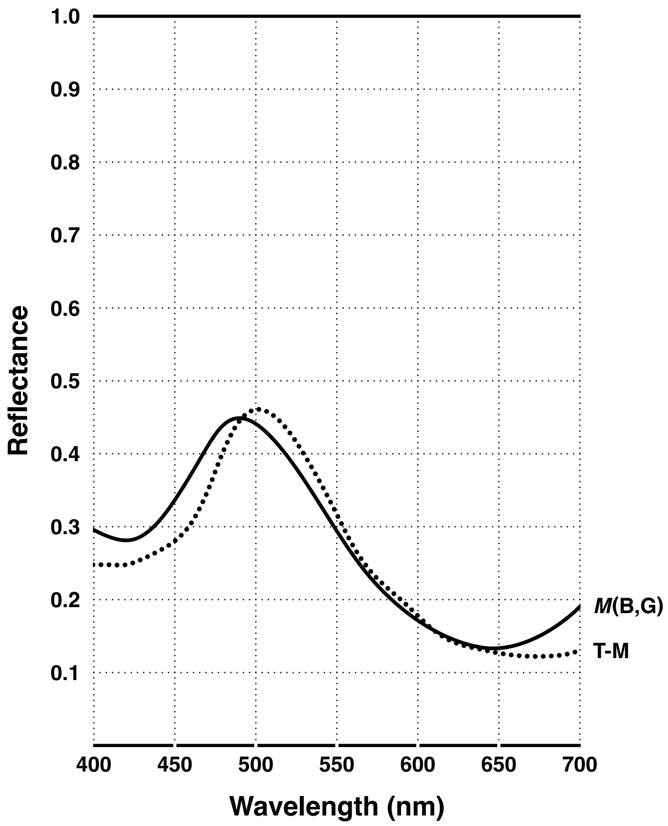


Note: M(R,B) is a quadratic function interpolated through points that are each the midpoint between respective y-values from Red and Blue SRP functions – approximated from graphed data by MacAdam (1985) as detailed in the Appendix – at sampled x-values, taken at 3-nm increments, including endpoints. P-M is a quadratic function interpolated through 10-nm increment points that constitute the SRP of 'Munsell 5P 4/10' provided by Centore (n.d.). Data aspect ratio and assignment of data to axes follow the relevant source figures by MacAdam (1985, pp. 6–7) to preserve data scale and facilitate consistent data interpretation.

and the lime match saliently deviates only by extent of the central 'hump' portion throughout approximately 520 nm to 600 nm, yet with closer matching start and end points than in the teal case.

Figure 9.

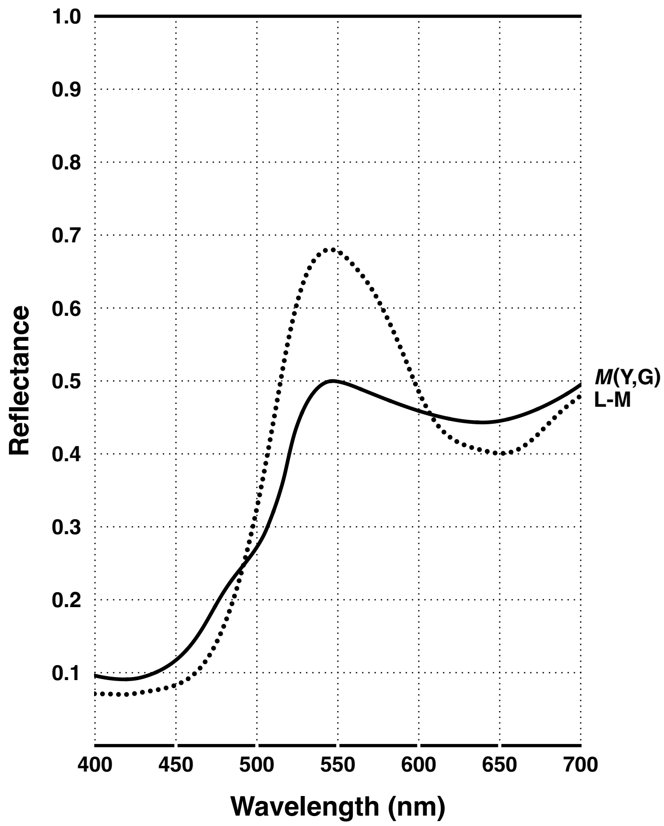
Superimposition of Teal ‘Munsell 5BG 6/6’ (T-M) Spectral Reflectance Profile (SRP) and function M(B,G)



Note: M(B,G) is a quadratic function interpolated through points that are each the midpoint between respective y-values from Blue and Green SRP functions – approximated from graphed data by MacAdam (1985) as detailed in the Appendix – at sampled x-values, taken at 3-nm increments, including endpoints. T-M is a quadratic function interpolated through 10-nm increment points that constitute the SRP of ‘Munsell 5BG 6/6’ provided by Centore (n.d.). Data aspect ratio and assignment of data to axes follow the relevant source figures by MacAdam (1985, pp. 4, 6) to preserve data scale and facilitate consistent data interpretation.

Figure 10.

Superimposition of Lime 'Munsell 5GY 8/10' (L-M) Spectral Reflectance Profile (SRP) and function M(Y,G)



Note: M(Y,G) is a quadratic function interpolated through points that are each the midpoint between respective y-values from Yellow and Green SRP functions – approximated from graphed data by MacAdam (1985) as detailed in the Appendix – at sampled x-values, taken at 3-nm increments, including endpoints. L-M is a quadratic function interpolated through 10-nm increment points that constitute the SRP of 'Munsell 5GY 8/10' provided by Centore (n.d.). Data aspect ratio and assignment of data to axes follow the relevant source figures by MacAdam (1985, pp. 4, 6) to preserve data scale and facilitate consistent data interpretation.

3.5. Further Empirical Investigation

The apparent empirical support, in the previous section, of the provisional model of colour SRP similarity structure demonstrates that neutrality, or openness, towards naïve realism can be scientifically productive. That is, evidently Pautz (2018) abruptly ends his empirical investigation of sensory–external correlations upon identifying apparent sensory–external incongruence, perhaps due to consistency with his potentially *internalist* motivation of sensory–external constitutive independence. Whereas, by the thoroughly physicalist naïve realist motivation of sensory–external constitutive dependence, such identification elicits further investigation to confirm whether hidden sensory–external dependence may be behind the appearance of sensory–external incongruence.

Nonetheless, given the provisional model undermines Pautz's (2018) identification of sensory–external incongruence via more thorough investigation, it is most appropriate, scientifically, to likewise subject my model to more thorough investigation. Indeed, whether or not the model would be thereby confirmed or falsified, evidently, it would in either case benefit from further investigation because in its development, I have not considered the following: How much of SRP information is processed neurologically, nor have I considered "metameric pairs" (Fish, 2021, pp. 166–167) – SRPs that are different structurally yet appear to correspond to the same colour (Fourier analysis may be insightful here) – nor have I considered the potential qualitative status of brown as a binary hue, nor potential 'novel' colours outside the conventional visible spectrum, nor whether midpoint functions between Mansell colours match the synthetic SRPs developed in this thesis[29].

Yet, the model successfully produces data that presents an answer to the first central question raised in section 1.3, the central purpose of section 3:

[29] Nor have I modeled the dominant wavelength of teal and lime, due to limited data available.

> Does Pautz's (2018) identification of colour sensory–external incongruence hold when taking into account that binary hues like purple are, according to Pautz (2006, pp. 208–209), qualitative 'combinations' of unique hues like blue and red?

Indeed, according to results of the model, purple being qualitatively more similar to blue than green is reflected quantitatively between corresponding SRPs, in light of which Pautz's (2018) identification of colour sensory–external incongruence does not hold.

3.6. Afterword on the Unique–Binary Hue Distinction

Results of the modelling above could be reasonably interpreted as demonstrating Pautz's (2018) identification of colour sensory–external incongruence is more appropriate when applied only to unique hues. To illustrate, consider that evidently SRPs are most reflective near their dominant wavelength (MacAdam, 1985, pp. 5, 18–20). Naturally, then, it is perhaps unsurprising that purple, being 'composed' of blue and red, has highly reflective peaks near the blue and red dominant wavelengths, and that purple has a trough of lowest reflectance near the dominant wavelength of its opposite, green. So, evidently the general layperson modelling of MacAdam's (1985) SRPs through identifying salient peaks and troughs, is approximately anticipated, at least via low-resolution, with respect to the positions of relevant dominant and or complimentary wave lengths, further solidifying colour sensory–external congruence underlying the data. Nonetheless, naïve realism is confronted with the fact the respective SRP shapes of the unique hues are neither, generally, all different nor all the same, as would be reasonably expected if the quantitative similarity space of SRPs is indeed to match the corresponding quality space of colour. That is, because *unique* hues are conventionally supposed to be maximally dissimilar from one another. Rather, the blue and green SRPs each share a general "'dip-hump-dip' structure" (Epstein, 2022, p. 793), whereas, the yellow and red SRPs each have a general ‘plateau-rise-plateau’ structure. In other words, apparently, the blue and green SRPs are quantitatively similar and the yellow and red SRPs are quantitatively similar, yet neither the blue nor green SRPs are similar to either the yellow or red SRPs and vice versa. These apparent pairs of *quantitative* similarities between unique hues potentially present a problem for naïve realism because no *qualitative* similarities are observed between unique hues (such hues being supposedly *unique* qualitatively)[30]. If, that is, this apparent lack of qualitative similarity has correlated neural patterns, which would thereby supporting internalism *over* naïve realism.

3.7. Findings of Section 3

In section 1.2.1 above, I argued that Pautz’s (2018) identification of colour sensory–external incongruence (between experienced colours and associated SRPs) is based on a critically incomplete analysis of the relevant similarity space, that purple is more similar to blue than to green, because he neglects the ubiquitous view that binary hues like purple are “combinations” (Pautz, 2006, p. 209), or “composite[s]” (Fish, 2021, p. 169), of unique hues like blue. That is, he does not consider the ubiquitous *way* in which purple is supposed to be similar to blue, as part blue and part red (Pautz, 2006, pp. 208–209). Consequently, his claim that a purple SRP is not quantitatively similar to a blue SRP in the way that purple and blue are qualitatively similar, constituting colour sensory–

[30] Perhaps this binary distinction of unique hue SRP shape could be illuminated from a ‘brain-based’ perspective by investigation into Burns’s (2020) “algorithms for generating a reflectance curve” with respect to “the ‘trichromatic’ nature of human color perception” (p. 1). That is, as opposed to the predictive model derived in the present thesis based on ubiquitous introspective report of the distinction between binary and unique hues.

external incongruence, raises the first central question of section 1.3: ‘Does Pautz's (2018) identification of colour sensory–external incongruence hold when taking into account that binary hues like purple are, according to Pautz (2006, pp. 208–209), qualitative ‘combinations’ of unique hues like blue and red?’. Accordingly, to determine the answer to this question, throughout section 3, I developed a quantitative model of qualitative similarity between binary hues and unique hues with which to test his claim of colour sensory–external incongruence. The additive version of the model, which derives binary hue SRPs by combining the reflectance's of corresponding unique hue SRPs, accurately predicts the purple SRP to which Pautz refers. Indeed, the derived purple SRP fits the contours of blue and red SRPs (from the same data set) superimposed, demonstrating that, quantitatively, purple SRPs are part blue SRP and part red SRP, as purple is part blue and part red in experience, thus contradicting Pautz's (2018) claim of colour sensory–external incongruence. Furthermore, this ‘additive’ congruence between experienced colours and corresponding SRPs is matched by the averaging model, from which can be derived all the conventional binary hues, thus solidifying *broad* colour sensory–external congruence beyond the relevant limited dataset to which Pautz appeals.

4. Modulations of Sensory Experience

In this section, I focus on answering the second central question raised in section 1.3:

> Under naïve realism, can sensory–external incongruence be rendered "systematic and regular" (Pautz, 2018, p. 15) through consideration of contributions to qualitative character by neural responses?

Through defence of a joint-determination interpretation of naïve realism, I argue that basic tenets of naïve realism entail that shape perception can be counterfactually dependent upon specific neural activity yet, simultaneously, not upon any determinable physical pattern impinging upon the sensory system. I speculate, via analogous mechanistic precedence, how this possibility could be mirrored in the case of colour perception. Thereby, I provide a positive answer to the above second central question raised in section 1.3.

In section 4.1, I revisit Pautz's (2018) notion of a joint-determination naïve realism. In section 4.2, I develop my answer to the above second central question by implicitly responding to a challenge constituted by Pautz's (2018) criticisms of joint-determination, principally regarding his repurposing of Block's (1990) 'inverted worlds' thought experiment. In section 4.3 I conclude that simple naïve realism is consistent with a greater observable dependence of qualitative character on neural responses than on extracorporeal physical properties.

4.1. Problems for a Joint-Determination Naïve realism

In section 2.2, I provided Pautz's (2018) account of a "joint-*determination view"* (Pautz, 2018, p. 29, n. 19) according to which "qualitative character "is partly grounded in what is perceived (grounded in causal connections to objects) *as well as* the way in which it is perceived (grounded in the neural response)" (Pautz, p. 29, n. 19). I clarified that Pautz defines this view as an adaptation of "extreme ways-based naïve realism" (p. 28) which posits "the qualitative character of your experience is not determined by *what* you perceive; it is determined by the *way* you perceive it, which is partly grounded in your neural response" (p. 28).

Pautz (2018, p. 29, n. 19) points out, by way of open questions, that the idea of a joint-determination view "faces problems" (p. 29, n. 19), he asks: "What is the relative 'contribution' of each factor? What could this even mean? And what is the general rule whereby the two components determine phenomenal character?" (p. 29, n. 19). Furthermore, Pautz questions how a joint-determination view is supposed to confront the following thought experiment that he repurposes from Block (1990).

Block (1990) posits a 'twin' of Earth that is virtually identical to Earth except inverted with respect to colour such that all blue items on Earth have yellow duplicates likewise termed 'blue' on twin Earth and, inversely, all yellow items on Earth have blue duplicates likewise termed 'yellow' on Twin Earth – and the same inversion holds between red and green items. Block considers "neural duplicat[e]" (Pautz, 2018, p. 29, n. 19) 'twins' on Earth, one of whom is unknowingly fitted with colour inverting lenses and placed on Twin Earth, leaving the 'non-inverted' twin on Earth (Block, 1990, pp. 63, 65). That is, Block suggests when the 'inverted' twin looks at say, a red item termed 'green' on Twin Earth, the lenses 'invert' the red wavelength to green before impinging upon the inverted twin's sensory system (Block, 1990, p. 65). So, if the inverted twin observes a stretch of grass – which is red on their inverted Earth, rather than green as on Earth – and the non-inverted twin observes the duplicate stretch of grass on Earth, then the twins will *both* report seeing green grass (Block, 1990, pp. 63, 66). That is, despite that the respective stretches of grass are *differently* coloured, at least as Pautz (2018, p. 29, n. 19) suggests, and that the twins are apparently “neurologically the same” (Block, 1990, p. 65)[31]. According to Block (1990), the twins would “hav[e] experiences with just the same qualitative contents” (p. 66) when considering “qualitative content” (p. 68) to be “supervenient on physical properties” (p.68).

Whereas, immediately upon referencing this repurposed thought experiment of ‘inverted worlds’ and ‘duplicate subjects’, Pautz (2018) explains that a *difference* in qualitative character between the duplicate subjects is implied by “the joint-determination version of the view” “even though” the subjects’ “are neural duplicates (because there is a difference in the ‘what-is-perceived’ factor)” (p. 29, n. 19)[32]. He then asks: “But what *evidence* could possibly be adduced for this view?” (p. 29, n. 19).

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[31] Block (1990) suggests, “[w]e could even suppose” the twins’ “brains are molecular duplicates” (p. 65).

