REQUEST FOR PROPOSAL

Issued By

COUNTY OF PEORIA
PURCHASING DIVISION

PEORIA COUNTY COURTHOUSE

324 MAIN ST * ROOM 501
PEORIA, ILLINOIS 61602
PHONE (309) 672-6931 * FAX (309) 495-4608

Sealed bids will be received at the Purchasing Office,
Peoria County Courthouse, Peoria, Illinois until
April 22, 2022, at 2:00 PM
for the goods or services described herein.

PEORIA COUNTY TRANSPORTATION EQUITY STUDY
RFP #33-01-22

Company Name Nerevu Group, LLC

County of Peoria Signature Sheet

EXECUTION OF THIS FORM CERTIFIES UNDERSTANDING AND COMPLIANCE WITH THE TOTAL BID PACKAGE.

THIS FORM SHALL BE COMPLETED FOR THIS BID TO BE EVALUATED.

Please print or type:

THIS BID SUBMITTED BY:

Company Name:	Nerevu Group, LLC
Authorized Agent Name & Title:	Reuben Cummings, President
Contact Person:	Reuben Cummings
Company Address:	820 SW Adams St. Suite C
City, State Zip Code	Peoria, IL 61602
Daytime Telephone:	234-738-2266
Daytime Fax:	
Daytime E-Mail (if available):	rcummings@nerevu.com
EEO Certificate of Compliance Num.:	03726-230630

Addenda Received: Resumes Studies Policies Capabilities

Attach statement that firm has sexual harassment and drug-free workplace policies in place.

Attach statement of ability to meet the specified requirements of this invitation to bid.

X _____ _____

Signature of Authorized Agent Date

Peoria County reserves the right to reject any and all bids, to wave technicalities and select the equipment/services best suited to the county.

DO NOT FAX OR EMAIL YOUR BIDS

NON-COLLUSION AND CERTIFICATION OF ELIGIBILITY
AFFIDAVIT OF PRIME BIDDER

State of Illinois)

County of Peoria) SS

Reuben Cummings, being first duly sworn, deposes and says that:

(1) He/she is President of Nerevu Group, LLC, the Bidder that has submitted the attached bid;

(2) He/she is fully informed respecting the preparation and contents of the attached bid and of all pertinent circumstances respecting such bid;

(3) Such bid is genuine and is not a collusive or sham bid;

(4) Neither the said Bidder nor any of its officers, partners, owners, agents, representatives, employees or parties in interest, including this affiant, has in any way colluded, conspired, connived or agreed, directly or indirectly with any other Bidder, firm or person to submit a collusive or sham bid in connection with the contract for which the attached bid has been submitted or to refrain from bidding in connection with such contract, or has in any manner, directly or indirectly, sought by agreement or collusion or communication or conference with any other Bidder, firm or person to fix the price or prices in the attached bid or of any other Bidder, or to fix any overhead, profit or cost element of the bid price or the bid price of any other Bidder, or to secure through any collusion, conspiracy, connivance or unlawful agreement any advantage against the County of Peoria of any person interested in the proposed contract; and

(5) The price or prices quoted in the attached bid are fair and proper and are not tainted by any collusion, conspiracy, connivance or unlawful agreement on the part of the Bidder or any of its agents, representatives, owners, employees, or parties in interest, including this affiant.

(6) That the Prime Bidder is not barred from contracting with any unit of State or local government as a result of a violation of either 720 ILCS 5/33E-3 (Bid Rigging) or 720 ILCS 5/33E-4 (Bid Rotating).

Signed X

President

(Title)

County of Peoria

References

The bidder must list **three (3)** references, listing firm name, address, telephone number and contact person to whom they have provided similar services, material or equipment for a period of not less than **not less than one (1) year**.

The bidder verifies that they have provided equipment or supplies to that contained in this contract to the following parties with needs similar to that of County of Peoria and authorizes the County to verify references of business and credit at its option.

In addition, please detail the following information:

- ✓ Length of account tenure

Company Name:	Greater Peoria Economic Development Council (GPEDC)
Address:	401 NE Jefferson St
City, State, Zip	Peoria, IL 61603
Contact Person:	Chris Setti
Telephone Number:	(309) 495-5910
Email:	csetti@greaterpeoriaedc.org
	Work completed by Reuben Cummings of Nerevu Group in May 2020

Company Name:	Illinois Department of Innovation & Technology
Address:	201 W. Adams St.
City, State, Zip	Springfield, IL 62701
Contact Person:	Reginald Lampkin
Telephone Number:	(312) 814-4603
Email:	reginald.lampkin.illinois.gov
	Work completed by Craig Williams of CW Financial & Management Group in June 2021

Company Name:	Peoria City County Health Department
Address:	2116 N. Sheridan Rd.
City, State, Zip	Peoria, Illinois 61604
Contact Person:	Monica Hendrikson
Telephone Number:	(309) 679-6100
Email:	mhendrickson@peoriacounty.org
	Work completed by Dr. Sarah Donohue of UICOMP in August 2021

Nerevu Group, LLC X _____ President _____

Company Name Signature Title

Signature of Bidder authorized the County of Peoria to verify business references.

RFP Response
PEORIA COUNTY TRANSPORTATION EQUITY STUDY
RFP #33-01-22

Peoria County Courthouse
Purchasing Office
324 Main Street, Room 501
Peoria, IL 61602

Due: Apr 22, 2022

Reuben Cummings, President
Nerevu Group, LLC
820 SW. Adams St. Suite C
Peoria, IL 61602

(234) 738-2266
rcummings@nerevu.com

Table of Contents

1. Introduction (transmittal letter)

Nerevu Group, LLC, along with CW Financial & Management Group LLC (“CWFMG”) and The Minority Business Development Center (MBDC) as subcontractors, are pleased to submit this Response to the Transportation Equity Study RFP (#33-01-22). This group will be referred to as Team Nerevu for the remainder of this Response.

a. Work to be performed

The aim of this study is to evaluate the, “interrelation between the mode, reliability, and affordability of transportation in accessing services” for residents of the 61605 zip code in Peoria, Illinois. Results from this study will be used to advise policymakers on allocating resources to improve transportation equity as they relate to economy, livability, and mobility.

This RFP is timely in that it is released less than a month after CityLink has implemented phase one improvements of its 2019 on the Move Study which reviewed “current routes, schedules, and ridership.” [1] These improvements impacted a substantial portion of the south side bus routes including 5, 7, 11, 13, and 15.

We foresee one goal of the Transportation Equity Study being to evaluate the effectiveness of these CityLink route improvements in 61605.

b. State licensing requirements confirmation

Nerevu Group is an Illinois Procurement Gateway (IPG) registered and Central Management Services (CMS) BEP Certified firm.

c. Substandard work confirmation

Team Nerevu confirms that no staff to be assigned to the project has had a record of substandard work within the last five years.

d. Unethical practice confirmation

Team Nerevu confirms that no staff to be assigned to the project has engaged in any unethical practices within the last five years.

e. Contract responsibility confirmation

Nerevu Group acknowledges that, if awarded the contract, we take complete responsibility for the entire contract, including payment of any and all charges resulting from the contract.

[1] https://www.ridecitylink.org/about/citylink-on-the-move

f. Additional information

Nerevu Group's founder, Reuben Cummings, was raised in Peoria's south side where he attended Roosevelt Magnet School and Manual High School. Current connections to 61605 include his mother, aunt, mother-in-law, and grandmother-in-law who all still reside there.

Reuben is also extensively familiar with Peoria's transportation system. He began riding the bus as a teenager and continues to use CityLink to commute to and from work in the Warehouse District. He has also frequently taken the Peoria Charter Coach to and from Chicago O'Hare.

Reuben also participated in the 2019 CityLink on the Move analysis by attending town halls, providing feedback, and speaking with CityLink and Nelson\Nygaard staff.

MBDC founder Denise Moore served two terms (2013 - 2021) as the first African American woman elected to the Peoria City Council. She represented Peoria's First District which includes 61605. Denise Moore still resides in 61605 as does the MBDC.

2. Background and Experience

a. Respondent's firm

Firm	Nerevu Group, LLC
Date of establishment	01/08/2019
Type of entity	Illinois incorporated LLC
Point of contact	Reuben Cummings, President
Address	820 SW Adams St., Suite C; Peoria, IL 61602
Phone number	+1 (234) 738-2266
Email address	rcummings@nerevu.com
DUNS number	079909596
CAGE code	7GUB9
IPG Vendor Registration Number	IPG-0476196
CMS Vendor Number	20592922

Small business status	Central Management Services (CMS) verified Minority Business Enterprise (MBE) Small Business Set-Aside Program (SBSP) Registered
NIGP Codes	20854 Microcomputer Software, Internet & Web Site Software 91812 Analytical Predictive Studies and Surveys Consulting 91821 Business Consulting 91829 Computer Software Consulting 91832 Consulting Services 91870 Inventory Consulting 91871 IT Consulting
Business expertise	Nerevu offers a portfolio of services that help organizations uncover the insights hidden in their real-time data. With a focus on the health care and life science industries, our key capabilities include: • Data Warehouse Development • Dashboard Design & Development • Predictive Analytics & Alerting Systems • API Development & Integration • Robotic Process Automation (RPA) • Enterprise Resource Planning (ERP) Data Integration • Electronic Health Record (EHR/EMR) Data Integration • Web Application Development • Key Performance Indicator (KPI) Consulting
Short history	Founded in 2014, Nerevu Group, LLC {nay-RAY-voo} is a data analytics firm owned and operated by Reuben Cummings. Mr. Cummings holds a Bachelor of Science Degree (SB) from the Massachusetts Institute of Technology (MIT) with a Major in Chemical Engineering and a Minor in Biomedical Engineering (BME).
Current ownership structure	100% owned by Reuben Cummings

b. Prior engagements

GPEDC

Agency	Greater Peoria Economic Development Council (GPEDC)
Website	https://greaterpeoriaedc.org/
Contact	Chris Setti, CEO
Date Completed	May 2020

Services Provided	Created a system to fetch employment, labor-force, education, industry, and demographic data for 5 counties comprising the Greater Peoria Region from the U.S. Census and Bureau of Labor Statistics APIs Transformed data and loaded it into Google Sheets so that it could be easily visualized

DoIT

Agency	Illinois Department of Innovation & Technology (DoIT)
Website	https://www2.illinois.gov/sites/doit/Pages/default.aspx
Contact	Reginald Lampkin, Procurement Manager
Date Completed	June 2021
Services Provided	CWFMG recently completed a contract with the DoIT for Business Consulting services. The contract required CWFMG to review DoIT's procurement methods and contracts to make recommendations for the Department to become more diverse in its contracting. As you are aware, many of DoIT's commodity codes fall under a sheltered market due to a lack of diverse contracting in the past. In addition, the State recently expanded its BEP aspirational goals from 20% to 30% beginning on January 1, 2022. CWFMG identified several findings and provided written recommendations that would allow DoIT to become more inclusionary in its contracting.