[32] Under naïve realism, at least outwardly at this stage, for there to be differing qualitative characters between the neural duplicates due to the presumed phsyical differences, given that the wavelengths the inverted twin receives from the lenses *are the same* as those received by the non-inverted twin, Block (1990) would need to be interpreted as suggesting the lenses do not feature perceptually but nonetheless ‘somehow’ *mechanistically* invert impinging wavelengths projected from physical differences. That is, as opposed to, say, if each lens dynamically instantiates appropriately inverting *translucent* colour at every resolvable point of the lens surface *relative to* surrounding instantiations of colour, analogous to the way highly tinted dark-red lenses could make a stretch of green grass appear red. In other words, Block (1990) would need to be interpreted as suggesting *not* that the lenses instantiate colours that feature perceptually (superimposed upon environmentally instantiated colours) but rather that the lenses ‘somehow’ adapt incoming light waves projected from extracorporeally instantiated colours without that adaptation thereby constituting a coloured material like tinted lenses.

Before continuing to Pautz's comments subsequent to referencing the inverted worlds scenario, note the following ambiguity signposted for further analysis: if a joint-determination view implies for Pautz (2018) differing qualitative characters between the duplicate subjects' due to the "'what-is-perceived' factor" (p.29, n. 19), then because this difference is a consequence of naïve realism generally (where that factor exclusively grounds qualitative character) it is unclear whether Pautz refers by 'this view' when he asks "[b]ut what *evidence* could possibly be adduced for this view?" (p. 29, n. 19) to either *specifically* the notion of a joint-determination naïve realism given distinctive implicit conditions of its demonstrability (or perhaps its lack of demonstrability) in the 'inverted worlds' scenario, or that specific notion as representative of a naïve realist interpretation of the inverted worlds scenario *more generally*[33]. This ambiguity is fastened by the fact Pautz proceeds to answer his question with reference to his empirical argument implemented against naïve realism proper that, by extension, is also applicable to a joint-determination naïve realism and is indeed referenced in the context of critiquing a joint-determination naïve realism.

That is, immediately following Pautz's (2018) question about citable evidence for 'this view' he continues: "Indeed it would seem" that "reason to reject this view" (Pautz, 2018, p. 29, n. 19) is supplied by his empirical argument against naïve realism that data comparisons he cites demonstrate physical patterns are, when compared with

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[33] Either way, although it could be reasonable to interpret Pautz's (2018) question as implying, rhetorically, that a difference in qualitative character between the duplicate subjects' would be "behaviorally undetectable" (Shoemaker, 2003, p. 270) as is "most frequently discussed" (Shoemaker, 2003, p. 270), as Pautz is *inexplicit* about what he supposes the thought experiment to show, my interpretation remains neutral. Instead, I attempt to resolve appropriate interpretations deductively based on that about which he is explicit: that there would be a difference in qualitative character under a joint-determination naïve realism.

associated neural patterns, ‘badly’ correlated with qualitative character. Pautz continues that, in consideration of this empirical incongruence argument, “the most reasonable view is that all the work is being done by the ‘way of being perceived’, grounded in the neural response. But then we are back to the point in the text: this is hardly a ‘naïve realist’ theory” (p. 29, n. 19) of qualitative character. ‘The point’ to which Pautz (2018) returns is evidently his objection to extreme ways-based naïve realism as ultimately implying “what is being perceived is no longer doing any work in determining the qualitative character of our experience of sensible properties. All the work is being done by the ‘way’ you perceive, which is constituted by your neural response” which he states after noting “proponents of the view” do not specify how physical properties are supposed to contribute qualitatively to experience (Pautz, 2018, p. 28): That this objection is the point to which Pautz (2018) returns is evidenced by the fact his consideration of a joint-determination view is entirely contained to a footnote accounting the view as a potential response to this objection. Accordingly, when Pautz (2018) says in the conclusion of his discussion of joint-determination that “all the work is being done by the ‘way of being perceived’ grounded in the neural response” (p. 29, n. 19), it is reasonable to interpret the ‘work’ that is being all done as referring to “work in determining the qualitative character” (p. 29) as phrased in the identified point to which he returns.

In light of this conclusion, evidently Pautz’s (2018) critique of a joint-determination view approximately constitutes the following ‘reversion’ empirical argument, provisionally:

1. Under a joint-determination view, qualitative character is partly grounded by a physical factor, “what is perceived (grounded in causal connections to objects)”, and also partly by a neurological factor, “the way in which it is perceived (grounded in the neural response)” (Pautz, 2018 p. 29, n. 19).

2. The notion of a specifically joint-determination naïve realism, or that notion as representative of naïve realism more generally, requires that, in the inverted worlds scenario, the duplicate subjects' respective experiences differ (technically 'in part') in qualitative character because the associated physical properties differ, despite that the subjects' have identical neural responses to those physical properties (Pautz, 2018, p. 29, n. 19).
3. Empirical evidence demonstrates that qualitative character is *incongruent* with associated physical properties whereas qualitative character is *congruent* with associated neural properties (Pautz, 2018). Therefore, the notion of physical properties grounding qualitative character is thereby empirically countervailed whereas the notion of neural properties grounding qualitative character is thereby empirically supported (Pautz, 2018).
4. Therefore, "most reasonably" (Pautz, 2018, p. 29, n. 19) a joint-determination view is empirically countervailed (because it requires that qualitative character is partly grounded by connections to physical properties). That is, or else the view reverts to the extreme ways-based naïve realism from which it is adapted, under which qualitative character is only grounded by the neurological factor – with a touted perceptual role for physical properties "remain[ing] somewhat under-specified" (p. 29) thus rendering the view "hardly a 'naïve realist' theory" (Pautz, 2018, p. 29, n. 19).

Notably, 4 does not necessarily depend upon 2, assuming for now that 2 is necessarily entailed by the first disjunct of 1. In which case, the supposed differing qualitative characters between the duplicate subjects' is apparently inconsequential to the reversion argument.

To illustrate, recall the signposted ambiguity (further indicated in 2), in relation to Pautz's (2018) repurposing of the inverted worlds thought experiment to the notion of joint-determination: Whether he questions citable evidence for 'this view' as referring to either *specifically* the notion of a joint-determination naïve realism given distinctive implicit conditions of its demonstrability (or a lack of demonstrability) in the 'inverted worlds' scenario, or that specific notion as representative of a naïve realist interpretation of the inverted worlds scenario *more generally*. The latter option – of effectively referring to naïve realism by proxy – is implied, at least upon a surface reading, by Pautz's (2018) conclusion – that the 'way' of perceiving exclusively does the "work in determining the qualitative character" (p. 29). That is, because he outwardly reaches this conclusion by connecting his question about citable evidence via the conjunctive adverb 'indeed' to his empirical incongruence argument. More simply, Pautz (2018) does not explicitly specify what relevance the duplicate subjects' supposed respective differing qualitative characters (under joint-determination), despite supposedly identical neural responses, has for his discussion of joint-determination. Rather, he proceeds immediately from stating that supposed implication of the inverted scenario to questioning citable evidence for 'this view' in inexplicit connection to his empirical incongruence argument. So, all else being equal, given his conclusion does not mention that qualitative difference, nor that difference in contrast to an associated neurological identity, if Pautz's (2018) reference to 'this view' is to serve as an effectual premise towards his conclusion, it is reasonable to interpret that reference as citing an instance of a view that he argues should be rejected in light of his empirical incongruence argument. And if that view can be a joint-determination naïve realism then – given the signposted ambiguity – it can be naïve realism proper[34].

In which case, the conclusion of the reversion argument, 4, is reachable (by premises 1 and 3) without reference to premise 2 (the requirement of differing qualitative characters), and so, assuming 2 is a necessary consequence of the first disjunct of premise 1 (the stipulation of part naïve realist qualitative character) and thus negated by premise 3 (the empirical argument against the naïve realist part of qualitative character), 2 is otherwise inferentially inactive within the greater reversion argument. If so, then the supposed differing qualitative characters between the duplicate subjects is outwardly inconsequential to the reversion argument; that argument effectively being reduceable to either that a joint-determination view is vulnerable to Pautz's (2018) empirical argument against naïve realism generally, or that a joint-determination view reverts to extreme ways-based naïve realism, the latter of which being inadequately naïve realist for Pautz (2018, p. 29, n. 19).

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[34] Alternatively, it could be argued that 'version of the view' can refer to *the application of joint-determination to* the 'view' that the inverted worlds thought experiment is legitimate – for example, that it is coherent or plausible and so on. Nonetheless, because more than just naïve realist theories are applicable to the thought experiment – for example, Block (1990) applies the thought experiment to internalism – for the specific application of joint-determination to be a 'version' of the thought experiment does not require that there is anything distinctive about joint-determination over and above entailing a consequence shared, in that context, with naïve realism more generally; that the duplicate subjects' experiences would differ in qualitative character under naïve realism, according to Pautz (2018). So, if Pautz refers to the 'view' that the inverted worlds thought experiment is legitimate, his reversion can be reasonably interpreted as applying to naïve realism generally.

Alternatively, Pautz (2018) could be reasonably interpreted as implying that the notion of a joint-determination view has, in the inverted worlds scenario, seemingly incompatible demonstrability conditions. That is, the duplicate subjects' respective qualitative characters are determined by supposedly *differing* wordily qualitative properties whilst being *simultaneously* determined by supposedly *identical* neural responses. So, unlike extreme ways-based naïve realism, naïve realism more generally, and internalism, there is apparently (all else being equal) no principle inherent to the evidence by which a joint-determination naïve realism can 'pick a side', as it were, to determine whether the duplicate subjects' have differing or identical qualitative characters by appeal to either the physical factor or neurological factor, respectively. Indeed, this supposed indeterminacy is a manifestation of Pautz's (2018) suggestion that a joint-determination naïve realism is faced with determining a "relative 'contribution' of each factor" that determines qualitative character (p. 29, n. 19).

Yet, given Pautz (2018) refers to 'the view' as explicitly requiring that the duplicate subjects' have *differing* qualitative characters, despite that their respective qualitative characters are partly determined by *identical* neural responses, in conjunction with the fact he does not refer to any greater relative contribution of the physical factor, then all else being equal, Pautz implies that *any* contribution to qualitative character by a physical difference will result in a difference in qualitative character, whether or not the subject can report the difference. In that case, a joint-determination naïve realism inherits from naïve realism more generally the problem of differing qualitative characters between the duplicate subjects, *regardless* of the relative contribution of the physical factor. Therefore, it is reasonable to interpret Pautz's (2018) enquiry about the demonstrability of "this view" (p. 29, n. 19), as referring implicitly to either of the following three demonstrability issues each committed to a difference of qualitative character between the duplicate subjects. First, that such a difference would be "behaviorally undetectable"

(Shoemaker, 2003, p. 270) under naïve realism generally (as is also the case under internalism), in which case his empirical argument takes over. Second, the auxiliary problem of detecting a 'relative contribution' of a physical factor under a joint-determination naïve realism given apparently incompatible demonstrability conditions. Third, Pautz's (2018) enquiry about the demonstrability of "this view" refers to the prior two demonstrability issues simultaneously.

However, whether a difference in qualitative character between the duplicate subjects could be detected, in the following section, I argue that a joint-determination naïve realism does not necessarily require that difference, undermining the potential relevance of the inverted worlds clause of Pautz's (2018) reversion argument. Furthermore, I argue that a joint-determination view is consistent with the basic tenets of simple naïve realism he defines. Consequently, joint-determination naïve realism need not revert to extreme ways-based naïve realism as Pautz (2018, p. 29, n. 19) suggests because joint-determination naïve realism can be equivalent to naïve realism generally. In which case, Pautz's (2018) argument against a joint-determination view collapses into his empirical argument against nave realism more generally, which is undermined, at least in the colour case, by the findings of section 3 above.

4.2. Detectable Difference and Experienced Difference

In this section, I show that, in accordance with the basic tenets of naïve realism detailed in section 2.1 above, the qualitative character of a subject's shape experience could, in principle, be equivalent (*for* the subject) to the qualitative character of a duplicate subject's shape experience despite this equivalence being undetectable due to the duplicate subject's attending to differently shaped objects, a scenario criticised by

Pautz (2018, p. 32)[35]. I expand this reasoning to colour experience between duplicate subjects, thereby demonstrating that the inverted worlds scenario under naive realism need not require differing qualitative character between the duplicate subjects, through which I develop an answer the second central question raised in section 1.3. That is, I effectively take Pautz's (2018) cryptic application of the inverted world's thought experiment as a challenge to determine the following: Whether the inverted worlds scenario requires that, under simple naïve realism, or joint-determination naïve realism, or both, the duplicate subjects' respective qualitative characters would be 'identical' – meaning qualitatively and epistemically equivalent, though separately instantiated, collections of qualitative properties – or 'different' – meaning qualitatively and epistemically different, and separately instantiated, collections of qualitative properties.

To prime the arguments developed throughout the present section, consider the following analogy that demonstrates – if the duplicate subjects are neurologically identical – that equivalent qualitative characters between the duplicate subjects is logically consistent under a joint-determination interpretation of naïve realism, all else being equal. Alternatively, the following analogy can similarly demonstrate the duplicate subjects need not be neurologically identical under naïve realism.

[35] I emphasise '*for* the subject' because, under naïve realism, equivalence of qualitative character between the duplicate subjects' can be epistemic but not metaphysical because differing *items* of awareness necessarily constitute differing experiential content, whether or not those items instantiate the same set of qualitative properties (Fish, 2009, pp. 81–84). Accordingly, references to 'identical' in the present thesis refer to isomorphisms between items (such as the *same* set of qualitative properties being separately instantiated), as opposed to referring to two items being one.

Recall again, the yellow vase-shaped afterimage viewed against a uniform white wall that occurs after sustained viewing of a blue vase. Suppose a subject experiencing such an afterimage had observed, the day prior, a yellow vase-shaped image projected by yellow light onto that otherwise uniformly white wall – the experience of which qualitatively matches their later experience of the yellow vase-shaped afterimage. Call the subject when experiencing the image on the wall the 'veridical perceiver', and the subject when experiencing the afterimage, the 'illusory perceiver'. These two perceivers are not supposed to be neurological duplicates with respect to their retinal sensitives because, although their respective experiences have equivalent qualitative character, the veridical perceiver's acquaintance with yellow is enabled by appropriately functioning photoreceptors, whereas the illusory perceiver's acquaintance with yellow is enabled by fatigued photoreceptors. That is, although the perceivers are presented with differently (dominant) instantiated sets of qualitative properties – a uniform white wall in one case, and a yellow image on a uniform white wall in the other case – the two perceivers nonetheless have equivalent experiences. Yet, this equivalence is not due to a neurological identity because the shared photoreceptors function differently between the perceivers.

Indeed, as a useful metaphor, consider that the sensory system of the veridical perceiver is akin to a set of key locks, and differing wavelengths of light are akin to the different keys that respectively fit the various locks. That is, each lock only takes input from a respective particular key or a unique subset of all keys, akin to how differing photoreceptors are sensitive to differing wavelengths. Accordingly, the overall metaphor is that just as a door is opened only when an appropriate key is secured in the lock (at least by design), so too the "visual channel is open so that direct visual awareness of external things takes place" (Johnston, 2004, p. 139) when an appropriate wavelength interacts with a correspondingly sensitive photoreceptor.

Refining the metaphor, when the veridical perceiver's sensory system becomes fatigued, resulting in the illusory perceiver, the 'locks' of the sensory system are modified, or rearranged, to receive 'keys' that would normally not fit – where the 'keys' are dominating wavelengths to which the photoreceptors would normally not be so sensitive. So, although the 'keys' received by both perceivers are the same (yellow light), the locks (photo sensitivities) are different. Conversely, if the keys were different, and the locks were the same, then the perceivers could have different experiences. That is to say, if both perceivers had appropriately functioning photoreceptors whilst being exposed to different wavelengths of light, then they would (assuming normal veridical perception) experience different colours.

Analogously, throughout the present section, I demonstrate that naïve realists can plausibly expect a similar metaphor to appropriately capture the relationship between neural structures and differing wavelengths of light. That is, where each 'lock' is a neural structure that only accepts a unique 'key', a unique wavelength or range of wavelengths. That is to say, with respect to the inverted worlds scenario, naïve realists can plausibly deny that the duplicate subjects could be neurologically identical if respectively sensing via different sets of wavelengths of light because their neural responses must be functionally different to enable acquaintance with differing wavelengths – their locks must be different to match their differing keys. So, inversely, naïve realists can consistently deny that if the subjects are considered neurologically identical, then they must be experiencing different colours.

Specifically, I propose neural responses can plausibly stand as a negating 'aperture' of acquaintance that determines *which* qualitative properties feature (are isolated) in sensory experience, analogous to the way an optical aperture can narrow the light available to film or a digital sensor. This negating of acquaintance is an extension of basic principles naïve realists can accept: Notably, that neural responses can, as in the case of afterimagery, modulate the *specific bounding* – or 'singling out'– of instantiated qualitative properties like yellow within a uniform white wall, whereas the fact there are any qualitative properties like yellow to be bounded is constituted by neural connection to physical properties. In other words, in accordance with basic tenets of naïve realism, I propose naïve realists can coherently hold that neural activity enables connection to a 'qualitative manifold' of varying superpositions of physically instantiated qualitative properties, and potential detection of *how* any particular qualitative property is singled out *can* be more empirically illuminating of qualitative character than detectable non-neural physical differences. More simply, as foreshadowed in section 1.2.2.2 above, I propose a model of acquaintance as neural activity modulating the enabling, and thus *specifying the bounds*, of connection with a phenomenal 'fill' instantiated in the external world thereby 'outlined' by neural activity. This notion of an 'aperture' of acquaintance is biologically analogous to the fact that, although experienced illuminance differences can exist mind-independently under naïve realism, experienced illuminance can also be modulated by the narrowing of the pupil (in which case experienced illumination can be jointly determined). I propose to demonstrate in the present section that there is scope for neural responses to analogously modulate experience of both shape and colour experience.

4.2.1. Specifying Shape Acquaintance

In this section, I argue that shape perception can be counterfactually dependent upon specific neural activity yet, simultaneously, not upon any detectable physical pattern impinging upon the sensory system. This argument extends from the following anticipatory argument from section 1.2.2: The vase-shaped afterimage case illustrates that it is not necessary under naïve realism, at least not universally, that perceptual experience *matches* saliently correlated extracorporeal measurements – the vase shape afterimage is not detectable on the wall exclusively in view – due to concurrent neurological dependencies of experience. So, the anticipatory argument is that, before determining perceptual experience, more generally, to be unsystematic–irregular, due to particular identified incongruences between experience and the world, it would be prudent to either justify that exclusive focus on extracorporeal measurements or consider whether, under naïve realism, unrecognised neurological dependencies of experience could be behind the respective appearances of sensory–external incongruence identified by Pautz (2018). In the present section, I pursue the latter option of investigating relevant potential dependencies of experience under naïve realism.

4.2.1.1. Constitutive Neural Activity under Naïve Realism. It could be argued that Pautz (2018, pp. 2–3) appropriately takes into account such neurological dependencies, via corresponding minor caveats on his formation of simple naïve realism. That is to say, such dependencies are arguably inconsequential to his arguments due to being constituted by abnormalities or underperformances of the sensory system, thus resulting in peculiar perceptions, in contrast to the paradigmatic examples of perception on which he focuses. That is, where 'paradigmatic' predicates perception as reference to cases in which the sensory system is biologically non-defective and the extracorporeal measurements *match* the sensory experience, as inherently implied by Pautz's (2018) attempts to identify *general* sensory–external congruence from *particular* cases (I elaborate upon this inherent implication in section 4.2.1.5 below). For example, whereas Pautz (2018) quotes his naïve realist adversary Campbell (2010, p. 206) as holding that investigation of what grounds qualitative character should be directed towards the external world and away from neural activity, Pautz more *conservatively* retorts that "in many cases" (p. 5) investigation of that which grounds qualitative character should be directed away from the external world towards neural activity. Furthermore, in Pautz's

(2018) discussion of naïve realism, he acknowledges that "*plus or minus a bit*, the qualitative character of your visual experience is constituted by your perceptual acquaintance with *objective, mind-independent* state of the external world" (p. 2). He elaborates that his understanding of naïve realism permits "cases in which due to for example differences in blurriness or the distribution of attention, different people perceive … the same states in 'different ways'" (p. 3), which he refers to as "a couple of exceptions" to his, more austerely 'world-directed', formulation of basic naïve realism (p. 28).

4.2.1.2. A Negative–Positive Distinction. It is important to note that this apparent suggestion of Pautz's (2018, p. 2) – that such idiosyncrasies of the neurological system are a 'bit' constitutively dependent of, or perhaps at least partly influential on, qualitative character – does not necessarily undermine his distinction between naïve realism and 'brain-based' views that posit qualitative character is most directly, and potentially therefore constitutively, dependent upon neural responses to proximal nervous stimulation. That is to say, it could be argued that permitting neural activity to 'directly' contribute to qualitative character – for example, by "shaping" (Fish, 2009, p. 6) the specific experience of extended space – permits by extension, all else being equal, that such a contribution could be *greater* than the concurrent contribution of extracorporeal properties, thereby undermining Pautz's (2018) implicit suggestion that the latter is *less* directly contributing. That is, where 'greater' is cashed-out in terms of there being more empirically correlated dependencies between experience and physical properties – in accordance with Pautz's empirical approach.

However, even if the neural contribution can be greater, the relevant idiosyncratic neurological dependencies – though apparently *constitutive* of relevant phenomena like afterimages – are arguably accentuations, or amplifications, of *limitations* on the sensory system as opposed to constituting experiential 'content'. That is, under naïve realism, such dependencies need only result in pervasive *negations* of qualitative character and so are not constitutively dependent thereof in the 'positive' way that extracorporeal properties are constitutively dependent thereof (Fish, 2009, pp. 61–65, 168). For example, under naïve realism, there would not be *any* experience of a vase-shaped patch of colour if one were unacquainted with an extended region within which shape and colour can be instantiated – and this marks a positive contribution of extracorporeal properties (Fish, 2009, pp. 61–65, 168; Pautz, 2018, p. 34). Whereas, if one sees the blue vase blurrily, or without the vase manufacture emblem, or instead sees a yellow vase-shape afterimage, these are each *failures* of the sensory system to "pick up on" (Fish, 2009, p. 168) salient qualitative properties *instantiated* in the relevant extracorporeal region; in this case 'blueness', 'edge-sharpness', and the 'region' where the emblem resides (Fish, 2009, pp. 61–65, 168). So, even though 'qualitative character' as the *specificity* of sensory experience – for example, that one sees yellow instead of blue, or sees a vase shape or not – can therefore be *highly* dependent upon neural activity under naïve realism, such dependence is apparently only *negatively* constitutive of qualitative character in the sense of being a limiting factor upon acquaintance with qualitative properties that are grounded in extracorporeal properties. Consequently, given that, under naïve realism, there would be no sensory experience for neural activity to limit if there were no acquaintance with qualitative properties grounded in extracorporeal properties, qualitative character is, therefore, *most directly* constitutively dependent upon extracorporeal properties than upon neural activity, under naïve realism.

4.2.1.3. Obscured Similarities or Dissimilarities. So, whilst the phenomena of afterimagery need not undermine Pautz's (2018) demarcation of naïve realism from the relevant brain-based views he identifies, afterimagery demonstrates that apparent sensory–external incongruence *can* be rendered congruent (sensory–neural–external congruent) upon considering associated neural measurements. Therefore, it can be argued that sensory–external incongruence cannot be reasonably concluded without considering associated neural measurements, at least not without justification. This argument is somewhat backed by the *conceivability* that the qualitative character of comparatively non-defective type of perceptions on which Pautz (2018, p. 2) focuses could be constituted by negations of acquaintance in a way that obscures sensory–external congruence from his limited sensory–external analysis.

To illustrate, consider that it is consistent with naïve realism (as well as being manifestly implied by the coincidental nature of biological evolutionary advantage) that the constitution of reality is not limited to that which humans can experience (Fish, 2021, p. 181; Pautz, 2018, p. 5; Pautz, 2021, p. 193;). Accordingly, then, it can be reasonably conjectured that the qualitative aspect to reality is richer in similarities and dissimilarities than is (at least presently) enabled for acquaintance by human sensory systems (Fish, 2021, p. 181; Pautz, 2018, p. 5; Pautz, 2021, p. 193)[36]. In that case, the ubiquitous view that blue and green are maximally dissimilar to one another – to which Pautz (2018) implicitly appeals when identifying colour sensory–external incongruence – need only be due to an insensitivity to how these colours are similar, qualitatively[37]. In that case, it could be coherently conjectured that a similarity between green and blue is 'blocked' by

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[36] For example, given wavelength differences throughout the visible spectrum of light constitute similarities and differences in colour, it is conjectured that wavelengths outside the visible spectrum may constitute or reveal similarities or differences in colour that are not (or at least not yet) visible to humans (Martin, 2006, p. 29).

[37] And as implied by Epstein's (2022) criticisms of Pautz's (2017; 2021) ambiguous standards of measurement, similarities between blue and green may, in principle, be *quantitatively* identifiable. Indeed, this is perhaps implied, under naïve realism, by the binary distinction of unique hue SRP shape detailed in section 3.6 of the present thesis.

neural processing or is, at minimal, not enabled for acquaintance by neural activity. Although that conjecture is highly speculative, there is analogous mechanistic precedent in everyday life. For example, when a subject learns to distinguish two shades of colour, it would be odd, under naïve realism, to conclude that reality 'updated', as it were, a single shade of colour into two shades. Rather, in that scenario, it would be sensible to conclude that there were two shades all along, but that the subject was initially incapable of identifying a difference between the shades.

4.2.1.4. Mechanistic Precedent. So, by analogy with afterimages, it is conceivable, and so provisionally *possible*, that the qualitative character of comparatively non-defective types of perceptions could be partly constituted by negations of acquaintance in a way that obscures sensory–external congruence from Pautz's (2018) analyses. However, given that such a possibility is here merely conjectured without explanation of how such a process is supposed to work – or indeed without any empirical indication of such a process – the onus is not reasonably on Pautz to eliminate (or confirm against his aims) that possibility by taking neural measurements into account in his identification of sensory–external congruence. However, in the present subsection, having established that the neurological system can be relevant to identifying sensory–external incongruence, I build upon this foundation to suggest *how* a biologically non-defective (though functionally atypical) human sensory system could, in principle, obscure the identification of sensory–external incongruence. In particular, I illustrate how basic capabilities of visual acquaintance permit the qualitative character of sensory experience to be more correlated with neural data than with extracorporeal data.

To prime the illustration, first consider the potential objection that the vase-shaped afterimage is insufficiently analogous for use in extrapolating possibilities of negatively contributing *neural responses* – such as responses constitutive of "distribution of attention" (Pautz, 2018, p. 3) – from possibilities of negative contributions of what *stimulates* those responses. That is to say, given the varying sensitivities of the relevant retinal cells that negatively contribute to the vase-shaped afterimage are causally prior to the neurological *response* to nervous stimulation *enabled by those sensitivities*, the fact the afterimage experience is highly dependent upon such sensitivities, is not obviously analogous to a high dependency upon neural responses. Whereas, afterimages would clearly be sufficiently analogous – to neural activity constitutive of qualitative character – if highly dependent upon neural responses, rather than upon what enables those responses.

However, in the present subsection, I argue that the negative contribution of the relevant fatigued retinal cells to qualitative character, in the vase-shaped afterimage case, can stand as appropriately analogous to potential similar contributions of neural responses: Just as the set of varying sensitivities of retinal cells negatively contributes to the specificity of the region visually attended to by the subject in the vase-shaped afterimage case, so too can neural responses (to proximal stimulation) negatively contribute to analogous specificity. To illustrate, consider an unchallenging two-dimensional maze puzzle with only one solution. Suppose the puzzle is printed in a book. The maze walls are printed in black and are thus starkly contrasted against the white of the relevant page. It is reasonable to suppose that, upon solving the puzzle several times, the correct maze route (the puzzle solution) might visually ‘pop out’ in the sense that the salience of the relevant region of the page occupies one’s full visual attention, as guided by perceptual memory, in comparison to the rest of the page.

In this case, there is acquaintance with contrast (in colour, or in illuminance, or in brightness and so on), between the maze walls and the page, that visually demarcates the correct route, which in turn enables acquaintance with the shape of the mind-independent region of the page that is that route. That is to say, attention to visual demarcations of extended space (filled in this case with matter reflecting light) is guided by edge detection via eye saccades, and as the correct route edges would not be detectable in the absence of detectable contrast – because, effectively, the page would in that case be blank for the subject – the tracking of the bounds of that contrast *enables* acquaintance with the shape of the correct route, which is the bounds of a region visually demarcated from the rest of the page (Findlay, 1997; Huang and Pashler, 2007, p. 606; Treisman and Gelade, 1980). In other words, sustained attention to the boundaries of the relevant region with little to no appropriately salient edges would be manifestly difficult if not impossible for a *normally* functioning human sensory system. Yet, all else being equal, such sustained attention would not be impossible for all possible functioning human sensory systems.

For example, to repurpose the 'common factor' thought experiment from section 1.1, suppose the specific proximal nervous stimulation that modulates visual tracking of the correct route occurs – either spontaneously or by artificial stimulation – when the subject views another page of the puzzle book, which is blank. Suppose further that the subject does not pay attention to the fact the page containing the maze puzzle flipped over to the blank page, and so the subject remains maximally primed to continue attending to the correct route, in so far as this process is assisted by perceptual memory. Call the subject when viewing the puzzle the 'authentic' perceiver and the subject when viewing the blank page the 'blank' perceiver. In the 'blank' perceiver case, it seems implied, or at least does not seem impossible, that under naïve realism, the blank perceiver would thereby become acquainted with the mind-independent shape of the portion of the blank page that has the same shape as the puzzle solution, where that shape is fixed for the blank perceiver relative to the authentic perceiver's varying viewing distances and angles from the page. Suppose, for simplicity, that the blank perceiver's bodily movements are, like their eye saccades, identical to those of the authentic perceiver. The blank perceiver's minimal and impoverished acquaintance with the correct-route-shaped region would perhaps be, expectedly, less visually pronounced than the comparatively stark visual demarcation of that region through the authentic perceiver's concurrent acquaintance with contrast between the maze and page. Certainly, such a significant diminution of shape acquaintance would be highly atypical and so, in that sense, its plausibility is reasonably suspect. Nonetheless, this hypothesis – of acquaintance with visual demarcations in the absence of acquaintance with *matching* visually-demarcating contrasts – seems to be a possibly permitted by basic capabilities of visual acquaintance[38].

For example, it seems that, via peripheral tracking of contrast between an open blank page of the puzzle book and a dark table on top of which the book is placed, one could thereby visually attend to the specific difference of location between the respective approximate centre points of general upper and lower portions of the uniformly blank page, despite there being no detectable contrast in either region. Indeed, this possibility is deducible from what it is for extension to feature in sensory experience. That is, under naïve realism, if one can experience that the uniform white *region* of the page *extends* from top to bottom, then one must be acquainted with at least some differences of relative location throughout. In this peripheral tracking case, the *narrowing* of one's acquaintance with the page to the respective approximate centres – of the vaguely defined upper and lower regions of the page – is enabled by one's ability to keep track of that page *more generally*. In which case, the subject is acquainted with the vague specificity of spatiotemporal centre regions *despite the absence* of acquaintance with *matching* visually demarcating contrasts. So, evidently the ability for one's visual attention to be guided throughout one's acquaintance with extended space, thereby

[38] That is not necessarily to permit scenarios in which there are *no* visually-demarcating contrasts.

narrowing one's attention to specific spatiotemporal differences, does not require concurrent acquaintance with contrasts matching those differences.