The Healthcare Collaborative

Agency	Peoria City County Health Department
Website	https://www.pcchd.org/201/Community-Health-Assessment-Plan
Contact	Monica Hendrikson, Public Health Administrator
Date Completed	August 2021
Services Provided	Team Nerevu member Dr. Donohue conducted a series of focus groups of residents living in 61603, 61604, and 61605 in collaboration with local community-based organizations. The topics included colon cancer, cervical cancer, mental health, and healthcare in general. She performed qualitative data analysis, presented results in an executive summary, and visually (graphically) presented to the Healthcare Collaborative and the Peoria City/County Health Department. These results will also be used as part of the Community Health Needs

	Assessment for 2022 for which other collaborators conducted additional focus groups on mental health in Tazewell and Woodford counties.

c. Uniquely relevant issues

In 2019, for her leadership on the Peoria City Council, Denise Moore received the “Outstanding Commitment as an Elected Official” award from the State of Illinois Treasurers’ office, the “Deborah Sawyer Award” in recognition of her work advancing women in small business development from the Illinois Black Chamber of Commerce, and the “Small Business Advocate of the Year” award from the Turner Center for Entrepreneurship.

Denise also oversees WPNV-LP 106.3 FM, Peoria's only African American owned community radio station. This affiliation will help immensely to spread the word about this study and related community events.

CWFMG completed outreach and engagement for the State of Illinois' Department of Innovation & Technology (DoIT) in 2021. The contract was intended to encourage minority owned firms to become certified under the State's Business Enterprise Program. In addition, the contract was to assist BEP firms already certified with becoming more procurement ready. Many of the outreach services performed during this contract directly translates into the work required for this project.

Designing a research study which includes both quantitative and qualitative data is a challenging task that requires extensive experience. Dr. Donohue brings over 20 years of such experience to this project which ensures this study will be built on a sound methodology and produce good quality data.

d. Relevant specialized knowledge

Team Nerevu member Alex Ferns conducted a number of reviews of the Palm Beach County Transit “Palm Tran” on their compliance with Code of Federal Regulations (CFR) 49 CFR part 21 (Effectuation of Title VI of the Civil Rights Act of 1964)[2] for the Florida Department of Transportation (FDOT). Alex was also a principal member of the team that conducted the Palm Tran's Service Fare Equity Analysis in 2018 to determine if their Route Performance Maximization (RPM) Program's bus network changes resulted in disproportionate adverse impacts to low income or minority populations.

In the focus groups Dr. Donohue conducted for the Healthcare Collaborative, health equity was examined from many different angles. Individuals living in Peoria's vulnerable zip codes of 61603, 61604, and 61605 were asked their opinions on health and healthcare, and transportation came up in almost every group.

[2] https://www.ecfr.gov/current/title-49/subtitle-A/part-21

Additionally, Dr. Donohue is currently a co-principal investigator on a Community Health Advocacy grant to assess the efficacy of providing free transportation to a primary care practice for low-income patients in the South Side of Chicago. As part of this study, Dr. Donohue has looked at access to services as a function of transportation.

3. Personnel/Professional Qualifications

a. Assigned staff members

Person Name	Position Name	Responsibilities
Alexander Ferns	Quality Control Researcher	- Conduct process design and improvement of the project plan - Ensure work hours are dedicated to the project plan - Review final products to ensure they are free of errors
Craig Williams	Senior Outreach Consultant	- Coordinate telephone survey outreach - Assist with study write-up
Denise Moore	Senior Outreach Consultant	- Follow up on door-to-door survey outreach - Coordinate town hall meetings & workshops
Dr. Sarah Donohue	Research Subject Matter Expert	- Provide consultation on disparities research and evaluation practices from a culturally responsive equity lens - Oversee mixed-methods studies using community engaged approaches that address structural and systemic inequalities
Reuben Cummings	Senior Researcher	- Maintain project database of participants, organizations, and survey responses - Perform administrative analysis, qualitative research, and methodological development
Reuben Cummings	Project Manager	- Plan and manage the project to ensure timely completion in the most efficient manner - Plan and designate project resources, prepare budgets, monitor progress, and keep stakeholders informed the entire way
Reuben Cummings	Senior Data Analyst	- Provide expertises in quantitative analytics, data modeling, and parsing/cleansing data sources

b. Resumes

See Addendum

4. Approach

a. Unique approach

Nerevu will approach this study in an evidence-based manner divided into four phases:

1. Planning
2. Research
3. Implementation
4. Analysis

Planning

The Planning Phase will begin with a kick-off meeting between our team and the project's program officer (PO). We will use this meeting to understand the objectives and primary questions this study will need to answer. We will also determine what additional information (anecdotal data, records, artifacts, etc.) exists and can be made available to us.

Next we will determine the milestones, deliverables, timelines, and meeting schedules. We will also map out the key stakeholders, community leaders, and organizations we will need to reach out to in order to ensure the best possible outcome for this project.

Finally, we will solidify the necessary data collection tools, methods, and evaluation metrics.

Both Denise Moore and Dr. Donohue have worked with community based organizations (CBO), churches, and health departments to conduct focus groups, town halls, and gather community input on various matters.

Research

The Research Phase will consist of reviewing existing literature, data sources, and other relevant information.

Currently, we've identified the following data sources and literature:

- National Equity Atlas[3]
- U.S. Census Commuting Characteristics[4]
- 2011 Feasibility Report of Proposed Amtrak Service, Chicago to Peoria
- 2016 Effectiveness Evaluation of a Modified Right-Turn Lane Design at Intersections
- 2017 BikeConnect HOI – Heart of Illinois Regional Bicycle Plan
- 2019 CityLink on the Move: Existing Conditions Report
- 2019 CityLink on the Move: Final Report
- 2019 Tri-County Emerging Mobility Strategy

[3] https://nationalequityatlas.org/indicators
[4] https://data.census.gov/cedsci/table?q=S0801

- 2020 Long-Range Transportation Plan
- 2021 JCRJE-Transportation-and-Mobility-Subcommittee-Minutes-11-01-2021
- 2021 Transportation Improvement Program
- 2021 PPUATS Public Participation Plan
- 2021 Annual Listing of Federally Authorized Transportation Projects
- 2021 PPUATS Unified Planning Work Program

Additionally, we wish to gain access to the following data sources:

- Crash and traffic data by intersection
- Source data from the 2019 CityLink on the Move study
- All residential addresses and phone numbers in 61605

Implementation

During the Implementation Phase, we will perform community outreach and commence collection of both qualitative and quantitative data. The qualitative data will consist of codes and themes extracted from interviews with 61605 residents. The quantitative data will consist of survey results. For these tasks we will apply the following methodologies:

- Focus groups/Town halls
- Surveys/questionnaires (in-person, phone, mail, and online)

The purpose of the interviews will be to explore the general feelings 61605 residents have about transportation. We will treat these interviews as a “pre study” and use the results to design a questionnaire. We will then administer the questionnaire by surveying a representative sample of the population. This research design is known as “exploratory sequential mixed methods”.

This approach will ensure that we capture both statistical information and the views, opinions, and beliefs of 61605 residents. We will perform rigorous quality assurance to ensure that the data we collect are accurate and complete.

Analysis

In the Analysis Phase, we will categorize, clean, and standardize the sourced and collected data. We will then analyze the data using various methods and compile our results into a report of our findings and recommendations. The analytical methods we plan to employ include the following:

- Qualitative Content Analysis
- Thematic Analysis
- Discourse Analysis
- Econometric Analysis
- Geographic Mapping

Additionally, we will anonymize the collected data and make it available to the community, stakeholders, legislatures, and general public by loading it into an open data portal.

In order to perform the above analysis, we will utilize the following software:

Software Name	Software Use
Smart Routes[5]	Outreach route optimization
Airtable[6]	Study database
Python[7]	Quantitative analysis
CKAN[8]	Open data portal
Squarespace[9]	Study website
QGIS[10]	Geographic mapping
Taguette[11]	Qualitative analysis

Finally, we will hold a series of community workshops to identify solutions to the problems uncovered in the report.

b. Innovative concepts

While the RFP states a desire to deploy a survey, “to every occupied dwelling in the 61605-zip code”, we recommend a different approach. Our recommendation is to instead survey a random sample of the residents. To improve response rates we will provide interviewer training; offer the respondents monetary incentives; and follow-up with non-respondents via reminder mailings, phone calls, and in-home visits. These actions will ultimately result in a more accurate representation of 61605 public opinion.[12, 13]

c. Scope of Services

Task	Experience
Aggregate existing studies	Nerevu has extensive data collection and organization experience and has already identified almost 40 relevant resources (websites, data, papers, and reports).

[5] https://smartroutes.io
[6] https://airtable.com
[7] https://www.python.org
[8] https://ckan.org
[9] https://www.squarespace.com
[10] https://www.qgis.org/en/site
[11] https://www.taguette.org
[12] https://www.pewresearch.org/methods/2017/05/12/methods-101-video-random-sampling
[13] https://www.aapor.org/Standards-Ethics/Best-Practices.aspx

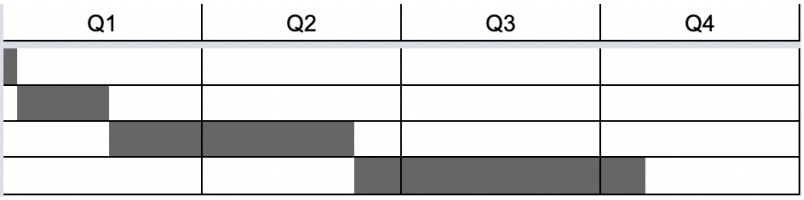
	Additionally, through her connection to University of Illinois Chicago (UIC), Dr. Donohue has the ability to access and assess current literature on transportation equity studies to see what has been done that is successful and where the gaps in knowledge are.
Create a summary document	Creating summaries and disseminating work is standard practice for research, and Dr. Donohue will be able to use her experience to ensure that the goals of the dissemination are met.
Advising policymakers	Dr. Donohue has experience presenting work to people from a wide variety of backgrounds, including politicians. For example, she presented some of her work on addiction in Germany to several German government officials. Having served on Peoria City Council for 8 years, Denise Moore has extensive experience on the best methods for advising local and state government officials.
Analyze data	Nerevu has extensive data analysis experience and has performed relevant work for GPEDC, ICC, and OSF.
Create a data portal / repository	Reuben co-organized the Peoria Civic Hackathon in 2019 and created an open data portal to house COVID-19 data.
Seek community input / outreach	Suggested 61605 organizations to add include: - Urban League - Market 309 - Carver Center
Incentivize interviewers and survey respondents	Through the Community Health Advocacy grant work, Dr. Donohue is developing a survey on transportation. She has extensive experience working with survey data, and will advise on practices to maximize response rates.
Hold public workshops and Town Halls	Denise Moore has held countless public meetings, town halls, and workshops through her previous role as Peoria City Councilwoman and her current work helping build minority businesses, contractors, and the workforce with the Minority Business Development Center.
Correlation with Central Illinois' Living Laboratory	Reuben personally knows the Central Illinois Living Laboratory (CILL) leaders Kurt Bialobreski and Philip Lockwood. He also served as a member of Distillery Labs' Prime Distillers Group. This group assisted with the architecture firm selection and provided

input into the building's final layout and design. CILL is an initiative of Distillery Labs.

Additionally, both Reuben and Denise serve on the Peoria Innovation Alliance board of which Philip is President.

5. Project Schedule

Phase	Start Week	End Week
1 - Planning	1	2
2 - Research	2	8
3 - Implementation	8	24
4 - Analysis	24	43



6. Proposed Compensation

a. General fee structure

Task	*Task Description*	Unit Cost	Quantity	Total Cost
Community survey	Send advance letters	$1	500	$525
	Respondent incentives	$5	500	$2,500
	Tablets to collect responses	$225	3	$675
Community survey Total		$7	500	$3,700
Data portal	Customize data portal	$1,200	1	$1,200
	Install data portal	$2,400	1	$2,400
	Install data portal plugins	$2,400	1	$2,400
	Load data into portal	$300	1	$300
Data portal Total		$6,300	1	$6,300
Town Hall	Summarize townhall results	$280	2	$560
	Town hall (event)	$1,497	2	$2,994
	Town hall (planning)	$1,10	2	$2,200
	Town hall (rental/snacks/supplies)	$125	2	$250
Town Hall Total		$3,002	2	$6,004
Workshop/Public session	Workshop (event)	$3,744	2	$7,488

	Workshop (planning)	$2,200	2	$4,400
	Workshop (rental/snacks/supplies)	$200	2	$400
Workshop/Public session Total		$6,134	2	$12,288
Grand Total				**$28,292**

b. Fully loaded hourly rates

Task	*Position*	Estimate Hours	Blended Rate	Cost not to Exceed
Admin	Craig Williams	32	$125	$4,000
	Denise Moore	20	$125	$2,500
	Dr. Sarah Donohue	8	$68	$544
	Reuben Cummings	32	$150	$4,800
	Various	48	$70	$3,360
Admin Total		140	$109	$15,204
Aggregate existing studies	Reuben Cummings	24	$150	$3,600
	TBD	40	$85	$3,400
Aggregate existing studies Total		64	$109	$7,000
Community survey	Alexander Ferns	4	$125	$500
	Craig Williams	12	$281	$3,375
	Denise Moore	14	$375	$5,250
	Dr. Sarah Donohue	10	$68	$680
	Reuben Cummings	46	$170	$7,800
	TBD	40	$40	$1,600
	Various	195	$30	$5,850
Community survey Total		321	$78	$25,055
Write study	Alexander Ferns	8	$125	$1,000
	Craig Williams	40	$125	$5,000
	Denise Moore	16	$125	$2,000
	Dr. Sarah Donohue	16	$68	$1,088
	Reuben Cummings	40	$150	$6,000

Grand Total	**645**	**$97**	**$62,347**

c. Other pricing information

Task	*Task Description*	Unit Price	Quantity	Cost not to Exceed
Institutional Review Board (IRB)	Prepare for IRB	$0	1	$544
Institutional Review Board (IRB) Total		$0	1	$544
Travel	Lodging	$150	4	$600
	Per Diem	$75	5	$375
	Travel (round trip flights)	$300	22	$600
Travel Total		$525	11	$1,575
Grand Total		**$525**	**12**	**$2,119**

Task	*Task Description*	Total Monthly Price	Max Months	Cost not to Exceed
Community survey	Database Software	$96	12	$1,152
	Route planning software	$32	12	$384
	Survey Software	$144	12	$1,728
	Survey Website Hosting	$33	12	$396
Community survey Total		$305	12	$3,660
Data portal	Data portal hosting	$250	12	$3,000
Data portal Total		$250	12	$3,000
Grand Total		**$555**	**12**	**$6,660**

Minor revisions to the project plan may be needed after the kickoff

7. Addendum

Resumes

REUBEN L. CUMMINGS

linkedin.com/in/reubano ◆ rcummings@nerevu.com ◆ +1 (309) 361-7702

CAPABILITIES:

Data: Extraction, Transformation & Loading (ETL), Integration, Cleansing, Conversion, Monitoring & Alerting
Development: API Development & Integration, Web Application Development, Process Automation, System Interoperability, Fast Healthcare Interoperability Resources (FHIR)
Business Intelligence: Dashboards Development, Data Analytics, Predictive Analytics, Reporting Automation, Data Warehousing

TECH STACK:

Python: Flask, SQLAlchemy, Pandas, BeautifulSoup
JavaScript: Node, Express, D3, Leaflet, Mithril, Lunr, Cypress
Cloud: GitHub, Heroku, DigitalOcean, AWS, Microsoft Azure, TravisCI
Database: SQLite, MongoDB, PostgreSQL, Memcache, Redis
Misc: BASH, SQL

WORK EXPERIENCE:

Nerevu Group — **Peoria, IL**
President & Owner
2014–Present

Nerevu helps organizations uncover the insights hidden in their real-time data.

2010–2013 **Global Cycle Solutions (GCS)** — **Arusha, Tanzania**
Business Development/IT Manager

GCS was a distributor of technologies for rural villagers.

- ➢ **Implemented** an inventory management process for the sales team
- ➢ **Designed** a reporting application to track prospects, opportunities, and sales
- ➢ **Developed** financial models and business plans to align with expansion strategy

2005–2010 **MIDIOR Consulting** — **Cambridge, MA**
Business Analyst

MIDIOR is a management consulting and technology services firm.

- ➢ **Created** a database application to track staffing levels and efficiently allocate resources
- ➢ **Developed** an automated revenue & expense reporting application
- ➢ **Built and maintained** customer data warehouses for ad-hoc business intelligence reporting

---

CLIENT PROJECTS:
2021–Present

OSF Healthcare—OSF Community Care (OCC) Dashboard

- ➢ **Designed and built** a Microsoft Power BI dashboard to show progress of the OSF OnCall Connect Pandemic Health Worker Program
- ➢ **Deployed dashboard** to a custom built web application via Microsoft Azure
- ➢ **Integrated and analyzed data** from Microsoft SQL Server databases

Prairie Spine & Pain Institute—Medical Record Data Extraction

- ➢ **Extracted patient documents** (EHR) from Microsoft SQL Server databases
- ➢ **Integrated** with cloud EHR vendor's API to load legacy patient documents

REUBEN L. CUMMINGS — PAGE TWO

linkedin.com/in/reubano ◆ rcummings@nerevu.com ◆ +1 (309) 361-7702

CLIENT PROJECTS:

2018–2021

Illinois Central College (ICC)—Workforce Equity Initiative Website

- ➢ **Developed data-driven website** to highlight the Workforce Equity Initiative's impact
- ➢ **Integrated and customized** content management system that powered the website
- ➢ **Created interactive visualizations** to display key performance metrics

Greater Peoria Economic Development Council (GPEDC)—Data Hub Automation

- ➢ **Developed** scripts to fetch economic statistics from government data sources
- ➢ **Created** automated service to keep economic statistics updated with most recent data

2015–2018

GO2 Foundation for Lung Cancer—Concept to Clinic

- ➢ **Created** a skeleton web application that would allow a user to apply a specific machine learning (ML) algorithm to analyze computed tomography (CAT) scans of lungs
- ➢ **Reviewed** code contributions to integrate ML algorithms into the web application
- ➢ **Engaged the community** by answering questions and evaluating contributions

United Nations OCHA—Humanitarian Data Exchange (HDX)

- ➢ **Wrote** scripts to automatically add and update external data sources to HDX
- ➢ **Developed** an automated service to monitor the recency of all HDX datasets
- ➢ **Designed and created** interactive visualizations for Oxfam and Red Cross

---

EDUCATION:

MASSACHUSETTS INSTITUTE OF TECHNOLOGY **Cambridge, MA**

2005 ***S.B. Chemical Engineering, Biomedical Engineering Minor***

Gates Millennium Scholar*:* full-tuition scholarship awarded to 1000 students across the U.S.

Relevant Coursework: Introduction to Computer Methods, Micro/Macroeconomics, New Enterprises, Dynamics of Biomedical Technologies, Building a Biomedical Business, Principles & Practice of Drug Development, Reaction Engineering, Molecular & Engineering Aspects of Biotechnology, Information Technology in the Health Care System of the Future

LEADERSHIP: Greater Peoria Economic Development Council (GPEDC) Board Member *(2020 – Present)*, Peoria Innovation Alliance Board Member *(2019 – Present)*, Greater Peoria Data Analytics Community Lead Organizer *(2019 – Present)*, Arusha Coders Lead Organizer *(2015 – 2017)*, MIT Educational Counselor *(2011 – 2017)*, MIT Enterprise Forum Advisory Board Member *(2014 – 2015, 2005 – 2007)*, MIT Reunion Committee Member *(2014, 2009, 2007)*, MIT Alumni Class of 2004 President *(2004 – 2009)*

OPEN SOURCE:

RIKO: A Python stream processing engine modeled after Yahoo! Pipes
MEZA: A Python toolkit for processing tabular data
CSV2OFX: A Python toolkit for processing tabular data

INTERESTS: Investing ♦ Traveling (have traveled to 20+ countries including 13 in Africa)

Sarah E. Donohue

University of Illinois College of Medicine Peoria
One Illini Drive, Peoria, IL 61605
sed03@uic.edu 309-671-8437

SUMMARY

I am the Director of Research Services at the University of Illinois College of Medicine Peoria. I have extensive experience working in higher education including teaching classes, mentoring students, and conducting research. I have published over 30 peer-reviewed articles and been involved in over 30 international conference presentations. My work in Peoria has primarily focused on health equity, and I have worked closely with the Peoria City/County Health Department on the current (2022) Community Health Needs Assessment.

EDUCATION

Kent State University

- MPH Epidemiology, (anticipated spring, 2023)

Duke University

- Ph.D. Neurobiology, Cognitive Neuroscience Program (2012) James B. Duke Fellowship and National Science Foundation Graduate Research Fellowship Awardee

Smith College

- B.A. Neuroscience, Cum Laude with High Honors in Neuroscience (2003), First Group Scholar and Dean's List (2000, 2001, 2003)

WORK HISTORY

University of Illinois College of Medicine Peoria *Director of Research Services (2020-)*

- Support students, residents/fellows and faculty in their research projects from start to finish
- Support grant applications, and other research-related activities

Neurology Clinic, Magdeburg, Germany *Postdoctoral Fellow* (*2012 to 2020)*

- Co-PI of a >200K grant to study addiction; managed personnel and studies related to this award
- Co-Instructor, Scientific Writing, Summers 2014 to 2018
- Guest Instructor, Forschungskolloquium (Seminar for Cognitive Psychology), Winter 2017/18

Women and Mathematics, Durham, NC *Volunteer (2008 to 2012)*

- As a mentor to underprivileged 8th grade girls, showed them opportunities for careers in math and science
- Awarded Mentor of the Year (2011) for coordinating activities

Duke University, *Teaching Assistant* **(**Fall 2007, Spring 2008)

Leiden University, the Netherlands *Visiting Researcher (Summer 2006)*

- Helped to develop an analysis pipeline for EEG data

UC Davis *Pediatric fMRI Consultant (Oct. 2005 to May 2006)*

- Trained researchers on scanner use and MRI safety

UC Davis *Lab Manager (Aug 2003 to May 2006)*

- Organized and managed IRB approval and compliance, subject recruitment, subject testing, and data analysis

Smith College *Master Tutor of Biology (2002 to 2003***)**

- Tutored peers on material and study techniques

MIT *Research Intern (Summers 2002, 2003)*

- Planned the study for undergraduate thesis and analyzed results

Smith College *Student Academic Advisor (2000 to 2001***)**

Sarah E. Donohue

University of Illinois College of Medicine Peoria
One Illini Drive, Peoria, IL 61605
sed03@uic.edu 309-671-8437