Nonetheless, it could be objected that, in the peripheral tracking case, the vague centre regions are attended to relative to the tracking of the contrast between the page and desk, whereas in the blank perceiver case, visual attention to the correct-route-shaped region of the page is supposed to be attended to relative to the tracking of contrasts with which one is *not* acquainted. In which case, it might seem that the blank perceiver's supposed acquaintance with the correct-route-shaped region is unsupported, all ese being equal, under naïve realism. However, even if the subject is 'mistaken' to be moving their eyes in various highly controlled directions exactly as they would if they were tracking appropriate contrasts, if they are successfully acquainted with the extended space within which those contrasts are supposed to exist, and there is no obvious reason this should not be so, this entails that the 'mistaken' guiding of their visual attention enables them to successfully attend, stably and sustainably, to the correct-route portion of the page, and thus be acquainted with that sub-region of their optical visual field.

Accordingly, then, the blank perceiver thought experiment appropriately demonstrates that neural responses could, in principle, make a significant negative contribution to qualitative character, given basic capabilities of visual acquaintance and the basic tenets of simple naïve realism according to Pautz (2018) surveyed in section 2.1 above: The "primitivism about sensible colors" (Pautz, 2018, p. 2) tenet is consistent with perception of the whiteness of the page, the "general diaphaneity assumption" (Pautz, 2018 p. 2) tenet is consistent with the correct-route-shaped region of the page being mind-independent (albeit modulated exclusively by neural activity), and the "basic causal theory of perceptual acquaintance" (Pautz, 2018, p. 3) tenet is consistent (albeit in a causally abnormal way) with the fact the blank perceiver's sensory system is equivalent to the authentic perceiver's. Indeed, the blank perceiver case demonstrates that, at least in some circumstances, simple naïve realism *is* a joint-determination theory: The correct-route visual demarcation of the white page is reasonably constituted by the *way* in which the white page is perceived, yet the shape demarcated by that way of perceiving is an external region thus constituting external qualitative character[39]. In which case, if the notion of a joint-determination theory is consistent with brain-based theories, then so too is simple naïve realism.

4.2.1.5. 'Paradigmatic' Perception. To explain the consequences of the blank perceiver thought experiment for Pautz's (2018) empirical argument, it is useful to clarify the implicit centrality of 'paradigmatic' perception in his reasoning. In section 4.2.1.1. above, I considered whether perceptions (or *misperceptions*) like afterimages are appropriately relevant to Pautz's empirical argument, which focuses on paradigmatic examples of perception. Precedingly, I defined 'paradigmatic' perceptions as those in

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[39] Perhaps it might be objected that the blank perceiver thought experiment suggests, through utilising the notion of demarcated *regions*, a disputable 'hylomorphic' view of shape perception – as attending to specific *forms* of space rather than *matter* occupying space. However, whilst the blank perceiver's experience of the correct-route region could be usefully *described* in terms of forms of space, ultimately, such a description need only stand as reference to *the limits of* distinct regions of matter instantiating qualitative properties – in this case, spatially distinct patches of white on the page. Nonetheless, that is not necessarily to suggest that, by an inverse principle, one could not attend to extended space *in the absence of* matter instantiating qualitative properties, because it seems manifestly contrary to everyday experience that, for example, perception of deep space could not result in experience of extended 'blackness' if there were no photons impinging upon the retina. However, see Nöe (2004, pp. 172-173) for the view that a supposed acquaintance with a totally uniform presentation of colour would not be a *visual* experience.

which the sensory system is biologically non-defective and the correlated extracorporeal measurements that Pautz (2018) identifies *match* the sensory experience, as inherently *implied* by his requirement of sensory–external congruence. This requirement of sensory–external matching is implied because Pautz requires that sensory experiences be congruent with correlated extracorporeal measurements *without* reference to any other data, nor to a specific standard of measurement. Whereas, the relevant extracorporeal properties would not necessarily have to match associated sensory experience if the identified sensory–external *incongruence* is explanatorily 'offset', as *congruent*, through identification of neural responses concurrently contributing to qualitative character; as exemplified by the blank perceiver case. Yet, as Pautz (2018) does not consider any such explanatorily offsetting data, he is reasonably interpreted as requiring congruence between *only* sensory experience and extracorporeal measurements, therefore requiring sensory–external *matching*.

Additionally, the notion of a *biologically non-defective* sensory system is implied, at least by good faith interpretation, by the fact Pautz (2018) *generalises* about "'normal' (non-illusory, non-hallucinatory) experience" (p. 2) based on particular cases, which would be effectively contradictory if requiring that defective, and so in that sense *atypical*, cases be representative of non-defective, and so in that sense *typical*, cases. That is, at least without further elaboration, all else being equal (indeed, Pautz does not explicate this generalisation[40]. To clarify, although in section 4.2.1.1 above I compared the notion of a 'biologically non-defective' sensory system to 'abnormalities or underperformances' of the sensory system, that contradistinctive use of 'non-defective' need not imply

[40] Apparently, Pautz (2018) does not consider cases of misperception towards his empirical argument against naïve realism because he considers that "what we know about how perception works in normal cases is enough to undermine naïve realism" (p. 5).

‘perfect operation’ because the sensory system need not be assumed generally successful (Dennett, 1991, pp. 467–468; Fish, 2013, p. 62). For example, consider a subject who, being unable to distinguish their keys amongst a mess of silverware, decides to first locate their thick-frame spectacles which are, in fact, sitting on their nose in plain sight, enveloping their field of view. The point, however, is that biological *abnormalities* or *atypical* underperformances of the sensory system, *such as* are each constitutive of the significant vase-shaped afterimage case, would not be, all else being equal, appropriately representative of perception more generally. So, with the centrality of ‘paradigmatic’ perception for Pautz’s (2018) empirical argument now in hand, the consequences of the blank perceiver thought experiment can be swiftly inferred.

4.2.1.6. An Atypically Functioning Sensory System. The blank perceiver case illustrates that it is not necessary under naïve realism, at least not universally, that biologically non-defective perceptual experience *match* saliently correlated extracorporeal measurement. Notably, the surface topology and SRP contrasts of the blank page and desk do not indicate perception of the correct-route shape, which would apparently only be indicated by neural activity and corresponding effects, such as introspective report and eye movement. In which case, Pautz’s (2018) implicit requirement of sensory–external matching is called into question and the notion of neurologically-obscured sensory–external congruence is supported.

However, it could be objected that whilst the blank perceiver sensory system is not biologically abnormal or atypically underperforming (indeed the blank perceiver shares with the *authentic* perceiver a sensory system with matching neural responses), the blank perceiver sensory system is *functionally* abnormal[41]. In particular, the thought

[41] Pautz (2018) specifies that simple naïve realism, to which his empirical argument is explicitly directed, requires that the “’suitable’ internal subpersonal physical state[s]” that bring about

experiment relies upon a genuine process of perceiving, that is then functionally transposed into an abnormal perceptual state wherein shape acquaintance is facilitated in the absence of appropriate contrast acquaintance. From the perspective of that objection, perhaps unless there is empirical indication that such functional transposition is relevant to the perceptual cases on which Pautz (2018) focuses, extrapolation from that abnormal perceptual functioning to the functioning of perception in the cases on which Pautz focuses is unwarranted, at least provisionally.

Yet, the underlying point of Pautz's (2018) empirical argument is to use neurological data to evidence whether neural activity *functions* to enable or generate qualitative character, through his identification of congruence or incongruence between sensory experience and (extracorporeal) physical properties. As detailed in section 1.1 of the present thesis, this question about whether neural activity is enabling or generative has its genesis in either functional process being *theorised*. So, setting aside the relevance of the blank perceiver thought experiment on grounds of *abnormal functioning* of the enabling of acquaintance with physical correlates, despite there being mechanistic precedent, is to inappropriately (from a scientific perspective) assume to know already,

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perceptual connections to "physical objects" be caused by "external state[s]" "in the biologically normal way" (p. 3). In which case it may seem that the blank perceiver case, as an instance of a perception caused in a non-normal way, fails to engage appropriately with Pautz's identification of sensory–external incongruence in the context of his empirical argument against naïve realism. Nonetheless, as it is ambiguous whether the greater observable dependence of the blank perceiver's experience of shape upon neural activity than upon extracorporeal properties is apparently consistent with Pautz's 'negative' claim of brain-based theories, the blank perceiver case is provisionally applicable to Pautz's arguments if brain-based theories can be so applicable.

prior to theorisation, how, under naïve realism, neural activity generally functions to enable acquaintance with physically-instantiated properties and colours in particular. Accordingly, then, Pautz's (2018) implicit requirement of sensory–external matching is at least called into question by the blank perceiver thought experiment because basic capabilities of visual acquaintance permit the qualitative character of sensory experience to be more correlated with neural data than with extracorporeal data. Furthermore, even if neural modulation of shape experience is abnormal, I propose it here as a reasonable possibility from which to analogise neural modulation of normal *colour* experience in the following section, 4.2.2[42].

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[42] In could be objected that the supposed acquaintance with the correct-route region of the page would not constitute a *perception* of shape, because that apparent experience of shape could arguably be imaginative or only a misbelief. However, whilst the claim of a shape experience effectively grounded partly in neural responses is a claim about phenomenology (thus relying on intuitions about what one might experience), it is also a logical claim, deducible, or extendable, from basic capabilities of visual attention (it is sustained attention to, and so acquaintance with, an *existing* physical demarcation) and supported by at least one scientific theory of visual attention. Notably, Huang and Pashler (2007), in their empirical derivations of fundamental mechanisms of visual attention, interpret the sensory system as permitting that in perception "the shape of the selected region … is data available to conscious access by itself" (p. 606). So, whether or not the correct-route region experience is considered perceptual or imaginative, it is reasonably considered to have non-zero external world phenomenology and so, need not be *exhausted* by any misbelief.

4.2.2. Specifying Colour Acquaintance

The blank perceiver case established in section 4.2.1 entails that, under naïve realism, specificity of shape experience can, in principle, be detectable by neural measurement yet, simultaneously, not by any other physical measurement. Using this possibility of shape experience as a template for possibilities of colour experience, in the present section, I speculatively consider how it could be analogously intelligible that, under naïve realism, specificity of colour experience might be likewise detectable only by neural measurement. In which case, it is not necessary, under simple naïve realism, that 'neural duplicate' subjects in the inverted worlds scenario would have differing qualitative characters, thus suggesting sensory–external incongruence may not be identifiable, at least not universally, without considering associated neural measurements.

In the previous section, I argued that the specific geometry of any shape experience is secondary to, as being effectively a negation of, a fundamental acquaintance with extension, more generally, of the 'qualitative manifold' – by which I refer monistically to the totality of instantiated qualitative properties. In other words, the external world is fundamentally extended, and 'shapes' are specific demarcations of that extension. A key property of this top-level–lower-level relationship between extension and shape, respectively, that underpins the ability of the sensory system to, in principle, modulate shape experience, is that *any* extended space can instantiate *any* shape. This key property is an a priori mathematical requirement of what it means for a space to be extended. For example, with respect to two-dimensional space, within any circle there is a square region, and within that square region there is a circle region, and so on *ad infinitum* or until a limit of divisibility – such as the Planck length or a limit of resolvable detail in a subject's optical field of view. In the present section, I use this key property of shape experience as a template for analogous possibilities of colour experience[43].

Accordingly, consider again that the authentic perceiver's experience of the correct-route shape is a narrowing of acquaintance to a specific correct-route shaped region within the extended qualitative manifold. This narrowing of acquaintance is modulated by the processing of contrast information available to their sensory system: Reflectance differences in a particular subset of the subject's field of view – SRP contrast between the puzzle and page. Similarly, as this interpretation of shape perception is consistent with basic tenets of simple naïve realism, so too is an analogous interpretation of colour perception: The specific hue or chromaticity of any colour experience is secondary to, as being effectively a negation of, a more fundamental acquaintance with the extended qualitative manifold. For example, experiencing a patch of red is to narrow acquaintance with that portion of the qualitative manifold to red and the narrowing of acquaintance to red is modulated by the processing of reflectance information in a particular subset of the subject's field of view.

That is to speculate, by the mechanistic precedent of the blank perceiver case, that just as any (resolvable) shape is separable within an extended region, any (resolvable)

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[43] Incidentally, such extrapolation from the metaphysics and mechanisms of shape perception – acquaintances with "primary qualities" (Pautz, 2018, p. 31) – to the metaphysics and mechanisms of colour perception – acquaintances with "secondary qualities" (Pautz, 2018, p. 31) – is outwardly harmonious with Pautz's (2018) expectations because he holds it would "be surprising if the metaphysics of primary quality perception were very different from the metaphysics of secondary quality perception" (p. 31). Pautz apparently qualifies this statement when he says, "if you have experiences as of colors, you must have experience as of extension and location" (Pautz, 2018, p. 34).

colour is separable within that which qualitatively 'fills' an extended region[44]. There are, perhaps at least, two ways to cash out this extrapolation from shape to colour[45]. First, consider that, at least in two dimensions, the only shape a square region can instantiate throughout its full boundary is a square, but that any resolvable shape whatsoever can be instantiated *within* that square. That is, within a *smaller* area therein. So, whilst any shape can be instantiated interior to any other, this can only be so where the interior shape has *less* extension. Analogously, then, the only colour that, say, a red surface, can instantiate, given maximal acquaintance with the reflectance of the relevant surface, is red – but any 'resolvable' colour whatsoever could, in principle, be instantiated *within* that patch of red, as a *smaller* set of reflectances therein, corresponding to any 'interior' colour's SRP. That is, provided, as in the case of afterimagery (recall the yellow within the uniformly white wall), that there is adequate reflectance throughout the visible spectrum such that by negating acquaintance corresponding to reflectance in particular

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[44] This shape–colour extrapolation results in an interpretation of simple naïve realism that is remarkably similar to "super pluralistic naïve realism" (Pautz, 2018, p. 25). However, whereas the latter "exceedingly complex" (Pautz, 2018, p. 27) naïve realism "depart[s] from simple naïve realism in rejecting the basic causal" (Pautz, 2018, p. 26) tenet by requiring, at least according to Pautz (2018, p. 26), that "causal relations are not enough to determine" (p. 26) what a subject perceives, the shape–colour extrapolation view instead explicitly adheres to the basic causal tenet. That is, due to negations of acquaintance with a superposition of colour being analogous to, as a particularly fitting example, negating perceived illumination by aperture changes in the pupil due to processing changes in light data. Incidentally, super pluralistic naïve realism could adhere to the basic causal tenet by taking on the shape–colour extrapolation view that differences of colour are differing negations upon a more fundamental acquaintance.

[45] I am grateful to Bill Fish for resolving, and encouraging me to address, this duality and its relation to the inverted worlds scenario (described below).

areas of the red SRP, any colour's SRP can remain to instead facilitate acquaintance with colour on the surface[46].

So, whilst the surface has a red SRP simpliciter, and so most fundamentally instantiates red, one *can become acquainted with other colours on that surface* through negation of that SRP (which is perhaps not all that unusual given surfaces can appear different colours in everyday experience, despite having a unique colour under controlled lighting). This notion of a negating mechanism of colour acquaintance is useful, at least as an analogy, with respect to the inverted worlds scenario for articulating a plausible mechanism by which the inverted lenses are supposed to work: It is possible for the *red* SRP of the grass on inverted Earth to arrive at the inverted twin's retinas as a *green* SRP if the red SRP is at least partly blocked, or perhaps filtered out; in other words, if the red SRP is negated.

The second way to cash out the extrapolation from shape to colour (such that any resolvable colour is separable within that which qualitatively 'fills' an extended region) is more outlandish: *Specific* shapes and *specific* colours are *aspects* of the qualitative manifold, such that just as the blank perceiver can become attuned to acquaintance with any shape whatsoever on the page of a single 'white' SRP or anywhere else, so too can the blank perceiver become attuned to acquaintance with any colour whatsoever on that

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[46] That is not necessarily to require that the remaining patch of colour, being a smaller set of light than the greater red set of light, would have an SRP generally lower in reflectance than the red SRP (and so less qualitatively 'bright') because, recall from section 3.1 above, the portion of light reflected at each nm for any SRP is practically invariant to intensity of the measuring light beam and so, less light reflected does not necessary equate to a duller colour – though it would potentially equate to a less illuminated colour, dependent upon lighting and optics (MacAdam, 1985, pp. 3–4).

page of a single ‘white’ SRP or anywhere else[47]. Whilst this notion, effectively of all colours being instantiated everywhere as different ‘aspects’ of a qualitative manifold, is exceptionally speculative and so, reasonably dismissed as implausible, at least a priori, there is arguably analogous precedent for openness to the notion. For example, space and time were believed to be separate, yet they have been found to be different aspects of a single manifold, space-time. As another example, if a subject’s sensory system were sensitive only to unique hues, then the notion of binary hues, colours with different ‘aspects’ – such as purple ubiquitously appearing to have a blue aspect and a red aspect – could reasonably be implausible for the subject, given colours are for them separate and not aspects of one another.

Whichever way is selected to cash out the extrapolation from shape to colour, essentially, just as acquaintance with a square region is not a distinct mechanism to acquaintance with a circular region, over and above being effectively differing *negations* (guided by differing neural responses) of acquaintance with extension, I propose the analogous case that acquaintance with say, red, is not a distinct mechanism to acquaintance with say, blue, over and above being effectively differing *negations* (guided by different neural responses), of acquaintance with ‘that’ which quantitatively fills

[47] In other words, the speculation is that all colours are instantiated everywhere at all times as differing ‘aspects’ of a monistic ‘supercolour’ filling extension, analogous to the way extension is effectively a ‘supershape’ of which differing shapes are different ‘aspects’. For example, particular squares and circles are different ‘aspects’ of extended space in the sense of being different negations of that extension (though, of course, differing shapes could be viewed as differing ways of bounding extension). So, the analogy is that particular colours are similarly different ‘aspects’ of that which qualitatively ‘fills’ extended space, a ‘supercolour’, in the sense that particular colours a different negations of that ‘supercolour’.

extension, a qualitative 'superposition of all colour' analogous to extension being a qualitative 'superposition of all shape'.

In that case, it is consistent with simple naïve realism to speculate further that the fact a surface (perhaps even the emission of a single wavelength) appears red rather than blue is not because that surface (or emission) does not instantiate blue or any other colour (under daylight). Rather, simple naïve realists can coherently hold that although isolating red from the qualitative manifold when confronted with 'red' spectral data may have provided a selective advantage in the evolution of the sensory system, had the isolation of blue upon equivalent confrontation with that 'red' spectral data provided that selective advantage, then 'red' spectral data would, generally, appear blue. Consequently, then, in the inverted worlds scenario, because the duplicate subjects are confronted with the same SRPs whilst having identical neural enabling conditions of qualitative character, they are enabled to negate the qualitative manifold in *the same way*, thus becoming acquainted with the same colours[48].

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[48] Perhaps it may seem that this notion of 'specificity' of colour not being fixed to any particular SRP is inconsistent with Pautz's (2018) definition of the primitivism tenet of simple naïve realism; he says, "the colors of objects are grounded in their reflectances: for instance, necessarily, if a thing has a certain reflectance profile, this grounds its being canary yellow" (p. 2). That is to say, when Pautz says that a *certain* SRP grounds canary yellow, he could be reasonably interpreted as requiring that SRPs determine that a *specific* colour is *exclusively* instantiated in a given surface – at least under uniform and continuous daylight. Whereas, under the speculations of the present section, there is no such exclusivity. Instead, specific SRPs ground specific *enabling's* of acquaintance, such that the SRP data has a modulative influence on qualitative character, just as it does in the case of shape, as when shape perception is guided by SRP contrast. Nonetheless, this view is consistent with colour being fully mind-independent instantiations, and thus 'primitive' in the appropriate sense; it is rather *differences* of colour

4.2.2.1. Qualifying the Analogy. Of course, at this point, the extrapolation from shape to colour "remains somewhat under-specified" (Pautz, 2019, p. 29) because whereas the notion that 'any extension is a superposition of all shape' has quasi-empirical support in logical capabilities of visual attention and a priori requirements of geometry, the speculated analogous notion that 'any qualitatively-filled extension is a superposition of all colour' (under daylight), has not yet received any such evidential treatment, being merely templated from the shape case, rather than being derived from empirical indication or indication by ubiquitous introspective report. Indeed, it could be reasonably argued that isolating colour within a superposition of all colours is not obviously a logical capability of visual attention nor an a priori requirement of geometry, and thus the template of shape acquaintance is not, or is only tenuously, applicable to colour acquaintance.

Nonetheless, the general framework of the shape–colour extrapolation – that differences of colour are, like shape, differing negations upon a more fundamental acquaintance – is perhaps supported by the findings of section 3 above. That is to say, although it may not be expected that logical capabilities of visual attention in conjunction with a priori requirements of geometry, in particular, establish a mechanism through with negation of the qualitative manifold might occur with respect to colour, the empirical indications of these capabilities, and associated a priori requirements, have isomorphic analogues (by way of symmetries) in the colour case.

To illustrate this isomorphism, consider again the notion of 'apparitional' sensory appearances developed in sections 1.2.2.2 and 1.2.2.3 and implemented throughout section 4.2.1 to articulate how the correct-route shaped region can feature, under simple

experience that is dependent upon neural activity, upon how colour is negated from the mind-independent qualitative manifold.

naïve realism, in the qualitative character of the blank perceiver's experience despite being only detectable by neural measurement. That is, the specificity of that region is negated from a fundamental acquaintance with a greater extension, the qualitative manifold, and so the *dependence* of that negated appearance on neural activity is a modulative enabling condition, rather than a supervenience base (of the appearance). More simply, shape can be causally determined by neural modulations upon an 'aperture' of acquaintance with the qualitative manifold – for example, the vase-shape afterimage is modulated by *bounds* of the sensory system, the contrast between varying photo sensitives.

This shape aperture-mechanism of reducing acquaintance with the qualitative manifold, thus specifying shape, is indicated first, phenomenologically, given shapes are consciously identifiable within one another because, for example, a triangle is at least vaguely identifiable within a square by narrowing attention to the area enclosed between two adjoining sides of the square. Second, the shape aperture-mechanism is indicated mathematically given the 'shapes within shapes' phenomenon is demonstrable by, for example, negating the area of the square that is not a specific triangular region therein.

Isomorphically, an analogous colour aperture-mechanism can be reasonably indicated first, phenomenologically, given, at least in the case of binary hues, colours are at least vaguely identifiable within one another because, for example, purple is ubiquitously supposed to be qualitatively part red and blue (Pautz, 2006, pp. 208–209). Second, the colour aperture-mechanism can be indicated mathematically given the 'colours within colours' phenomenon is apparently demonstrable by the additive model because, for example, the red and blue SRPs are each derivable by negating from the purple SRP, as reversely exampled by Figure 3. Alternatively, that 'colours within colours' phenomenon could be demonstratable by the averaging model because, for example, the purple SRP is derivable by locating the midpoint between the red and blue SRPs. Although the notion of a midpoint between two values is not universally equivalent to a *negation* of two values, it can be in particular cases. For example, if in Figure 8, the '*M*(R,B)' purple SRP is considered a baseline, with reflectance values towards the red SRP from Figure 2 considered negative relative to *M*(R,B), and with values towards the blue SRP from Figure 2 likewise considered negative relative to *M*(R,B). In other words, in that case, the reflectance axis corresponds to a physical property with units nm, the amount of light reflected, and a logico-mathematical aspect, a baseline of each given binary hue between corresponding unique hues with units relative to the baseline (negating in either direction of the baseline results in the relevant binary hue).

It could be objected that the phenomenological analogy between the shape aperture-mechanism and the colour aperture-mechanism fails because red and blue cannot obviously be isolated from purple in experience as a triangle can within a square. Yet, the latter capability can be amplified in a blank perceiver case by matching the neural responses of an authentic perceiver looking at an appropriate triangle, and so, by analogy, a capability to reduce acquaintance with the red or blue aspect of purple (thus leaving only one of these colours in experience) could perhaps be coherently amplified in a blank perceiver case by matching the neural responses of an authentic perceiver looking at a red or blue SRP. Indeed, that is effectively what the inverted worlds scenario requires if the twins are neural duplicates; perceivers confronted with different SRPs but nonetheless experiencing the same colours due to identical acquaintance enabling neural responses.

4.3. Broadening The Scope of Naïve Realism

Throughout section 4, I have argued from a joint-determination interpretation of simple naïve realism that, whilst qualitative properties supervene upon the external world, the fact a given shape features in sensory experience, rather than some other shape, can in be, in principle, counterfactually dependent upon specific neural responses, yet, simultaneously, not upon any determinable physical pattern impinging upon the sensory system. In which case, specificity of shape experience can be detectable by neural measurement whilst being undetectable by any other physical measurement. Specifically, I argued that the correct-route shape of the puzzle book page could be, in principle, experienced by a blank perceiver – with a duplicate authentic perceiver's neural responses – in the absence of appropriate topology or SRP contrast. Using this possibility of shape experience as a template for possibilities colour experience, I speculated how it could be analogously intelligible that, under naïve realism, specificity of colour experience might be likewise detectable only by neural measurement. For example, it is intelligible, by the analogy of shape experience, that any given colour, say red, could be experienced in the absence of conventionally 'red' SRP data by a blank perceiver endowed with the equivalent neural responses of an authentic perceiver confronted with that 'red' SRP data. That is, if the neural enabling of any given colour acquaintance is not necessarily *fixed* to (though would usually be guided by) a specific associated SRP – as in the case of the neural enabling of any given shape acquaintance, which is apparently not necessarily fixed to (though would usually be guided by) a specific associated pattern of SRP contrast.

This view, that the *specificity* of basic qualitative character – the specific set of shapes and colours a subject experiences – can be detectable by neural measurement whilst being undetectable by any other physical measurement, significantly refines the 'principle of difference' detailed in section 2.1.1 above, which is consistent with simple naïve realism: Differences in qualitative character need not correspond to *empirically detectable* differences in the perceived scene. That is, the possibilities of basic qualitative character developed throughout section 4 demonstrate simple naïve realists can coherently hold that, at least in some circumstances, differences in basic qualitative character (comprised of shapes and colours) can be empirically detectable *only by* differences in neural responses – call this the 'updated principle of difference'. Indeed, it is coherent, given the blank perceiver template, that Pautz (2018) is mistaken to expect that, in the inverted worlds scenario, if the duplicate subjects are neurologically identical, they would have "different colour experiences" under a joint-determination naïve realism due to "a difference in the 'what-is-perceived' factor" (p. 29, n. 19). Instead, in that case, neural equivalency determines *which* qualitative properties feature experientially, as instantiated physically.

Furthermore, the updated principle of difference entails that – if indeed perceptual confrontation with any SRP can result in any colour experience – structures of colour similarities are not *necessarily* dependent upon isomorphic structures of *empirically associated* SRPs[49]. Therefore, simple naïve realism can be *compatible* with colour sensory–external incongruence, thereby providing counterevidence to Pautz's (2018) general claim that naïve realism is undermined by such incongruence. Moreover, the blank perceiver thought experiment, especially when applied to both shape and colour cases (thus accounting for *overall* basic qualitative character) demonstrates a positive answer to the central question raised in section 1.3: 'Under naïve realism, can sensory–external incongruence be rendered "systematic and regular" (Pautz, 2018, p. 15) through consideration of contributions to qualitative character by neural responses?'. In which case there is reason to doubt whether Pautz (2018) is justified in identifying unsystematic–irregular extracorporeal groundings of qualitative character because he does not, at least not to that end, consider any associated neural data. Nonetheless, given the *highly speculative* nature of the blank perceiver thought experiment, particularly

[49] Nonetheless, throughout section 3, I demonstrate that such an isomorphism is identifiable.

when applied as a template for analogous possibilities of colour experience, sensory–external incongruences, as comparatively concrete empirical observations, can be reasonably interpreted as empirical evidence of unsystematic–irregular extracorporeal groundings of qualitative character, at least provisionally.

Yet, despite the highly speculative nature of the blank perceiver thought experiment, its coherence and consistency with basic tenets of naïve realism demonstrate that the logical *scope* of influence neural activity can have on qualitative character is far broader under naïve realism than Pautz (2018) suggests. For example, in section 2.2 above, I argued that if Pautz's (2018) 'positive' claim of brain-based theories – that qualitative experience is "most directly dependent on our subjective *neural response* to external items" (p. 10) – is interpreted as an empirical claim, in accordance with his empirical approach, then naïve realism could be considered a brain-based theory if permitting sensory experience to be more *detectably* correlated – and in that sense more 'directly dependent' observationally – with neural responses than with extracorporeal properties. As this greater detectability is embodied by the blank perceiver cases, then, contra Pautz (2018), simple naïve realism can be considered a brain-based theory, thus collapsing his argument against naïve realism, which is supposed to favour of brain-based views. Nonetheless, as detailed in 2.2.1.1 above, Pautz's positive claim could be reasonably interpreted as a theoretical commitment to internalism, and as detailed in section 4.2.1.2 above, his positive claim could be reasonably interpreted as pertaining to *positive* not (blank perceiver) *negative* contributions to qualitative character. Therefore, the claim that naïve realism is a brain-based theory is only a *potential* significant consequence of the present thesis.

Yet, the empirical consistency between naïve realism and the positive claim of brain-based theories – given blank perceiver experiences are more counterfactually dependent upon specific neural responses than associated specific extracorporeal properties –

reveals that the potential dependence of sensory experience on neural responses is far broader than Pautz (2018) implicitly anticipates by expecting naïve realism to be undermined by sensory–external incongruence without consideration of any associated neural data. In other words, the scope of possible experiences under naïve realism is broader than Pautz implicitly anticipates; sensory experience under naïve realism can, in principle, be highly modulated by neural responses such that neural measurement can be more scientifically illuminating of qualitative character than associated extracorporeal measurement – exemplifying the view that naïve realism and internalism cannot be demarcated empirically[50].

So, although Pautz's (2018) general identification of sensory–external incongruences with unsystematic–regular groundings can be reasonably upheld (except apparently in the colour case), his associated claim that naïve realism thereby conflicts with science is fundamentally undermined by basic tenets of naïve realism being systematically *compatible* with sensory–external incongruence, as evidenced by, at least some, blank perceiver cases being mechanistically explicable. Indeed, given blank perceiver cases demonstrate qualitative character can be more empirically correlated with dependencies upon neural activity than upon extracorporeal properties, and given the quantitative modelling of binary hue (developed in section 3) demonstrates sensory–external incongruences can be rendered congruent by expanding upon the relevant dataset, from a naïve realist perspective, sensory–external incongruence need only demonstrate the following: Rather than standing as satisfactory dead ends of scientific enquiry, identifications of sensory–external incongruence more reasonably stand as elicitations

[50] That is, neural responses *can* be "more than a general 'enabling condition'" (Pautz, 2018, p. 21) of qualitative character, they can be *specifying* enabling conditions thereof that determine *which* set of physically-instantiated qualitative properties feature in sensory experience.

for further empirical and theoretical investigation into structures of correlations between sensory consciousness and *both* neural and extracorporeal measurement.

5. Conclusion

Throughout two central investigations of the present thesis, I demonstrated that, contra Pautz (2018), his identifications of sensory–external incongruence do not entail a conflict between naïve realism and contemporary science.