- Elected by peers to give advice on course planning, study techniques, and academic success to incoming students

UC San Francisco *Summer Fellow (Summer, 2001)*

- Collected and analyzed behavioral data in human subjects
- Presented findings at the Cognitive Neuroscience Society Meeting (2002) while still an undergraduate

SELECTED GRANT FUNDING RECEIVED

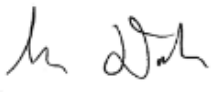
Title: "Does providing free transportation to primary care visits improve outcomes? A pilot program in Chicago's Washington Heights neighborhood."
Funding Source: Community Health Advocacy
PIs: Donohue & Pritzker
Award Period: Jan 2022-Jan 2023.
Amount: $75,009

Title: "NIH RECOVER: A Multi-site Observational Study of Post-Acute Sequelae of SARS-CoV-2 Infection in Adults."
Funding Source: NIH/NHLBI OT2HL161847-01
PIs: Katz/Horwitz/Troxel PIs (Donohue: Co-I in Peoria as part of sub award)
Award Period: October 2021-May 2025.
Amount: $448,259,603

Title: "Voice Vitals: A New Approach for Anxiety and Depression Screening in the Era of COVID-19"
Funding Source: Jump ARCHES.
PIs: Pietrowicz, Finkenbine, and Donohue
Award Period: May 2021-2022.
Amount: $74,973

Title: "From Reward to Addiction, the Neural Correlates of Craving"
Funding Source: Sonderforschungsbereich (SFB 779 TPA14N), Neurobiology of Motivated Behavior, from the Deutsche Forschungsgemeinschaft (DFG).
PIs: Donohue, Schoenfeld, and Harris
Award Period: January 2016-2020
Amount: 219,500 Euros

April 18th, 2022



ALEXANDER L. FERNS, CIA, CFE, CISA, CGAP

PROFILE:
Mr. Ferns is an Audit Professional with extensive experience in operational and compliance auditing, risk assessment, business process evaluation, information technology assessments, and fraud investigation. Proven ability to build and lead teams and drive organizational efficiencies through effective planning, coaching and administration. Recognized as a progressive thinker with strong problem solving and time management skills. An excellent communicator and good listener with the ability to work with all levels of the organization.

INTERNAL AUDIT EXPERIENCE:

- Conducted financial, operational, compliance and performance audits in accordance to GAAS, *GAGAS and Standards for the Professional Practice of Internal Auditing.*
- Develop risk assessments for critical business processes, and integrity of IS systems.
- Assess internal control procedures specific to business and function areas to determine the adequacy and effectiveness of controls, procedural and organizational effectiveness and efficiency, the safeguarding of assets and the identification of fraud and abuse.
- Plan and develop audit scope, objectives and audit programs using risk and control based auditing techniques.
- Review transactions, documents, records, and processing methods to validate accuracy and effectiveness and to identify inefficiencies, fraud, waste and/or abuse.
- Propose recommendations for improvements in processes and system controls.
- Prepare Audit reports to be presented to auditee management and Audit Committees.
- Conduct post audit follow ups to measure outcome of implemented recommendations and/or actions taken.
- Managed and supervised audit staff.
- Lead audit teams, by coaching, developing, reviewing and supervising team members.

EDUCATION/ CERTIFICATIONS:

- Master of Business Administration – MBA
- Bachelor of Arts degree – Economics major
- Certificate Degree in Personnel Management - Florida Atlantic University, Boca Raton, FL.
- Currently pursuing Certificate Degree in Forensic Accounting – University of North Carolina.
- Certified Internal Auditor - CIA
- Certified Fraud Examiner - CFE
- Certified Information Systems Auditor – CISA
- Certified Government Auditing Professional - CGAP

PROFESSIONAL AFFILIATIONS:

- Member - Institute of Internal Auditors (IIA)
- Past President; Past Vice-President; Member - Board of Governors – Gold Coast Chapter Institute of Internal Auditors –
- Member - Association of Certified Fraud Examiners
- Member - Control Self Assessment Center
- Member - Information Systems Audit and Control Association
- Member - Infragard
- Speaker on auditing topics for IIA, ASA and other associations.

CRAIG C. WILLIAMS

4855 Baker Woods Lane
Decatur, IL 62521
(561) 386-3356
craig@cwfmgroup.com

SUMMARY

- Responsible and dependable team player with a positive and professional attitude.
- Experience and education in financial and budget management.
- Excellent analytical and decision-making skills.

EDUCATION

Illinois State University — Normal, IL
B.S. Degree ***Major in Economics /Minor in Business Administration** — 1998

EXPERIENCE

- Chief Financial Officer of COVID-19 Alternative Care Site
- Chief Financial Officer for State of Illinois Mental Health Network (Nine state-operated hospitals)
- Feasibility Studies
- Capital Improvement Planning/Prioritization
- Debt Issuance Support
- Affordability Analysis and Program Development
- Inventory and Asset Management
- Redevelopment and Special Area Strategic Planning

EMPLOYMENT

CW Financial & Management Group LLC — Lake Worth, FL
Owner — 03/19-Present

Palm Beach County Water Utilities Department — West Palm Beach, FL
Assistant Director for Finance & Administration — 07/10-07/19

Illinois Department of Human Services/Division of Mental Health — Springfield, IL
Chief Financial Officer — 05/08 – 07-10

Illinois Department of Agriculture — Springfield, IL
Finance Review Manager — 04/06 – 05/08

City of Springfield, IL — Springfield, IL
Budget Analyst II — 05/04 – 04/06

City of Hollywood Florida — Hollywood, FL
Management and Budget Analyst — 07/03 - 04/04

State of Illinois - Bureau of the Budget — Springfield, IL
Budget Analyst II — 07/00 - 01/03

State of Illinois –Department of Human Services — Springfield, IL
Human Services Case Worker — 04/98 - 07/00

U.S. Army — Various locations
Medical Specialist
7/90 - 12/92

Denise Moore, CPCU, AFSI

denisemoore2020@yahoo.com | 723 W. Spring Hollow Lane - Peoria, IL 61605 | (309) 573-1134

BUSINESS & PROGRAM DEVELOPMENT * LEADERSHIP & MENTORING * STRATEGIC PLANNING

Results-driven professional specializing in building and leveraging relationships vital to business and leadership development, strategic planning, and engagement

PROFESSIONAL EXPERIENCE

Black Business Alliance Peoria Chapter, Inc., **Present – 2013**
Minority Business Development Center
Regional Workforce Solutions Center

- **Founder/CEO/Executive Director**
  - Founded Peoria Black Business Alliance chapter (a 501c3 non-profit)
  - Developed organizational strategic plan for economic and workforce growth
  - Implemented monthly educational programming
  - Collaborate with local economic development organizations and individuals to provide FREE training
  - Developed a successful funding strategy for organizational sustainability

- **General Manager/WPNV 106.3 LP FM Radio Station** **Present - 2014**
  - Established the first African American non-profit owned/operated radio station in Peoria County
  - Acquired equipment and personnel by leveraging relationships with corporate partners
  - Developed operational procedures and training processes for efficient station operation
  - Providing leadership and mentorship to an all-volunteer staff

City Council Member, Peoria, IL **2021 - 2013**

- **First African American Woman elected to the Peoria City Council**
- Represent the 1st District consisting of approximately 25,000 (predominately minority) people
- Provide constituent services that assist in the upgrading of the quality of life in the district
- Advocate for funding, services, jobs/reduced crime/improved safety
- Influenced the startup of neighborhoods/watches

Mass Mutual Financial Group, Peoria, IL **2014 - 2010**

- **Financial Professional**
  - Assist business and non-business clients in uncovering exposures within financial portfolios
  - Assess client financial needs based upon their short- and long-term goals
  - Research, compare/contrast various options.
  - Recommend solutions to reduce financial exposures

Black Business Alliance, Inc., Bloomington, IL **Present - 1997**

- **Former President/CEO, Board Member**
  - Founded the first Minority Economic Development organization in McLean County
  - Developed organizational strategic plan
  - Implemented monthly educational programming
  - Created/Edited/Produced "The Griot", a monthly business newsletter for 200 subscribers

- **General Manager/WXRJ 94.9 LP FM Radio Station** **2010 - 2007**
  - Established the first African American owned radio station in Mclean County
  - Acquired equipment and personnel by leveraging relationships with corporate partners
  - Developed operational procedures and training processes for efficient station operation
  - Providing leadership and mentorship to current volunteer staff

Cultural Expressions/Moore Art on Water/ Up4Moore, Peoria/Normal, IL **2010 - 1995**

- **Retail Management/Business Consultant**
  - Founded the largest African American gift store between Chicago and St. Louis
  - Consultant to others in retail sales/business start-up/ business plans/sales & marketing/best practices
  - Researched and provided cultural gift items focusing on African Americans and Hispanics
  - Establish workflow procedures for optimal employee production
  - Expanded operations to include professional picture framing services

State Farm Insurance Companies, Bloomington, IL **2010 - 1989**

- **Commercial Business Underwriting Management**
  - Accountable for developing and monitoring yearly unit budget while maintaining departmental goals for quality and service levels
  - Directed the training and development of new underwriters
  - Hired and supervised the activities of underwriters and clerical personnel
  - Communicated corporate policies to internal and external clients

- **Staff Assistant/Agency Department**
  - Provide overall educational and technical assistance to field Sales agency force.
  - Monitor and troubleshoot Agency use of Business Management & Sales Process system
  - Research, usability test new software and evaluate its' application within the operation
  - Liaison between external vendors and corporate departments

- **Analyst - Business Lines: Property & Casualty Underwriting**
  - Generalist that coordinated process improvements corporate-wide
  - Researched Franchise businesses for collaborative insurance agreements
  - Established and disseminated the department multi-Cultural and Women's markets strategy
  - Field Underwriter/Premium Auditor of Contractors and Workers Compensation policies

PROFESSIONAL DEVELOPMENT

Bachelor of Science: Business Administration
Illinois State University, Normal, IL

Associate Degree: Banking and Finance
South Suburban College, South Holland, IL

Chartered Property Casualty Underwriter, Professional Degree
The American Institute for Chartered Property Casualty Underwriters, Malvern, PA

'Associate' in the Financial Services Institute, Professional Degree
Life Office Management Association, (LOMA) Atlanta, GA

Series 6 & 63 securities licensed

Life & Health and Property & Casualty Insurance Licensed

Relevant Community Engagement

Peoria Downtown Development Corporation Board Member, 2021 -2014
Spring Grove Neighborhood Association - President, 2016 - 2014
Women In Leadership, Member - 2016 – 2014
Community meetings/town halls/listening sessions 2021 -2013
'Women of Influence' Region-wide recognition, 2013 - IBI Magazine
Proctor Hospital Foundation Board Member- 2013-2012
Minority Business Enterprise- Peoria County Board Ad hoc committee, 2014 - 2012
South-town TIF advisory committee, a Peoria City Council Ad hoc committee 2012
Focus ForwardCI: S.M.A.R.T. Goals and Wealth Transfer committees 2012
St. Paul Baptist Church Member, Present - 2012
National Association of Women's Business Owners Member Board -Secretary - 2012-2011
'Women Making Modern History' Award 2010 -Afra Victoria Magazine
'25 Women In Leadership' Award-Peoria 2009 Marketeer Magazine/WEEK-TV/Peoria Chamber
Professional Woman of McLean County - Member/Board member – 2009 -2008
Woman to Woman Small Business Expo & Showcase – 2008-2003 Facilitate Community Engagement
Toastmasters District 54 - Area 4--'Outstanding President of the year' 1991-1992
Recognized in numerous 'Peoria Journal Star' articles on Economic Development

Studies

Healthcare Collaborative Executive Summary

The Healthcare Collaborative is a partnership between the University of Illinois College of Medicine, the Peoria City/County Health Department, UnityPoint, OSF, Heartland, AMT, United Way, and Bradley University. These groups have come together to end health inequities for people of color living in Peoria, Illinois. In order to find solutions to end health inequities, we needed to gather data to determine what the baseline metrics are in Peoria and to determine what obstacles/challenges people are facing when it comes to their health/healthcare. Ten focus groups were conducted of Black/African American and Hispanic/Latinx residents of the following zip codes: 61603, 61604, and 61605, which have been identified as vulnerable locations in the Peoria area. Based on recent data examined by the Peoria City/Region health department mental health, colon cancer, and cervical cancer were among the top reasons why people in the community were hospitalized. The focus groups conducted specifically targeted these health conditions where disproportionally high numbers of people of color ended up hospitalized or died, in order to better understand how to tackle the current health inequities that exist.