First, upon investigating Pautz's (2018) identification of *colour* sensory–external incongruence, I demonstrated, through counterevidence, that sensory–external incongruence need only indicate further investigation is required to identify hidden underlying sensory–external *congruence*, thereby validating Epstein's (2022, p. 797) postulation that such counterevidence could be latent. Specifically, I argued that Pautz's (2018) analysis of colour similarities and his collation of relevant data are each critically incomplete due to a neglect of the ubiquitous qualitative unique–binary hue distinction. Accordingly, by expanding upon the relevant dataset and quantitatively modelling the unique–binary hue distinction, I showed that this distinction isomorphically matches a quantitative unique–binary hue distinction evident between corresponding Spectral Reflectance Profiles. Therefore, there is extensive colour sensory–external congruence *underlying* the wider dataset cited in part by Pautz (2018) as evidencing colour sensory–external incongruence. Evidently, then, even if identifications of sensory–external incongruence are undermining of naïve realism as Pautz requires, such identifications need not be accepted without concurrent investigation into potential hidden sensory–external congruence, yet Pautz does not present any such adversarial investigation.

Second, I demonstrated that basic tenets of naïve realism are compatible with sensory–external incongruence. In which case naïve realism is not necessarily in conflict with contemporary science even if any of Pautz's (2018) identifications of sensory–external incongruence hold up to scrutiny. Specifically, I argued that 'blank perceiver cases' demonstrate qualitative character can be, in principle, more empirically correlated with dependencies upon neural activity than upon extracorporeal properties. In other words, under basic tenets of naïve realism, neural measurement can be, in principle, more illuminating of qualitative character than associated extracorporeal measurement. Combining this possibility of naïve realism with the prior finding that sensory–external incongruences can be rendered congruent by expanding upon a relevant dataset, I concluded the following: Identifications of sensory–external incongruence need not be accepted as satisfactory dead ends of scientific enquiry. Indeed, in the absence of any adversarial investigation, identifications of sensory–external incongruence more reasonably stand as elicitations for further empirical and theoretical investigation into structures of correlations between sensory consciousness and *both* neural and extracorporeal measurement.

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Appendix

Contents

A.1. Purpose and Content

In this Appendix I provide encoded mathematical approximations of graphed data from MacAdam (1985) for clear reference and/or exact reproduction if required, with the approximation mathematics and method explained accessibly. The graphed data are explicitly approximated *numerically* to ensure unambiguous reproducibility of thesis results – notably curve sample combination and transformation – enabling both quantitative and – via data visualisation – qualitative analyses. I use this unambiguous, and thereby *objective,* method of analysis in the main text to refine improvements to the *subjective* function comparisons critiqued in main text section 3; the approximations constitute the ‘purple’, ‘blue’, ‘green’, ‘yellow’, ‘orange’ and ‘red’ functions represented in main text Figures 1–7. In sections A.2 and A.3 I respectively explain the mathematics and encoding utilised for the approximations. By extension, in section A.4 I explain the method of approximation; essentially, the original continuous data are sampled and ‘composite Bézier curve’ equations are used to accurately interpolate the remaining data. In section A.5 I provide the approximations.

A.2. Composite Cubic Bézier Curves

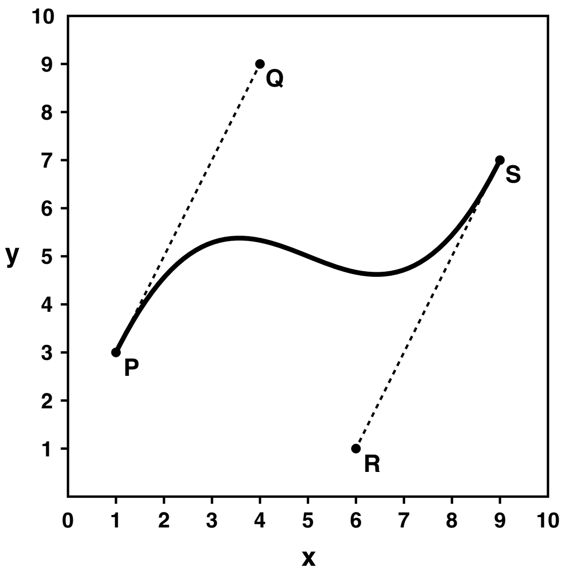
Cubic Bezier curves are defined by four variable Cartesian co-ordinates, the ‘control points’ (Mortenson, 1999, pp. 270–272) – here denoted generally as P, Q, R and S. For example, see Figure A1. The start and end points of the curve are P and S, respectively. Whereas, Q and R are the ‘handles’, the respective positions of which determine curvature of the line, P–S, which is a continuum of decimal or fractional values in a unit-length domain of parameter *t*, denoted mathematically as ‘*t* is greater-than-or-equal-to 0 and less-than-or-equal-to 1’, or ‘$0 \leq t \leq 1$’, see Figure A2 (Mortenson, 1999, pp. 264–267; Adobe Inc. n.d.)[51]. Essentially, the handles determine curve location at every value of *t* via *recursive interpolations* of ‘control lines’ P–Q, Q–R and R–S, where each control line constitutes a linear and uniform continuum of decimal or fractional values beginning with 0 or 0/1 and ending with 1 or 1/1 (Mortenson, 1999, pp. 264–267). That is, located on each control line is the equivalent value of a given *t*; the resulting three points are consecutively joined by two secondary lines; located on each secondary line is the equivalent value of the given *t*; the resulting two points are joined by a tertiary line; located on this tertiary line is the equivalent value of the given *t*; the resulting point is the location of the curve at the given *t* (Mortenson, 1999, pp. 264–267).

To illustrate, consider Figure A3. The following four geometric operations determine where P–S is positioned at $t = 0.3$ or 3/10:

[51] In Figure A2, the continuum is dynamic because cubic Bézier curvature is proportional to the rate at which units in *t* are separated. For example, greater curvature from 0.1–0.4 *t* and 0.6–0.9 *t*, compared with 0.4–0.6 *t*, corresponds to greater unit separation change in the former cases.

Figure A1.

Example control point coordinates



Note: P = (1, 3), Q = (4, 9), R = (6, 1) and S = (9, 7).

Figure A2.

Continuity of t

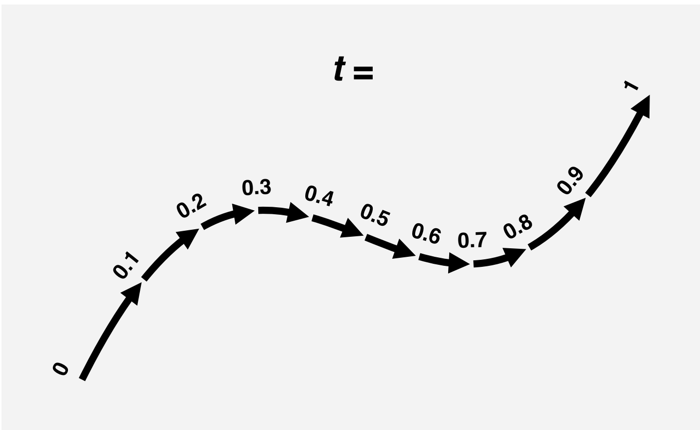
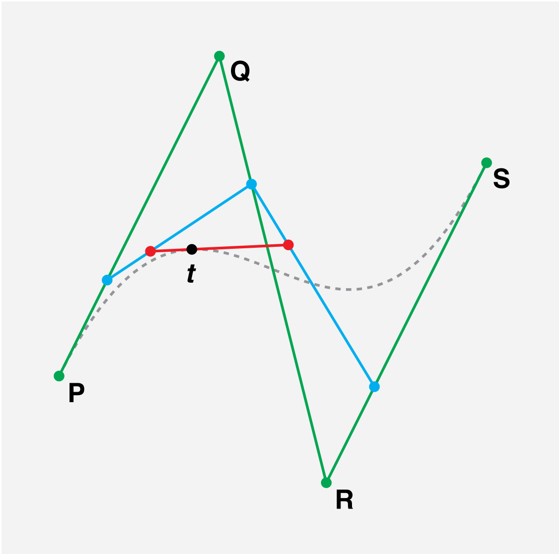


Figure A3.

t = 0.3 or 3/10 geometric construction



1. Marked in green, a line extends from P to Q, a second line extends from Q to R, and a third line extends from R to S.

2. Marked in blue, a line extends from a point 3/10 of P–Q to a point 3/10 of Q–R, a second line extends from that latter point to a point 3/10 of R–S.

3. Marked in red, a line extends from 3/10 of the first blue line to 3/10 of the second blue line.

4. 3/10 of the red line is the position $t = 0.3$ or 3/10.

The above operations can be performed to determine the position of any other value of *t* by replacing '0.3' or '3/10' accordingly (Mortenson, 1999, pp. 264–267).

Algebraically, every point along a given cubic Bezier curve can be graphed on a Cartesian plane by a 'parametric' component function for each axis, fx(t) and fy(t), each taking the same four Cartesian point inputs – i.e. the given unique 'control point' values for P, Q, R and S – where the 'parameter' *t* is any value from 0 to 1; $0 \leq t \leq 1$ (Maekawa & Patrikalakis, 2002, p. 1). In other words, respectively inputting a given value of *t* and the given unique control point values into each of the two component functions conjunctively outputs a set of co-ordinates for that value of t (Maekawa & Patrikalakis, 2002, p. 1). Consequently, the infinite set of all curve points, i.e. the entire curve, is equivalent to the two component functions combined continuously throughout the entire domain of t (Maekawa & Patrikalakis, 2002, p. 1):

$$f(t) = (f_x(t),\ f_y(t)),\ (0 \leq t \leq 1) \tag{A1}$$

where $f_x(t)$ and $f_y(t)$ have the following form (Mortenson, 1999, pp. 267–269):

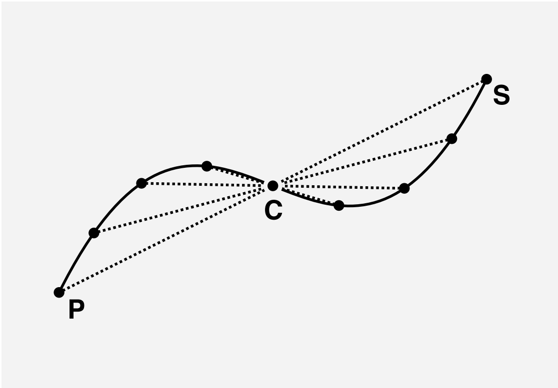
$$\begin{aligned} f_x(t) &= (1-t)^3\ P_x + 3\ t\ (1-t)^2\ Q_x + 3\ t^2\ (1-t)\ R_x + t^3\ S_x \\ f_y(t) &= (1-t)^3\ P_y + 3\ t\ (1-t)^2\ Q_y + 3\ t^2\ (1-t)\ R_y + t^3\ S_y \end{aligned} \tag{A2}$$

To straightforwardly demonstrate this general cubic Bézier function through evaluating its component functions, consider as a test example $t = 0.5$, the corresponding coordinates of which are visually evident in Figure A1 without requiring algebraic treatment given the curve P–S has, in this specific case, ‘point’ symmetry about point ‘(5, 5)’, call this the ‘centre point’, denoted ‘C’ in Figure A4. To illustrate this symmetry, consider the following operations on curve P–S from Figure A1 as exampled in Figure A4.

Locate any point along the curve and extend a line from that point through the centre point. That extended line contacts the curve again on a point inverted from the initial located point with respect to the centre point. For example, where the initial located point is the start point, P, the associated inverted point is the end point, S. Similarly, if the initial located point is halfway along the curve from P to the center point, then the

Figure A4.

Point symmetry of curve P–S



associated inverted point is halfway along the curve from the center point to S[52]. This inverted symmetry holds for every point along the curve, P–S. Consequently, the centre point must have value $t = 0.5$, i.e. half the domain, because the rate at which units in t are decreasingly separated from P to the centre point is inversely equal to the rate at which units in t are increasingly separated from the centre point to S[53]. In other words, the same 'distance' is required, five-tenths of the domain, to transverse from P to the centre point as it does from there to S; as exampled by the dynamic units of t in Figure A2. So, with this known value in hand, the above component functions for each axis, $f_x(t)$ and $f_y(t)$, can be demonstrated; inputting into these respective functions $t = 0.5$ alongside the control point values from Figure A1 should conjunctively output the centre point, '(5, 5)'. Indeed, it does:

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[52] For ease of illustration, 'halfway' is here referring to uniform units dotted along the curve exampled in Figure A4, not to the dynamic decimal values of the parameter, *t*.

[53] Alternatively, this inverse relationship could be visualised via the 'rotational' symmetry about point '(5, 5)'. That is, if the section of the curve from P to '(5, 5)' is rotated 180 degrees in any direction, the result exactly matches the remaining part of the curve, from '(5, 5)' to S.

$$f_x(0.5) = (1-0.5)^3\ 1 + 3\ 0.5\ (1-0.5)^2\ 4 + 3\ 0.5^2\ (1-0.5)\ 6 + 0.5^3\ 9 = 5$$

$$f_y(0.5) = (1-0.5)^3\ 3 + 3\ 0.5\ (1-0.5)^2\ 1 + 3\ 0.5^2\ (1-0.5)\ 9 + 0.5^3\ 7 = 5$$

Manifestly, if one handle is sufficient to specify curvature between P and S, then the redundant handle can be positioned equivalently to the start/end point to which it is most directly associated in the parametric equations – Q to P or R to S – so that the redundant handle and connected start/end point act as one. That is, as opposed to modifying the component functions to each take only three control points. For example, Figure A3 demonstrates that Q contributes to curve location based on the respective positions of blue points '3/10 from P–Q' and '3/10 from Q–R'. Accordingly, if Q is equivalent to P, then blue point '3/10 from P–Q' is likewise equivalent and blue point '3/10 from Q–R' is effectively 3/10 from P–R. In that case, effectively only three sets of co-ordinates determine curvature. For simplicity, this manifest equivalence is embodied in some of the approximations I provide in Appendix section A.5 to accord with the general cubic Bézier function.

Multiple cubic Bézier curve functions can combine to create a piecewise function, a "composite cubic Bézier curve" (Mortenson, 1999, pp. 275–276). Such extension can be straightforwardly achieved by creating a continuous piecewise function whereby curve location is determined by different cubic Bézier curve functions at different points throughout an *extended* domain[54]. To demonstrate, consider composite cubic Bézier

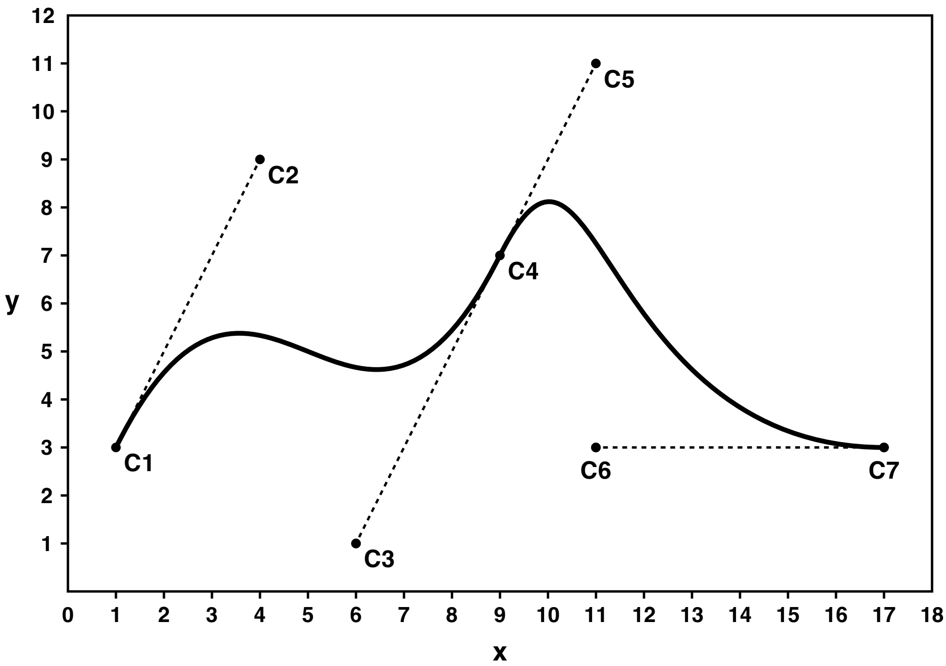
---

[54] There will no doubt be more elegant methods, however, this obvious approach simplifies matters because it primarily requires minor domain changes, rather than, for example, modifications to the more complicated general cubic Bézier curve function. Whatever method is used, combining the functions simplifies reference to the *aggregate* curve and constitutes explicit curve continuity, which is required for accuracy because all the original functions I approximate in Appendix section A.5 are presented continuously.

curve C1–C7 illustrated in Figure A5, which is constituted by two cubic Bézier curves, as demarcated in Figure A6, each extending throughout separately indicated domains of *t* and each with a different set of respective co-ordinate values for the general cubic Bézier curve function variables P, Q, R, and S – as plotted in Figure A5.