The focus groups were conducted in the months of June and July, 2021. All focus groups had a member from the College of Medicine Peoria present (Dr. Sarah Donohue and/or Dr. Sara Kelly) as well as medical student scribes to write what was said. The groups were held at the East Bluff Neighborhood Housing Services (three groups), the South Side Mission (one group), St. Paul Baptist Church (one group), Friendship House (three groups, Spanish speaking), and Carver Community Center done via Zoom (two groups). For all groups, the individual leading the group was from each respective organization, which helped to build trust and create open dialogue around difficult topics. Participants in these groups received a $30 gift card for participation in a 1.5 hour session.

Results from the 85 participants illustrate that mental health care, for both adults and children, is of upmost concern to the community compared to the other health issues asked in the focus groups. Findings suggest a need to focus on improving health literacy, specifically focusing on additional education and prevention programs in the community. Results from the focus group also underscored the need to improve access to care and resources that are available, including support groups, counseling, and in-patient care. In addition, participants reported they did not feel heard or listened to which they attributed to their race or ethnicity. Moreover, the participants preferred a doctor of the same race/ethnicity to better establish trust and rapport with their healthcare providers. In all, the following pieces should be addressed when developing solutions to tackle health inequity in the Peoria area: focus on health literacy, improve access and resources particularly for mental healthcare, and enhance diversity among healthcare workers.

Received: 12 August 2019 | Revised: 20 October 2019 | Accepted: 12 November 2019

DOI: 10.1111/ejn.14622

RESEARCH REPORT

EJN European Journal of Neuroscience FENS WILEY

Electroencephalography reveals a selective disruption of cognitive control processes in craving cigarette smokers

Sarah E. Donohue[1,2] | **Joseph A. Harris**[1,2,3] | **Kristian Loewe**[1,4] | **Jens-Max Hopf**[1,2] | **Hans-Jochen Heinze**[1,2] | **Marty G. Woldorff**[1,2,5,6,7] | **Mircea A. Schoenfeld**[1,2,8]

[1]Department of Neurology, Otto-von-Guericke University Magdeburg, Magdeburg, Germany

[2]Leibniz Institute for Neurobiology, Magdeburg, Germany

[3]Department of Psychology, Bradley University, Peoria, IL, USA

[4]Department of Computer Science, Otto-von-Guericke University, Magdeburg, Germany

[5]Center for Cognitive Neuroscience, Duke University, Durham, NC, USA

[6]Department of Psychiatry and Behavioral Sciences, Duke University, Durham, NC, USA

[7]Department of Psychology and Neuroscience, Duke University, Durham, NC, USA

[8]Kliniken Schmieder, Heidelberg, Germany

Correspondence
Sarah E. Donohue, Department of Neurology, Leibniz Institute for Neurobiology, Otto-von-Guericke-University Magdeburg, Leipziger Strasse 44, 39120 Magdeburg, Germany.
Email: donohue.sarah.e@gmail.com

Funding information
Deutsche Forschungsgemeinschaft, Grant/Award Number: SFB779 TPA14N

Abstract

Addiction to nicotine is extremely challenging to overcome, and the intense craving for the next cigarette often leads to relapse in smokers who wish to quit. To dampen the urges of craving and inhibit unwanted behaviour, smokers must harness cognitive control, which is itself impaired in addiction. It is likely that craving may interact with cognitive control, and the present study sought to test the specificity of such interactions. To this end, data from 24 smokers were gathered using EEG and behavioural measures in a craving session (following a three-hour nicotine abstention period) and a non-craving session (having just smoked). In both sessions, participants performed a task probing various facets of cognitive control (response inhibition, task switching and conflict processing). Results showed that craving smokers were less flexible with the implementation of cognitive control, with demands of task switching and incongruency yielding greater deficits under conditions of craving. Importantly, inhibitory control was not affected by craving, suggesting that the interactions of craving and cognitive control are selective. Together, these results provide evidence that smokers already exhibit specific control-related deficits after brief nicotine deprivation. This disruption of cognitive control while craving may help to explain why abstinence is so difficult to maintain.

KEYWORDS

addiction, craving, EEG, event-related potentials, nicotine

Abbreviations: ACC, anterior cingulate cortex; CNV, contingent negative variation; DLPFC, dorsal lateral prefrontal cortex; EEG, electroencephalography; ERP, event-related potential; fMRI, functional magnetic resonance imaging; FTND, Fagerström test for nicotine dependence; ICA, independent component analysis; ITI, inter-trial interval; Pe, error positivity; pre-SMA, pre-supplementary motor area; QSU, questionnaire of smoking urges; ROI, region of interest; RT, response time; SEM, standard error of the mean; VEOG, vertical electro-oculogram.

Edited by Dr. Sophie Molholm.

The peer review history for this article is available at https://publons.com/publon/10.1111/ejn.14622

1 | INTRODUCTION

Despite the many health warnings and known negative consequences, smoking remains a relatively popular habit throughout the world, with the World Health Organization projecting that over 1 billion people will regularly smoke tobacco by 2025 (Bilano et al., 2015). Although quitting is a goal for many smokers, the state of craving that accompanies nicotine deprivation is a formidable obstacle in maintaining abstinence, with the measured strength of this urge positively correlating with relapse (Killen & Fortmann, 1997). Smokers who successfully quit recruit cognitive control mechanisms to actively suppress their feelings of craving, thereby avoiding relapse (Potenza, Sofuoglu, Carroll, & Rounsaville, 2011). Specifically, to maintain abstinence, a smoker must inhibit the automatic urge to smoke, ignore the distracting smoking-related cues around them and focus on other non-smoking-related tasks, so as to avoid cue-induced craving effects (Carter & Tiffany, 1999). In this way, craving and cognitive control mechanisms during abstinence are pitted against one other, with successful cessation or relapse representing alternative outcomes of this competition. The strength of craving, however, is twofold, as it can be both an acute reaction, often triggered by smoking-related cues, but also a tonic state, independent of such cues (Ferguson & Shiffman, 2009). An important question is if, in the absence of smoking-related cues, the more tonic state of craving is disruptive to cognitive control mechanisms in a way that might account for the failures of nicotine abstinence during nicotine deprivation.

Cognitive control, a form of executive function, is a term that encompasses the subcomponents of cognition necessary for goal-directed behaviour, including (but not limited to) the inhibition of unwanted responses, flexible preparation for upcoming events, and selecting that which is relevant in the presence of conflicting input (see Banich, 2009 and Gratton, Cooper, Fabiani, Carter, & Karayanidis, 2017 for reviews). These cognitive control processes are thought to entail dynamic interactions involving frontal-lobe networks (Helfrich & Knight, 2016), with specific frontal subregions being implicated in different control processes (Badre & Nee, 2018). The various facets of cognitive control have been characterized using EEG and fMRI measures, with each control process showing a unique signature in terms of the timing and distribution of underlying activations. For example, in Go/NoGo tasks requiring response inhibition, inhibition-related activity is often found in the right inferior frontal gyrus, the insula and pre-SMA (Garavan, Ross, & Stein, 1999; Sebastian et al., 2012; Zhang, Geng, & Lee, 2017), and manifests electrophysiologically as an N2/P3 ERP difference (e.g. Albert, López-Martín, Hinojosa, & Carretié, 2013; Harper, Malone, & Bernat, 2014; Huster, Enriquez-Geppert, Lavallee, Falkenstein, & Herrmann, 2013; Pfefferbaum, Ford, Weller, & Kopell, 1985). Preparatory activity for a given task has been associated with a fronto-centrally distributed, slow negative-polarity ERP wave, referred to as the contingent negative variation (CNV; Astle, Jackson, & Swainson, 2006; Poljac & Yeung, 2014), which increases when more effort is required (e.g. when the participant must switch tasks and maintain the correct task in working memory (Astle, Jackson, & Swainson, 2008; Poljac & Yeung, 2014; Vandamme, Szmalec, Liefooghe, & Vandierendonck, 2010)). This component has been reported to have contributing sources in regions that include the insula and supplementary motor areas (Nagai et al., 2004), and fMRI has revealed that, in addition to activation of pre-SMA, task switching recruits the basal ganglia and DLPFC (Crone, Wendelken, Donohue, & Bunge, 2006). Finally, conflict processing has been most often associated with the ACC, manifesting in EEG data as a greater negativity for incongruent relative to congruent trial types, known as the N_{inc} or N450 (Carter, 1998; Carter & van Veen, 2007; Donohue, Appelbaum, Appelbaum, McKay, & Woldorff, 2016; Silton et al., 2010; West & Alain, 1999). Together, these processes, in conjunction with selective attention, allow for the control of actions, and when these processes are not effectively invoked, unwanted behaviours such as compulsive substance usage in addiction can emerge.

One hallmark of addiction is indeed poor cognitive control, and inhibitory control is the specific control process that is most often noted as being deficient in individuals who regularly use nicotine, alcohol or illegal drugs (Belin, Belin-Rauscent, Murray, & Everitt, 2013; Flaudias et al., 2016; Goldstein & Volkow, 2011). Although cognitive control is more often characterized in users of other addictive substances, there is evidence that such cognitive control deficits also exist in smokers (e.g. Billieux et al., 2010; Dinn, Aycicegi, & Harris, 2004; Wagner et al., 2012). Indeed, a meta-analysis of behavioural studies concluded that inhibitory control deficits are present in smokers compared with controls, particularly in the Go/NoGo task (Smith, Mattick, Jamadar, & Iredale, 2014). Further, such reduced inhibitory control in smokers can be observed with neural measures, even if no obvious behavioural deficit is present (Luijten et al., 2014). The evidence for neural inhibitory deficits, however, is not entirely consistent, with two studies comparing smokers to controls in a Go/NoGo task finding differences on the N2 but not on the P3 (Buzzell, Fedota, Roberts, & McDonald, 2014; Luijten, Littel, & Franken, 2011), and another study showing that non-smokers had a greater difference in P3 amplitude for NoGo versus Go trials than smokers (Evans, Park, Maxfield, & Drobes, 2009). Moreover, in an fMRI study of a Go/NoGo task, the only differences observed between smokers and controls were found in non-frontal regions, such as the cerebellum (Weywadt, Kiehl, & Claus, 2017), whereas another study found decreased neural activity in prefrontal regions for smokers relative to controls (Nestor, McCabe, Jones, Clancy, & Garavan, 2011). Interestingly,

only one of the aforementioned neural studies (Nestor et al., 2011) found a behavioural difference between smokers and controls in inhibitory control, suggesting the importance of neural measures to pick up on more subtle effects and compensatory mechanisms. As such, although there is evidence to suggest that inhibitory control is impaired in smokers, the exact nature of the impairment is not very clear.