Figure A5.

Composite Bézier curve C1–C7

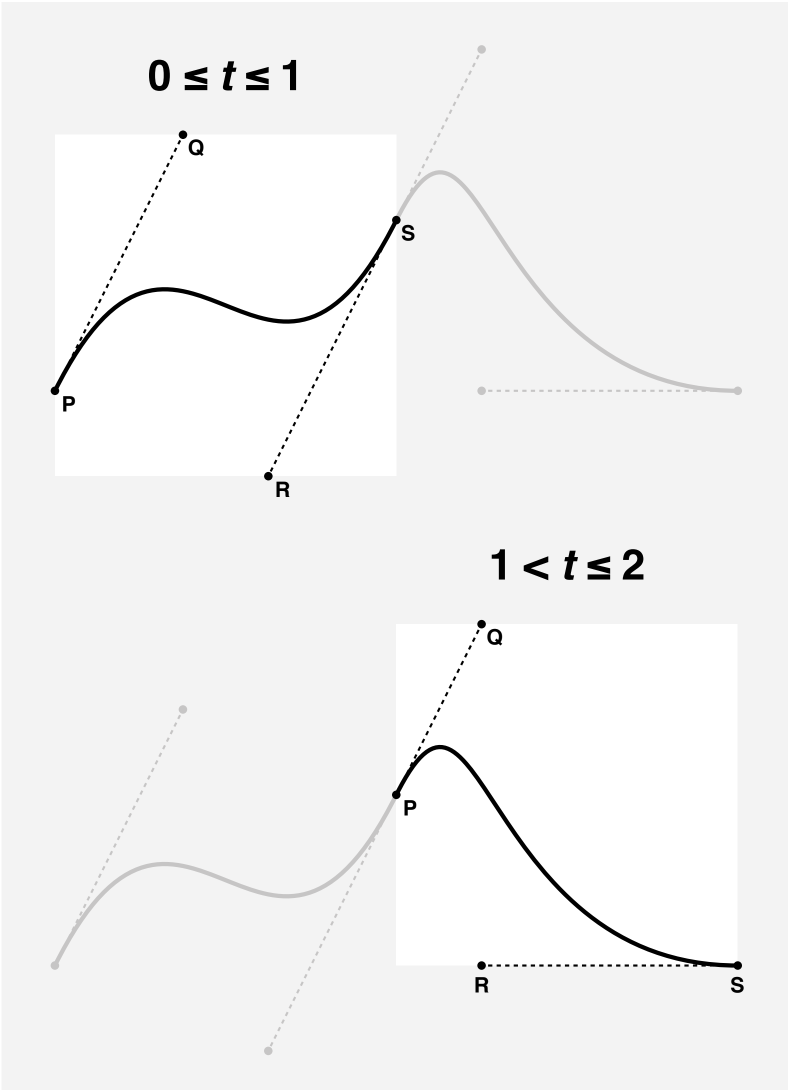


Note: C1 = (1, 3), C2 = (4, 9), C3 = (6, 1), C4 = (9, 7), C5 = (11, 11), C6 = (11, 3) and C7 = (17, 3).

For simplicity, control points C1–C4 match the control point co-ordinates from Figure A1 and extend throughout the same domain; $0 \leq t \leq 1$. Accordingly, the corresponding 'first' portion of the composite cubic Bézier curve, cubic Bézier curve C1–C4, is appropriately constructable by Equations A1 and A2. Given this first portion is thus curve location throughout the entirety of the domain $0 \leq t \leq 1$, yet there is another half of the greater continuous composite cubic Bézier curve to be specified, the overall domain therefore needs to extend by another unit-length interval, becoming $0 \leq t \leq 2$ throughout

Figure A6.

The two cubic Bézier curves that constitute curve C1–C7 from Figure A5



an appropriately amended Equation A1. That is, this extension provisions for the specification of the 'second' portion of the composite cubic Bézier curve, cubic Bézier curve C4–C7, which can specify curve location greater than 1*t*; $1 < t \leq 2$[55]. Consequently,

[55] The focus on C4–C7 specifying curve location *greater* than 1, rather than *equal-to-or-greater-than* 1, is because otherwise, given 1 is already specified by C1–C4, *t* = 1 would have *two* sets

this second cubic Bézier curve is not, in that case, appropriately constructable by Equation A2, which takes values of t from 0–1[56]. To correct for this discrepancy, the interval length, by which the original domain of Equation A1 was extended, one unit, can be negated from each instance of t in an appropriately amended Equation A2, so that $1 < t \leq 2$ effectively becomes $0 < t \leq 1$. That is to say, with respect to the overall composite cubic Bézier curve, the second cubic Bézier curve, C4–C7, specifies curve location throughout $1 < t \leq 2$, though within the corresponding amended Equation A2, values of t are negated by 1 and so the domain is effectively transformed therein to $0 < t \leq 1$.

Adding this amended Equation A2 to the amended Equation A1 – recall the latter's extended domain – constitutes the overall composite cubic Bézier curve function, with corresponding updated parametric component function subscripts: see Equation A3.

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of co-ordinates thereby constituting an overlap of curve location. Whereas, the overall curve needs to be continuous to accurately approximate functions in Appendix section A.5.

[56] Inputting values of t outside of this domain would undermine the appropriate functioning of Equation A2. Although explicating this incompatibility would be unnecessarily expansive for the purposes of this Appendix, the following comparison suffices to demonstrate existence of the problem. Inputting into Equation A2 the control point values C4–C7, then $t = 0$, then $t = 0.5$, then $t = 1$ respectively outputs (9, 7), (11.5, 6.5) and (17, 3), spanning 8 and -4 on the x and y axes, respectively. Whereas, Inputting into Equation A2 the same control point values then $t = 1$, then $t = 1.5$, then $t = 2$ respectively outputs (17, 3), (31.5, 11.5) and (61, 47), spanning 44 and 44 on the x and y axes, respectively. So, changing the domain significantly altered the shape of the resulting curve.

$$\mathrm{f}(t) = \left\{ \begin{array}{l} (\mathrm{f}_{x1}(t),\ \mathrm{f}_{y1}(t)),\ (0 \leq t \leq 1) \\ (\mathrm{f}_{x2}(t),\ \mathrm{f}_{y2}(t)),\ (1 < t \leq 2) \end{array} \right\},\ (0 \leq t \leq 2) \tag{A3}$$

$$\overbrace{\begin{array}{c} \mathrm{f}_{x1}(t) = (1-t)^3\, C1_x + 3\, t\, (1-t)^2\, C2_x + 3\, t^2\, (1-t)\, C3_x + t^3\, C4_x \\ \mathrm{f}_{y1}(t) = (1-t)^3\, C1_y + 3\, t\, (1-t)^2\, C2_y + 3\, t^2\, (1-t)\, C3_y + t^3\, C4_y \\ \mathrm{f}_{x2}(t) = (1-(t-1))^3\, C4_x + 3\,(t-1)\,(1-(t-1))^2\, C5_x + 3\,(t-1)^2\,(1-(t-1))\, C6_x + (t-1)^3\, C7_x \\ \mathrm{f}_{y2}(t) = (1-(t-1))^3\, C4_y + 3\,(t-1)\,(1-(t-1))^2\, C5_y + 3\,(t-1)^2\,(1-(t-1))\, C6_y + (t-1)^3\, C7_y \end{array}}$$

In Equation A3, $\mathrm{f}(t)$ is the overall composite cubic Bézier curve function defined over the domain $0 \leq t \leq 2$. The parametric component function pair $\mathrm{f}_{x1}(t)$ and $\mathrm{f}_{y1}(t)$, which corresponds to cubic Bézier curve C1–C4, determines curve location for $0 \leq t \leq 1$ and is equivalent to Equation A2. Whereas, the component function pair $\mathrm{f}_{x2}(t)$, and $\mathrm{f}_{y2}(t)$, which corresponds to cubic Bézier Curve C4–C7, determines curve location for $1 < t \leq 2$ and each instance of *t* within these functions is negated by 1.

This piecewise $\mathrm{f}(t)$ extension process – of extending the overall domain and negating one less than the value of that extension from instances of the domain parameter within additional parametric component functions – can be iterated for any additional cubic Bézier curve added to the given composite cubic Bézier curve. Following the logic implemented when adding the second cubic Bézier curve, given that, as Mortenson (1999, pp. 264–267) explains, cubic Bézier curves are defined over a unit-length interval of *t*, then tautologically, every such curve added to $\mathrm{f}(t)$ requires extending the overall domain by a unit-length; by 1. In other words, if n is the number of cubic Bézier curves constituting $\mathrm{f}(t)$ at the point at which each new cubic Bézier curve is added, then the domain of $\mathrm{f}(t)$ is defined over '$0 \leq t \leq$ n'. Accordingly, required by extension, added to $\mathrm{f}(t)$ for each additional cubic Bézier curve are corresponding additional parametric component functions $\mathrm{f}_{xn}(t)$, $\mathrm{f}_{yn}(t)$ wherein each instance of *t* is negated by n-1 so that the domain is effectively transformed therein to $0 \leq t \leq 1$ ensuring $\mathrm{f}_{xn}(t)$, $\mathrm{f}_{yn}(t)$ are effectively equivalent to the corresponding general cubic Bézier curve parametric components, Equation A2.

Therefore, this piecewise f(*t*) extension process can constitute any composite cubic Bézier curve, the only variations between such curves being control point co-ordinates and, by deductive extension, the number of corresponding cubic Bézier curves with which to adjust the overall domain and form the additional component functions pairs inherently required[57]. Consequently, control point co-ordinates can serve as economical shorthand for any cubic Bézier curve, and for any composite cubic Bézier curve by extension, assuming knowledge of the general cubic Bézier function and, if required, as in this thesis, an appropriate piecewise extension process.

A.3. Encoding Composite Cubic Bézier Curves

Control point co-ordinates shorthand is utilised by technical computing software/libraries/languages and graphics applications to automatically generate composite cubic Bézier curves from control points; essentially sets of points are interpreted as 'encoded' parametric equations. Such automation is particularly useful for stating approximated functions in this Appendix concisely as possible because the reader is not reasonably expected to laboriously scrutinize masses of corresponding parametric equations, if avoidable, for visual verification etc – particularly as the approximation functions each involve many cubic Bézier functions with high-precision

[57] Composite cubic Bézier curves are entirely constituted, via the approach in this Appendix, by endwise-connected cubic Bézier curves (Mortenson, 1999, pp. 275–276). Therefore, the number of control points for any given composite cubic Bézier curve is 4 for the first cubic Bézier curve and then 3 more for every additional connected cubic Bézier curve.

decimal co-ordinates. By contrast, the full piecewise parametric form is useful for performing explicit mathematical operations on the composite cubic Bézier curves. For example, if the reader wants to combine functions, such as exampled in main text Figure 3, given the approximation functions of this Appendix are each comprised of differently segmented cubic Bézier curves, control points values between any two functions misalign and therefore cannot be summed appropriately in encoded form without further operations to determine additional aligned co-ordinate pairs. Furthermore, it is sensible to perform such operations on the full piecewise parametric function form because, as one salient example, causes of operation error can involve underlying/automated mathematical procedures obscured by utilised technical computing software or graphics applications. So, stating equations explicitly can simplify operation verification. Accordingly, for broad applicability, suitable accessible software through which the approximation functions of this Appendix can be straightforwardly evaluated by the reader need to include both a built-in function to generate composite cubic Bézier curves from control points and the functionality to perform mathematical operations on those control points.

Both criteria are straightforwardly met by the 'Wolfram Mathematica' system (Wolfram Research, Inc., 2025); combined intuitive programming language, 'Wolfram', and technical computing software and computer algebra system, 'Mathematica', centring around an interactive 'Notebook' interface into which encoded approximation functions copied from this Appendix can be pasted and straightforwardly evaluated (displaying the code output). Furthermore, the Wolfram Mathematica system is highly accessible to researchers via a free trial on the developer's website and various institutional licencing options. Therefore, Wolfram Mathematica is the system I have selected through which to encode the approximated functions in Appendix section A.5.

A straightforward Wolfram Language function for generating composite cubic Bézier curves is “BezierCurve[]” wherein placed between the function square brackets are the relevant set of co-ordinate pairs enclosed in braces, as are equivalently enclosed each pair of co-ordinates therein (Wolfram Research, Inc., n.d.). For example, see Figure A7, which illustrates a Wolfram Mathematica Notebook wherein inputted code is evaluated, outputting a visual representation. The “In” *code input* ‘cell’ section of the Figure A7 Notebook contains “exampleCurve”, which is the BézierCurve[] function enclosing the control point co-ordinates from Figure A5. Subsequently, exampleCurve is placed within further Wolfram Language code specifying a visual representation of exampleCurve that matches the graph styling of Figure A5. Accordingly, the subsequent “Out” *code output* ‘cell’ section of Figure A7 effectively contains a graph of the composite cubic Bézier curve constituted by the co-ordinates of exampleCurve, thus matching the Figure A5 graph[58].

In like manner, I provide in Appendix section A.5 below the approximated ‘purple’, ‘blue’, ‘green’, ‘yellow’, ‘orange’ and ‘red’ functions – represented in main text Figures 1–7 – encoded in the Wolfram Language, any of which could be, if required, copied and pasted into a Wolfram Mathematica Notebook with appropriate visualisation code, then evaluated, effectively outputting respective graphs of the approximated functions.

For example, if verification of approximation accuracy is required regarding the approximations provided in the below section, the ‘data aspect ratio’ of the graph output of a given approximation – the proportional relationship between the respective visual scale allocated for the graph x and y axes – could be straightforwardly rendered to match

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[58] To evaluate a Wolfram Mathematica Notebook input to display the output, either select ‘Evaluation > Evaluate Cells’ or simultaneously press ‘Shift + Return’ on macOS or ‘Shift + Enter’ on Windows or Linux.

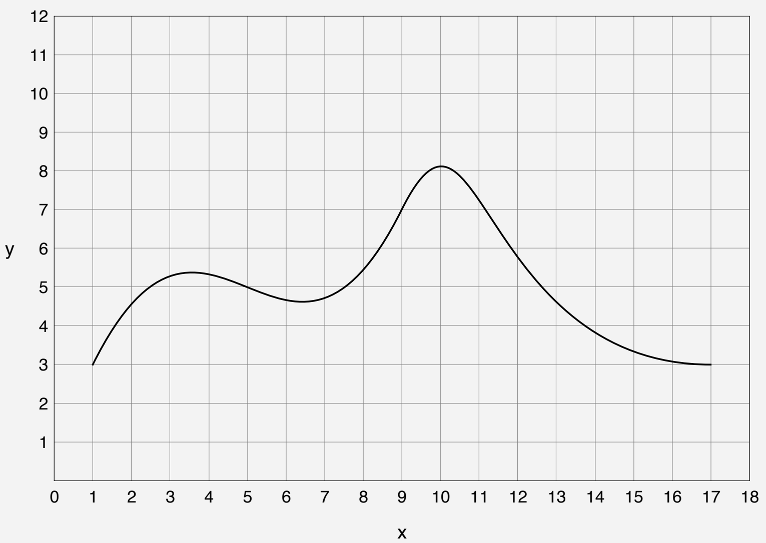
Figure A7.