Others aspects of cognitive control have been less thoroughly examined in smokers, and the few studies that have sought to test these facets have also yielded mixed results. A behavioural study implementing a wide variety of executive function tasks in smokers found that the level of smoking (the product of average daily use × years of smoking) was a significant predictor of some executive function measures, including task switching and response speed in the inhibition-related Go/NoGo and Stop-Signal tasks, but this did not influence conflict processing as measured with a Stroop task (Glass et al., 2009). In an fMRI study investigating conflict processing in smokers versus controls, smokers showed decreased accuracy and reduced activity in the right anterior insula for one conflict condition relative to controls, but not for all conflict conditions (Fedota et al., 2016). Yet another study found that smoking history only influenced performance on task switching and not on conflict or other attention-related executive function measures (Razani, Boone, Lesser, & Weiss, 2004). Importantly, the participants there were almost all former smokers, and only those who had once been heavy smokers showed the task-switching impairment. Together, these data suggest that in addition to the aforementioned inhibitory impairments, smokers may have impairments in cognitive control related to task switching, but other aspects, such as conflict, may only be moderately affected.

Given the impairments of cognitive control in smokers, it is reasonable to expect that the state of craving would only exacerbate these problems. Surprisingly, however, this is not necessarily the case. Dawkins and colleagues (Dawkins, Powell, West, Powell, & Pickering, 2007) found that deprived smokers had impaired inhibitory control in responding to stimuli, which was rescued by the administration of nicotine, but also that other aspects of cognitive control such as working memory were not impaired. These results would suggest that craving selectively influences certain control processes. Nevertheless, their study used only behavioural measures, and it is entirely possible that there may have been differences in the underlying neural activity, which the behavioural measures were unable to capture. That is, craving could still operate in a non-specific manner, altering all attention and cognitive control processes, with behavioural ramifications only showing up for certain cognitive control tasks. In a previous study (Donohue, Woldorff, et al., 2016), we observed that when smokers were in a state of craving, they had an enhanced sensory-evoked P1, suggesting a higher general level of arousal. Surprisingly, this had no consequences for an attentional-shift-related task, with smokers showing comparable behavioural and neural effects in both sated and craving conditions. The task we used previously, however, primarily engaged ventral visual regions (Hopf et al., 2000) and was not designed to test more control-related areas.

To specifically test the behavioural and neural ramifications of craving on cognitive control, we implemented a cuing paradigm with manipulations of task switching, conflict processing and response inhibition while recording EEG measures of brain activity. This paradigm was run on each smoker twice: once when they had smoked immediately prior to the experiment (i.e. a non-craving condition) and once when they had abstained from smoking for the three hours leading up to the session (i.e. a craving condition). If craving were exclusively a low-level process that mainly influences arousal, then we would not expect to see any task-specific influences as a function of craving, but perhaps just a general impairment of performance. In contrast, if craving does have specific detrimental effects on cognitive control, as previous behavioural results have suggested (Dawkins et al., 2007), then these effects would manifest in some but not all of the cognitive control tasks implemented here.

While the task used here focused on various subcomponents of cognitive control, a final aspect to consider is the motivation of the participants, and specifically, how they respond to feedback. When a participant receives feedback, this can translate into performance monitoring, where behaviour on subsequent trials may be adjusted according to this feedback (Ridderinkhof, Ullsperger, Crone, & Nieuwenhuis, 2004). Because the task we used was relatively challenging, we gave our participants feedback on their performance at the end of every trial. They were specifically awarded points (more for faster accurate responses), and once they had reached 3,000 points, the session ended and they were free to go smoke. We included this to keep subjects engaged in the task, but we also sought to examine how craving influenced the response to feedback. Smokers who have been deprived of nicotine for 12 hr have been found to show decreased sensitivity to monetary rewards (Lydon, Roberts, & Geier, 2015) and have decreased signatures of performance monitoring (Schlienz, Hawk, & Rosch, 2013). We therefore hypothesized that it could be the case that the smokers in our study would be overall less sensitive to the feedback when they were craving, but also that they may differentiate more between low and high feedback, as high feedback would bring them closer to their reward of smoking. To fully assess the response to feedback, we examined this reward-related feedback not only on the current trial, but also on the subsequent trial, to see how it ramified. If smokers are less sensitive to feedback when they are craving, then this should not only be reflected in a decreased feedback-related P3 response (Ullsperger, Fischer, Nigbur, & Endrass, 2014) on the current trial, but it

should also manifest in a lack of feedback-related changes in preparation and performance on the subsequent trial.

2 | METHODS

2.1 | Subjects

Smokers were recruited from the Otto-von-Guericke University of Magdeburg and the surrounding community. In total, data from 24 participants (mean age 27.2 years, range 18–45, 12 female) were included in the final analysis. A sample size of 23 participants was calculated with G*Power (Faul, Erdfelder, Lang, & Buchner, 2007) to be sufficient for a moderate within-subject effect size (Cohen's $f > 0.25$) at an alpha of 0.05. Additionally, studies examining similar components have used a similar (or smaller) sample size (e.g. 23 subjects for the CNV (Morie, Sanctis, & Foxe, 2014); 20 subjects for the N_{inc} (McKay, Berg, & Woldorff, 2017)). All included participants had neither a history of (or current) drug or alcohol abuse nor any diagnosis of neurological disease/psychiatric illness. Data from several additional participants were excluded due to an excessive amount of physiological noise in their EEG data in one or both sessions ($N = 5$), or due to poor performance on the task ($N = 3$). All smokers reported smoking on average at least 10 cigarettes per day (mean = 15) and had all smoked regularly for at least two years (mean years smoked = 10). All participants gave written, informed consent, and all procedures were approved by the Ethics Committee of the medical school at the Otto-von-Guericke University, Magdeburg, Germany.

2.2 | General experiment design

Each participant participated in two separate sessions, occurring on different days. In one session, the *non-craving session*, the participant smoked immediately prior to the start of the experiment. In the other session, the *craving session*, the participant arrived at the laboratory, smoked a cigarette and then waited for three hours under direct experimenter supervision to ensure he/she did not smoke within this time period. After these three hours, the experiment began. The order of the sessions was randomized and counterbalanced across participants. In both sessions, the experimental task was the same, with the only difference being whether or not the participant had recently smoked.

2.3 | Stimuli and task

The paradigm used here was a task-switching paradigm, designed to invoke switching, incongruency and inhibitory effects. For each trial, a circle of one of four colours (e.g. green, blue, red and brown) appeared, indicating which task the participants should prepare for (i.e. a cue). Two of the four colours corresponded to an even/odd judgement on an upcoming number stimulus. The other two colours indicated that participants should make a greater than/less than five judgements on the upcoming number stimulus. Two colours were used instead of one for each type of judgement to prevent the observed effects being attributable to cue-colour-switching costs rather than task-switching costs (Mayr & Kliegl, 2003). This cue was presented for 300 ms. After a delay period (during which only a fixation cross was present for 1,100–1,400 ms, randomly jittered), the target stimulus (single-digit number, 1° wide × 1.5° high) was presented for 300 ms. On 80% of the trials, the target stimulus was presented in the same colour as its preceding cue, and participants were instructed to make the relevant judgement as quickly as possible. On 20% of the trials, the target stimulus would be presented in a fifth colour (e.g. magenta), and in these cases, participants were asked to withhold their response (i.e. a NoGo condition). After the target stimulus was presented, another fixation cross was present for 1,000–1,300 ms (jittered), to allow participants enough time to respond. Following the response, participants were given feedback (lasting 700 ms) as to their accuracy and how many points they had won for that trial. The cue stimulus was 2.5° of visual angle in diameter, and all stimuli (cue, target, feedback) were presented at 1.5° below fixation using Presentation (Neurobehavioral Systems). The colour corresponding to which judgement/NoGo signal was randomized across participants, but remained the same for a given participant across both sessions.

2.3.1 | Task-switching component

From trial to trial, the task assigned by the cue would either switch (i.e. go from an even/odd judgement on the previous trial to a greater than/less than judgement on the current trial, or vice versa) or repeat (i.e. both the current trial and the previous trial would be even/odd judgements, or both be greater than/less than judgements). The ratio of switch to repeat trials was 40% to 60%. An example excerpt from the trial sequence is shown in Figure 1a.

2.3.2 | Congruency component

For each task, a response button was assigned to a specific judgement. For example, if a number were odd, participants were asked to press "M," whereas if it were even, they were asked to press "C." The same response buttons were used for the greater than/less than five judgement task, such that "C"