Example Wolfram Mathematica Notebook evaluation

```
In[•]:= (* Example composite Bézier curve *)
        exampleCurve = BezierCurve[{{1, 3}, {4, 9}, {6, 1}, {9, 7},
            {11, 11}, {11, 3}, {17, 3}}];

        (* Example visual representation *)
        Graphics[
         {exampleCurve},
          PlotRange -> {{0, 18}, {0, 12}},
          AspectRatio -> 2/3,
          Frame -> True,
          FrameLabel -> {"x", "y"},
          RotateLabel -> False,
          FrameTicks -> {{Range[0, 12, 1], None},
            {Range[0, 18, 1], None}},
          FrameTicksStyle -> Directive[FontSize -> 8],
          GridLines -> {Range[0, 18, 1], Range[0, 12, 1]}
         ]
```

Out[•]:=



the approximate mean data aspect ratio of the corresponding graphs as presented in MacAdam (1985). As an example, if creating code functionally similar to that exampled in Figure A7, 'AspectRatio' could be updated to 1/0.775, assuming 'PlotRange' is '{{400, 700}, {0, 1}}' and 'GridLines' is '{Range[400, 700, 50], Range[0, 1, .1]}'. That is, a mean ratio is sensible because the respective data aspect ratio of each graph provided by MacAdam (1985) differ from one another slightly; approximately, the mean ratio is 1/0.775. So, in that case, approximation accuracy can be made straightforwardly discernible through visually comparing each function as represented in the original text to its visualised approximation in this Appendix, given the data aspect ratio would be effectively the same in either case[59]. Furthermore, visually comparing the approximation functions to the source representations in approximately the same data aspect ratio, with equivalent axes assignment, minimises reliance upon subjectivity of comparison by removing visual discrepancies that are effectively not differences between *data*, rather being differences between *representations* of data.

Whereas, within the main text, all figure graphs corresponding to approximated functions encoded in this Appendix are visually represented via the data aspect ratio, '3/2', which has increased visual scale on the y axis, relative to the source y axis mean ratio. I have selected this lengthened ratio to provide adequate room to display dispersed sampling in main text Figure 3 whilst remaining sufficiently similar to the original mean ratio so as to preserve data scale and facilitate consistent data interpretation.

[59] More direct comparison between the original graphed data and the corresponding approximations in this thesis via superimposition of the latter on the former would not be appropriate if legally permissible because the original graphs have some Cartesian intersections that do not involve right-angles, so each original set of gridlines would not line up with the respective corresponding approximation under such a superimposition. The approximation method accounts for this incongruence.

A.4. Approximation

To approximate the graphed data from MacAdam (1985), co-ordinate data samples are digitally estimated from the relevant graphs, constituting cubic Bézier curve start/end control points, between which are specified corresponding handles to interpolate the remaining data by visually matching the resulting cubic Bézier curve and original graph with a degree of accuracy appropriate for viewing the source text, MacAdam (1985), at 100% scale.

Critically, the graph images provided in the digital copy of MacAdam (1985) cited in this thesis are off-axis relative to the rectangular-grid co-ordinate system used (in this appendix) for approximation – which is achieved via mapping the latter on the former – and some of the opposing graph corners are not at right angles to one another, constituting slightly non-rectangular graph grids[60]. Given the commonsensical scientific convention of presenting Cartesian graphs in rectangular form, it would be unnecessarily complex, all else being equal, to assume the corner distortions to be purposeful as opposed to, for example, accidental to the plotting or publishing processes, or similar. Furthermore, because MacAdam (1985) does not mention the distortions nor the method used to transfer the graphs to, or render them within, the pages in which they are presented, there is no implicit information with which to determine the genesis of the corner distortions, and by extension, whether these distortions were considered when plotting the graphs[61]. Appropriately, then, it is parsimonious to accept the graph data

[60] See, for example, the 'typical orange' function from Figure 1.4 in MacAdam (1985). The upper-right graph corner is 'pulled' in slightly towards the upper-left graph corner.

[61] That is not necessarily to suggest information about the plotting or publishing process should be expected from MacAdam (1985).

explicitly as presented in MacAdam, as within a co-ordinate system relative to the non-rectangular shape of each graph, and to accept the graph images as distortions of data graphed rectangularly in accordance with commonsensical scientific convention.

Accordingly, to accurately map the graphs to the sampling co-ordinate system, each graph orientation is corrected, as are the accompanying frame distortions via projective corner transformations, such as to linearly align the underlying co-ordinate system as closely as is reasonable prior to linear sample estimation. ‘Projective corner transformations’ here refers to adjusting the given graph corner positions such that, within the graph, straight lines remain straight to preserve linear relationships between graph points, but parallel lines can converge to offset, and so render parallel, the non-parallel relationship between the original opposing frame sides (Hartley & Zisserman, 2004, pp. 25, 32–36). Given the graph images are here accepted as distortions of data graphed rectangularly, the slight distortions of distances between points that result from projective transformation of the images effectively constitute restorations of original proportional relationships between graph points.

Relatedly, the original graphs from MacAdam (1985) have some *ununiformly* distributed units as opposed to the *uniform* distribution used by the rectangular-grid co-ordinate system used for sampling and so, it is important – in order to substantiate accuracy of approximation – to address that the former does not perfectly map onto the latter. However, the uniformity is minor, being off-by an approximate mean of 0.05 units with an approximate upper bound of 0.07 units. Indeed, the difference is pragmatically negligible – with respect to the visual acuity required given the approximation degree of accuracy specified in this Appendix – because introducing uniformity would undermine accuracy of visual approximation. To illustrate, consider that if the ununiform units were made uniform, this would necessarily introduce kinks in the originally smooth curvature of each function graph as presented by MacAdam (1985). Yet, it would be effectively deceptive, and thereby academically unprofitable, if MacAdam had purposefully made the units slightly ununiform so as to perfectly hide coincidently matching kinks in otherwise smooth curvature without mentioning any such procedure or aim. So, it is parsimonious and charitable to infer no such purpose, nor to posit that the kinks exist in the data but were perfectly obscured unknowingly. Furthermore, the non-uniformity is consistent with, perhaps understandable, minor copy inaccuracies such as the drawing of gridlines slightly off-set from each unit within a uniform distribution. Therefore, the respective axes unit ranges and graph border can reasonably be accepted as the basis of co-ordinate estimation, and from these data uniform distributions of units/gridlines can be reasonably deduced.

Accordingly, to secure appropriate mapping, the graphs are imported into image graphics editor Adobe Photoshop (Adobe, 2025a, Version 26.3) in the density of pixels in in which the relevant graphs are provided in the original text, MacAdam (1985). As required, each graph is respectively reorientated in Adobe Photoshop via the measurement and rotation features, and made rectangular by adjusting the corner positions via the 'distort' feature.

Subsequently, the rectangular graphs are imported into co-ordinate system graphics editor Adobe Illustrator (Adobe, 2025b, Version 26.3) to extract precise co-ordinate estimates via its intuitive 'Pen' tool through which the composite cubic Bezier curves are manually drawn over each graph by click-and-dragging to create 'anchor-point' start/end point samples upon which handles are generated, which by default maintain smooth connections between curve segments (Adobe, n.d.)[62]. The handles are then manually

[62] The transition between cubic Bézier curves connected endwise at a common control point is manifestly smoother the more that point is positioned linearly with respect to the preceding and following control points (Mortenson, 1999, pp. 275–276). Otherwise, the respective directions in

fine-tuned to accurately match the given graph curve by adjusting the distance between each handle and the anchor point to which each handle is most directly connected – as Q is to P and R is to S in Figure A1.

Because the co-ordinate system of Adobe Illustrator has its axes zero-point at top-left as opposed to the mathematical convention – utilised exclusively in this thesis for broad applicability – of bottom-left, each graph image is therefore flipped on its horizonal axis so that co-ordinates are correctly orientated for extraction. Jarringly, each graph in the original text, MacAdam (1985), has a large x-axis range of 400–700 and a small y-axis range of 0–1. If this extreme 1/300 range-axis-ratio-disparity was utilised as the data aspect ratio for extracting exact mapped co-ordinates, curvature would manifestly be rendered too subtle to approximate accurately: each curve being effectively stretched visually flat.

Accordingly, each graph image is instead scaled to the ratio of the grid layout presented in the original graphs, 10/6; so, 10/6 in Adobe Illustrator's default co-ordinate units, 'points', and positioned from the top-left. The resulting scale constitutes a balance between visual and numerical alignment; each graph closely matches its original data aspect ratio to enhance visual approximation, and the gridlines therein align at values – in the graphics editor co-ordination system – that simplify sample scaling, which is necessarily required given the original 1/300 range axis ratio is not used for approximation. The sample scaling is simplified because, although the resulting sampled

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which the curve travels from either side at the limit of the common control point would be different, thereby constituting a kinked transition. For example, see the smooth transition either side of C4 in Figure A5 and note that in Figure A3 the curve initially travels towards Q from start point P and from end point S towards R; analogously C4 is an end and start point with respect to C3 and C5, respectively.

co-ordinates are consequently vastly disparate with respect to the data being approximated, the relevant disparities can be easily corrected for by scaling via integer values: Dividing the y values by 10 and multiplying the x values by 50 and then adding 400 to each resulting x value. That is, the scaled data aspect ratio, 10/6, becomes the original range axis ratio, 1/300, by dividing the former numerator by 10 and multiplying its denominator by 50, and because the x axis is supposed to begin at 400 not 0, 400 is added lastly to all x values.

Such translation is integral for accuracy because the original graphed *data* is to be approximated as opposed to only visually approximating *graphs* of that data. This data/graph distinction is illuminated when considering that the curve comparisons made by Pautz (2018) detailed in main text section 3 manifestly concern relations between the underlying data, not only particular visual representations of that data, and that any potential comparisons between the results of this thesis and further empirical data need not rely upon subjective comparison of visual representations, but can instead employ objective analysis utilising common units.

The sample co-ordinates are extracted in Adobe Illustrator by selecting each anchor point and copying its co-ordinates from the 'Transform' window. Handle co-ordinates are similarly extracted by proxy. That is, 'Guides' are attached to each handle, one vertical and one horizontal, via the 'Smart guides' and 'Snap to Point' features which can together lock-onto a handle position, then an anchor point is placed at the intersection of those guides, and the co-ordinates of the anchor point are extracted[63]. I then use Wolfram code to batch translate the given graph co-ordinates to the correct scale.

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[63] Alternatively, the co-ordinates can be extracted via exporting the Adobe Illustrator document as an 'SVG' file – within which co-ordinate-based curves, such as composite cubic Bézier curves, are encoded as a string of numbers and letters called a '<path>' element – to be opened in a

A.5. MacAdam (1985) Functions

This section provides encoded composite cubic Bézier curves that each approximate respective graphed data from MacAdam (1985).

Listing A.5.1.
Approximation of the “typical green paint” function from Figure 1.1 from MacAdam (1985, p. 4)

```
green = BezierCurve[{{400, 0.12042}, {400, 0.12042}, {416.61,
     0.09926}, {429.055, 0.11222}, {472.085, 0.15703}, {468.955,
     0.34997}, {497.69, 0.37465}, {519.715, 0.39356}, {547.415,
     0.27665}, {564.675, 0.21764}, {573.51, 0.18744}, {606.835,
     0.08095}, {639.045, 0.0582}, {666.975, 0.03847}, {700,
     0.11929}, {700, 0.11929}}];
```

Listing A.5.2.
Approximation of the “typical blue material” function from Figure 1.2 from MacAdam (1985, p. 6)

text editor from which to copy the co-ordinates encoded therein for transformation to standard co-ordinate form (Mozilla, 2025). However, utilizing this method would introduce unnecessary complexity into this Appendix because different relevant SVG <path> letters effectively constitute different kinds of co-ordinate placeholders each of which essentially require unique decoding to return the overall set of co-ordinates to standard form (Mozilla, 2025).

```
blue = BezierCurve[{{400, 0.47264}, {400, 0.47264}, {409.885,
     0.46015}, {416.2, 0.45668}, {450.315, 0.4379}, {455.355,
     0.66265}, {502.53, 0.49809}, {551.835, 0.32609}, {558.68,
     0.21246}, {640.76, 0.21246}, {677.73, 0.21246}, {700,
     0.26436}, {700, 0.26436}}];
```

Listing A.5.3.
Approximation of the “typical yellow material” function from Figure 1.3 from MacAdam (1985, p. 6)

```
yellow = BezierCurve[{{400, 0.07375}, {431.8, 0.07656}, {448.565,
     0.07922}, {464.615, 0.08603}, {483.89, 0.09421}, {499.105,
     0.12734}, {507.835, 0.23926}, {509.5, 0.2607}, {515.18,
     0.32466}, {519.82, 0.43676}, {523.64, 0.52918}, {533.53,
     0.67716}, {547.65, 0.7215}, {559.805, 0.75967}, {580.095,
     0.78294}, {608.14, 0.80603}, {627.745, 0.82217}, {677.77,
     0.85237}, {700, 0.87128}}];
```

Listing A.5.4.
Approximation of the “typical orange material” function from Figure 1.4 from MacAdam (1985, p. 6)

```
orange = BezierCurve[{{400, 0.0356}, {411.39, 0.0353}, {433.93,
     0.03653}, {448.635, 0.03408}, {463.34, 0.03163}, {511.45,
     0.03193}, {525.33, 0.05}, {539.21, 0.06806}, {547.765,
     0.1084}, {559.085, 0.25422}, {561.955, 0.29113}, {578.045,
```

```
     0.56094}, {581.32, 0.5999}, {585.82, 0.65341}, {592.495,
     0.75383}, {619.08, 0.79371}, {643.67, 0.8306}, {686.15,
     0.85693}, {700, 0.86451}}];
```

Listing A.5.5.
Approximation of the “typical red material” function from Figure 1.5 from MacAdam (1985, p. 7)

```
red = BezierCurve[{{400, 0.06284}, {432.9, 0.06038}, {454.715,
     0.04902}, {464.505, 0.04785}, {477.34, 0.04633}, {548.105,
     0.04399}, {569.685, 0.05787}, {574.9, 0.06123}, {580.81,
     0.06307}, {585.425, 0.09887}, {592.195, 0.1514}, {597.29,
     0.23396}, {603.105, 0.32489}, {609.11, 0.41885}, {615.37,
     0.55566}, {626.31, 0.6208}, {627.8, 0.62967}, {635.73,
     0.6823}, {649.04, 0.70433}, {663.76, 0.72868}, {688.105,
     0.75193}, {700, 0.76218}}];
```

Listing A.5.6.
Approximation of the “typical purple material” function from Figure 1.6 from MacAdam (1985, p. 7)

```
purple = BezierCurve[{{400, 0.56422}, {400, 0.56422}, {413.99,
     0.58835}, {424.655, 0.60984}, {444.4, 0.64969}, {469.63,
     0.72991}, {498.515, 0.5284}, {521.03, 0.37134}, {552.845,
     0.34932}, {557.58, 0.34922}, {568.615, 0.34899}, {577.66,
     0.37265}, {581.855, 0.40066}, {590.36, 0.45742}, {599.775,
```

```
0.58618}, {604.7, 0.63393}, {609.325, 0.67848}, {620.365,
0.76544}, {638.33, 0.79667}, {665.92, 0.84463}, {700,
0.88447}, {700, 0.88447}}];
```