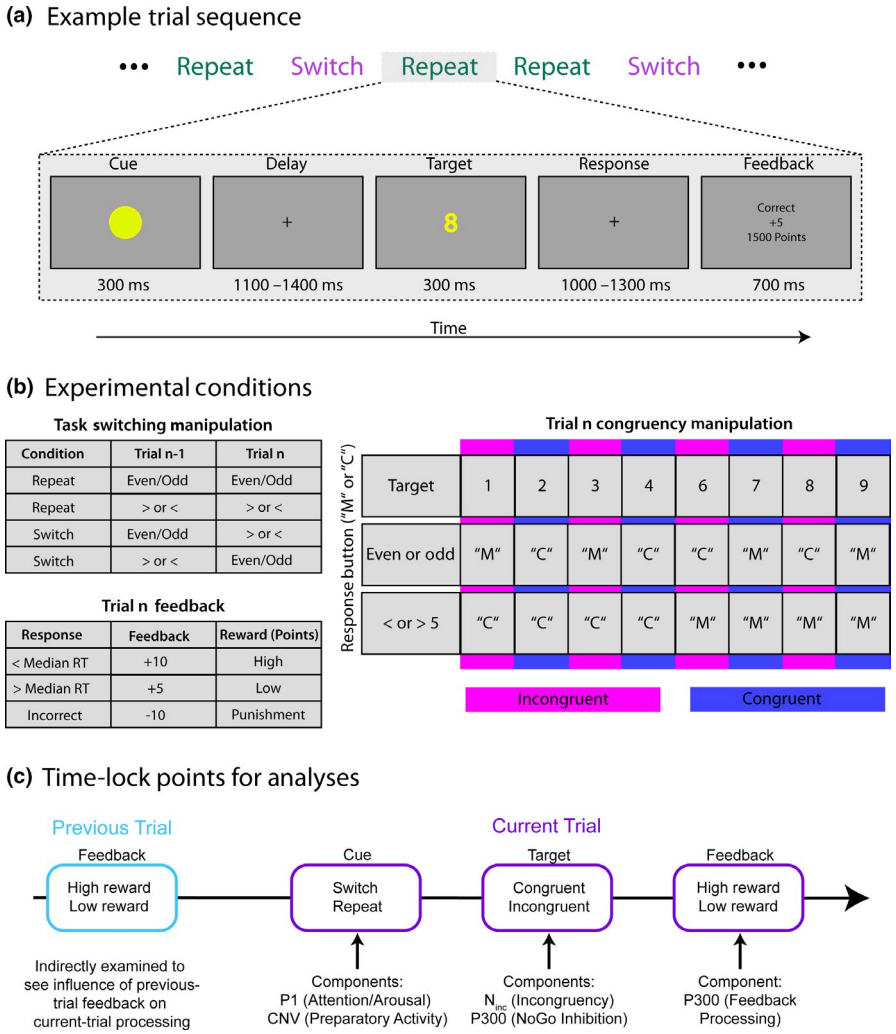


FIGURE 1 (a) Example Trial Sequence. From trial to trial, the task could either repeat (e.g. an even/odd judgement followed by another even/odd judgement, or a greater than/less than judgement followed by another greater than/less than judgement) or switch (e.g. an even/odd judgement followed by a greater than or less than five judgement, or vice versa). Displayed here is one trial (a repeat), showing the cue, delay, target, response and feedback periods. Following the feedback, a jittered ITI was presented before the next trial began. (b) Experimental Conditions. The three task manipulations (task switching, congruency and feedback) are depicted here. Of note, the incongruency effects were induced by a response conflict, where a given target had either one response regardless of task or two possible responses, contingent upon task. The feedback was given on every trial, and once the participant had earned a total of 3,000 points, the experiment was ended (and he/she was free to smoke). (c) Time-lock Points for Analyses. Each of the arrows points to an event to which the time-locked ERP averaging was calculated, and listed below these arrows are the components of interest that were extracted. [Colour figure can be viewed at wileyonlinelibrary.com]

could be used for numbers less than five and "M" was used for numbers greater than five. This created two different levels of congruency as a function of response. That is, for half the numbers, regardless of which task the participants were cued to do, the response would be the same (i.e. a congruent condition). For the other half of the numbers, the response was task-dependent (i.e. would have been "M" for one task and "C" for another task), thereby representing an incongruent condition. Participants were not told which numbers were congruent or incongruent, and, based on debriefing, if this were learned at all, it was learned implicitly. A depiction of the congruency by stimulus mapping is shown in the right panel of Figure 1b.

2.3.3 | Response inhibition

As mentioned above, for 20% per cent of the trials the target number would appear in a fifth colour, and participants needed to withhold from making a response (NoGo trials). All the other trials were thus considered "Go" trials.

2.3.4 | Feedback

In order to motivate participants to perform quickly and accurately, performance feedback was provided following every trial and indicated points earned for each correct

response given. For the first trial of each task type, participants earned 10 points for every correct response given. After this, the median RT was obtained and if a participant responded more quickly than this value, he/she earned 10 points (high feedback), and if a participant responded slower than this value, he/she earned 5 points (low feedback). During piloting, we observed that, for many participants, their overall RT was a bit faster for the greater than five/less than five task and thus to avoid biasing one task, two separate median RT counters were kept, one for each task and the speed for a given trial was only calculated relative to that task's previous responses. Responses that fell outside the response window (150–1,200 ms after target onset) were counted as misses. For the NoGo trials, correctly abstaining from responding earned participants 10 points, and all incorrect responses, including false alarms on NoGo trials, cost participants 10 points. At the start of the experiment, participants were told that the session ended once they reached 3,000 total points. The total value of points earned was displayed on every trial, along with the feedback for that particular trial. Participants were told that if they had not achieved 3,000 points after an hour of recording time, the experiment would be ended automatically. Of note, the data reported here were from participants who earned 3,000 points in both sessions before the hour was up.

2.4 | General procedure

Each session took place in a dimly lit, electrically shielded recording chamber. At the start of each session, participants received one or more practice blocks to ensure that they had learned the response mapping and were comfortable with the task. Within the task, after every ~7 min, participants were given a break and could press a button when they wished to resume the experiment. The first trial of the experiment and the first trial after each break were excluded from analysis.

2.5 | Questionnaires

At the start of each EEG session, participants were given the Questionnaire of Smoking Urges (QSU; Tiffany & Drobes, 1991) to determine their level of self-reported craving. This questionnaire results in data that are sorted into two factors. Factor one captures the anticipation of the pleasure of smoking (positive aspect), and the second factor measures the anticipated relief of the unpleasant symptoms of nicotine deprivation (negative aspect). Both factors were analysed to determine whether our craving manipulation was effective insofar as self-report measures can provide. Additionally, the Fagerström Test for Nicotine Dependence (FTND; Heatherton, Kozlowski, Frecker, & Fagerström, 1991), as well as a questionnaire on smoking history, were administered.

2.6 | EEG measurement

Continuous EEG data were recorded using Brain Products Amplifiers and caps (the 32-Channel ActiChamp System with an Acticap and Vision Recorder software (Brain Products Inc., Gilching, Germany)) during both the craving and non-craving sessions while participants performed the task. The EEG data consisted of 32 channels, arranged in a standard 10–20 montage and referenced online to the right mastoid. The data were sampled at a frequency of 500 Hz, and impedances were maintained at or below 5 kOhms. One VEOG channel was placed under the right ocular orbit to monitor blinks.

2.7 | EEG analysis

Offline, the EEG data were processed using EEGLab (Delorme & Makeig, 2004) and ERPLab (Lopez-Calderon & Luck, 2014) software toolboxes in MATLAB. The EEG data were epoched (−400 to 1,600 ms), separately for time-lock points at the cue, target, and feedback onsets. An initial blink-based artefact rejection was performed for ±200 ms after the onset of each event to ensure that only trials for which the subject had perceived the stimulus were retained (i.e. that he/she had not blinked during that display). After this, ICA decomposition was run on the epoched data, separately for the cues, targets and feedback. The output of this decomposition (i.e. 32 components for each trial period and subject) was then inspected by examination of the spatial distribution of each component and its respective time course. Components that could be clearly identified as noise (e.g. blink-related) were removed. After these components were removed, a second round of artefact rejection was implemented to remove any trials still containing major physiological artefacts not removed during the ICA. The total amount of trials rejected ended up being: cue (non-craving) mean = 1.69%; range = 0%–9.31%; cue (craving) mean = 1.46%; range = 0%–4.24%; target (non-craving) mean = 1.25%; range = 0%–8.17%; target (craving) mean = 0.77%; range = 0%–4.45%; feedback (non-craving) mean = 1.55%; range = 0%–9.15%; feedback (craving) mean = 2.07%; range = 0%–11.18%. Importantly, for the cue, target and feedback, there were no significant differences between rejection rates for craving and non-craving sessions (all $p's > 0.3$). The data were then selectively averaged, low-pass filtered at 30 Hz, re-referenced

to the algebraic average of the left and right mastoids, and relevant difference waves were obtained for the respective conditions.

2.7.1 | Statistical analysis of ERP data

Each event (cue, target and feedback) had different components of interest. Figure 1c delineates which components were expected to be elicited during each time period. The precise time windows and analysis for each are detailed, below, and a summary of the ERP analyses conducted is presented in Table 1.

Cue-locked ERPs

For the cue period, the initial sensory-evoked responses (the P1 at occipital sites O1 and O2 from 110 to 150 ms) were examined as a function of task, the feedback from the previous trial, and craving. Based on our previous work, we hypothesized that craving would influence this component (Donohue, Woldorff, et al., 2016). The time window and sites were selected by collapsing across both sessions/conditions and visually inspecting the data to see the location/time of the first occipitally located positive-going deflection in the data, and taking ±20 ms around the peak. The mean amplitudes at these sites and for this time period were then extracted for each session and condition, and submitted to a 2 × 2 × 2 repeated measures ANOVA, with the factors of craving (craving, non-craving), task switching (switch, repeat) and feedback (previous-trial high, previous-trial low). The second cue-locked component of interest was the CNV. Again, here, the data were collapsed across all sessions and conditions and the location of the maximal negative-going deflection (at site Cz) was obtained. The time period for the CNV was divided into an early (700–1,000 ms) and late (1,000–1,300 ms) time period. For each time period, a 2 × 2 × 2 repeated measures ANOVA was conducted on the mean amplitude values with the factors of craving (craving, non-craving), task switching (switch, repeat) and feedback (previous-trial high, previous-trial low).

Target-locked ERPs

For the ERP time-locked to the onset of the target, we examined an incongruency-related effect (the N_{inc}) and a Go/NoGo response inhibition-related effect. Based on previous literature (Donohue, Appelbaum, et al., 2016; Liotti, Woldorff, Perez, & Mayberg, 2000), we expected a centrally distributed negativity for the N_{inc} (incongruent minus congruent), occurring roughly between 300 and 600 ms. To refine the time window and distribution for this experiment, we isolated the effect via a collapsed localizer in which the difference wave of all incongruent minus all congruent trials was obtained. This revealed a time range (350–550 ms) and distribution (maximal at Cp1, Cp2, Pz, P3, P4) of this difference, which was subsequently examined for the effects of craving, switching and feedback. That is, the mean amplitudes for this time window averaged across the aforementioned sites were analysed in a 2 × 2 × 2 × 2 repeated measures ANOVA, with the factors of craving (craving, non-craving), task switching (switch, repeat), feedback (previous-trial high, previous-trial low) and incongruency (incongruent, congruent). Of note, as this effect was defined based on incongruency, a significant main effect of incongruency is circular; nevertheless, this was included as a factor in the ANOVA to track modulations of the incongruency effects by the other factors (i.e. to examine potential interactions). Based on previous literature, we expected to see two primary effects for the Go/NoGo component of the task: an N2 and a P300. Visual inspection of all NoGo minus all Go trials revealed no clear N2, and this component was therefore not analysed further. A clear P300 was present, however, maximal at site Cz, and lasting from 300 to 700 ms. The mean amplitudes were then extracted at this site for this time range and submitted to a 2 × 2 × 2 × 2 repeated measures ANOVA, with the factors of craving

TABLE 1 Task period, components, time windows and factors used in ERP analyses

Task Period	Component	Time Window	ANOVA Factors
Cue	P1	110–150 ms	Craving (craving, non-craving); Task Switching (switch, repeat); Previous Feedback (prev-high, prev-low)
Cue	CNV (early)	700–1,000 ms	Craving (craving, non-craving); Task Switching (switch, repeat); Previous Feedback (prev-high, prev-low)
Cue	CNV (late)	1,000–1,300 ms	Craving (craving, non-craving); Task Switching (switch, repeat); Previous Feedback (prev-high, prev-low)
Target	N_{inc}	350–550 ms	Craving (craving, non-craving); Task Switching (switch, repeat); Previous Feedback (prev-high, prev-low); Congruency (congruent, incongruent)
Target	P300 (Go/NoGo)	300–700 ms	Craving (craving, non-craving); Task Switching (switch, repeat); Previous Feedback (prev-high, prev-low); trial type (Go, NoGo)
Feedback	P300	300 – 400 ms	Craving (craving, non-craving); Feedback (high, low)

(craving, non-craving), task switching (switch, repeat), feedback (previous-trial high, previous-trial low) and trial type (Go, NoGo).

Feedback-locked ERPs

For feedback-locked activity, we examined the P300 component. Here, the distribution of this component (collapsed across types of feedback) revealed a brief peak around 350 ms at site Cz, and the time period around this peak (300–400 ms) was examined. Specifically, a 2 × 2 repeated measures ANOVA with the factors of craving (craving, non-craving) and feedback (current trial high, current trial low) was run to determine whether the P300 was modulated by these factors. As the number of incorrect trials was small, those were not included in this analysis. Of note, the results of all ANOVAs reported for all analyses are Greenhouse–Geisser corrected.

2.8 | Behavioural analysis

The behavioural analysis examined only those trials associated with artefact-free EEG data. Accuracy (error rates) and response times (RTs) were submitted to a 2 × 2 × 2 × 2 repeated measures ANOVA with the factors of craving (craving, non-craving), task switching (switch, repeat), congruency (incongruent, congruent) and feedback (previous-high vs. previous-low). Because incorrect feedback occurred on a very small number of trials, those trials following an incorrect response and corresponding feedback were excluded from this analysis in lieu of its inclusion as a 3rd level of the feedback factor. All values reported are Greenhouse–Geisser corrected.

2.9 | Supplementary analysis with gender as a factor

Previous work has found that males and females exhibit differential effects of smoking-related attentional capture (Perlato, Santandrea, Libera, & Chelazzi, 2014). To determine whether gender also influenced any of the effects in our study, we conducted an additional analysis on the behavioural and ERP data using gender as an additional factor in our ANOVAs (with all other factors kept the same). The results of these analyses are reported in the Supporting Information.

3 | RESULTS

3.1 | Questionnaires

Participants smoked on average 15 cigarettes per day (range: 10.0–22.5) and had an average FTND score of 4.1 (range = 1.0–6.0). To determine whether the craving manipulation was effective, we compared the two factors of the QSU (the anticipation of pleasure from smoking, and the anticipation of relief from negative symptoms by smoking; see Methods) for when subjects were craving and when they were non-craving. For both QSU factors, there was a highly significant effect of craving (Factor 1: mean non-craving = 4.18, mean craving = 5.65, $t(23) = 9.03$, $p < .001$; Factor 2: mean non-craving = 1.98, mean craving = 3.08, $t(23) = 7.54$, $p < .001$).

3.2 | Behaviour

The error rate data were submitted to a 2 × 2 × 2 × 2 repeated measures ANOVA with the factors of craving (craving, non-craving), task switching (switch, repeat), congruency (incongruent, congruent) and feedback (previous-high, previous-low). This analysis revealed a main effect of task switching ($F(1,23) = 15.01$, $p = .001$, $\eta_p^2 = 0.40$), with switch trials showing higher error rates than repeat trials, a main effect of feedback ($F(1,23) = 4.31$, $p = .049$, $\eta_p^2 = 0.16$), with participants being more accurate following a trial with low feedback, and a main effect of congruency ($F(1,23) = 86.89$, $p < .001$, $\eta_p^2 = 0.79$), with participants committing fewer errors on congruent trials than incongruent ones. Additionally, there was a trending interaction of craving by congruency ($F(1,23) = 3.00$, $p = .097$, $\eta_p^2 = 0.12$), a significant interaction of switching by congruency ($F(1,23) = 15.45$, $p = .001$, $\eta_p^2 = 0.40$) and a significant interaction of feedback by congruency ($F(1,23) = 7.91$, $p = .01$, $\eta_p^2 = 0.26$). No other main effects or interactions were significant (all $p's > 0.1$). The interaction of switching by congruency was driven by a difference between the incongruent conditions as a function of switching (repeat incongruent vs. switch incongruent, $t(23) = 4.45$, $p < .001$), with the switch incongruent condition inducing poorer performance, and no significant difference between the congruent conditions as a function of switching (repeat congruent vs. switch congruent, $p > .1$). The feedback by congruency interaction was driven by a significant difference between the incongruent conditions as a function of feedback (incongruent when previous-high feedback vs. incongruent when previous-low feedback, $t(23) = 3.88$, $p = .001$), with the performance on incongruent trials following low feedback being better than those following high feedback. There was no significant difference between the congruent trials as a function of feedback ($p > .1$). Figure 2a-b depicts the main effects and significant interactions for the error rate data. Of note, it is also the case that the number of false alarms to the NoGo stimuli did not differ as a function of craving (mean craving = 5.58, mean non-craving = 5.13, $p > .1$).

The RT data were also submitted to a 2 × 2 × 2 × 2 repeated measures ANOVA with the factors of craving

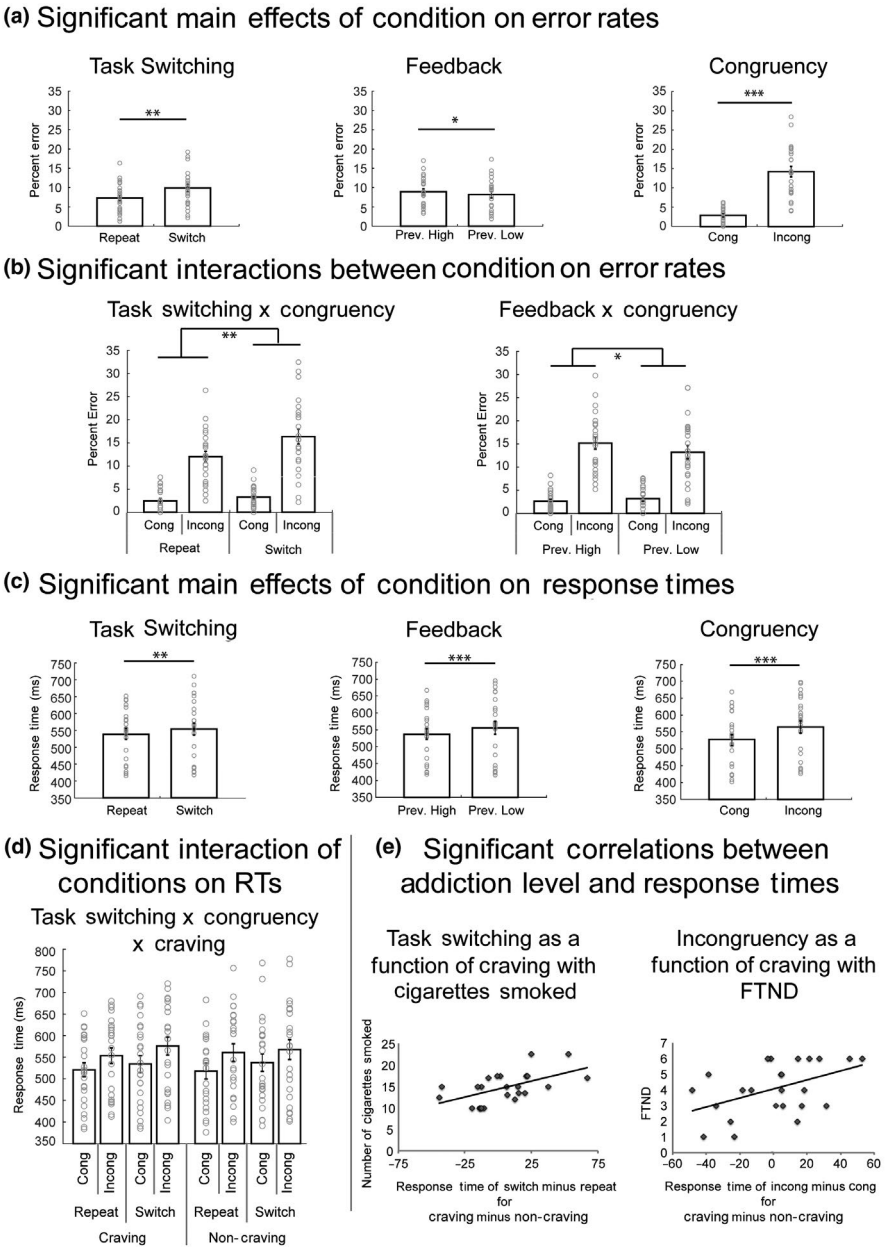


FIGURE 2 (a) Main Effects of Condition on Error Rates. All significant main effects are shown, with the expected modulations of switch costs and incongruency-related decreases in accuracy. (b) Significant interactions of condition on Error Rates. The effects of incongruency were larger under conditions of task switching, and the incongruency effect was larger for high previous feedback than for low previous feedback. (c) Main Effects of Condition on Response Times (RTs). Task switching and incongruency gave rise to slower RTs, as did trials following low feedback. (d) Significant 3-way interaction between Conditions on RTs. Here, craving interacted with switching and incongruency, indicating that craving modulated these control processes. Although significant differences are denoted in the above graphs with asterisks, as these interactions are more complicated, significant effects are not marked here in the figure (see text for details of significant differences). (e) Correlations Across Subjects between Addiction Level and RTs. The left graph shows the significant correlation between the average amount of cigarettes smoked per day and the switch costs as a function of craving. The right graph shows the significant correlation between the FTND (Fagerström Test for Nicotine Dependence) and the incongruency-related effects as a function of craving. In both cases, the more an individual smoked and was addicted to nicotine, the more these switch costs and incongruency-related costs were present when craving relative to when non-craving. *$p < .05$ to 0.01, **$p < .01$ to 0.001, ***$p < .001$. All error bars represent the standard error of the mean (*SEM*)

(craving, non-craving), task switching (switch, repeat), congruency (incongruent, congruent) and previous-trial feedback (high vs. low). This revealed a main effect of task switching ($F(1,23) = 13.17$, $p = .001$, $\eta_p^2 = 0.36$), a main effect of feedback ($F(1,23) = 21.97$, $p < .001$, $\eta_p^2 = 0.49$), a main effect of congruency ($F(1,23) = 54.35$, $p < .001$, $\eta_p^2 = 0.70$), a three-way interaction of craving by switching by congruency ($F(1,23) = 4.46$, $p = .046$, $\eta_p^2 = 0.16$) and a significant

four-way interaction of craving by feedback by switching by congruency ($F(1,23) = 11.52$, $p = .002$, $\eta_p^2 = 0.33$). The three-way interaction primarily appeared to be driven by a significant difference between the repeat incongruent and switch incongruent RTs in the craving condition ($t(23) = 2.99$, $p = .007$), with no such difference present in the non-craving condition between the repeat incongruent and switch incongruent RTs ($p < .1$). Figure 2c and d show the plots for the various significant effects for the response time data, and Table S1 shows the mean RT values for all conditions. Table S2 shows the results of the post hoc comparisons for the four-way interaction on the RT data.

In order to determine whether the level of nicotine dependence influenced the RTs as a function of condition and craving, we performed an exploratory correlational analysis on the RTs with two measures we obtained from the questionnaires (total FTND, total cigarettes smoked) as individual differences in task performance have previously been observed to be related to smoking behaviour (Libera, Zandonai, Zamboni, Santandrea, Sandri, Lugoboni, Chiamulera, & Chelazzi, 2019). Of note, although these two measures are closely related and tend to show a relationship with each other, they were not significantly correlated with each other ($r = .376$, $p = .07$) and were therefore examined independently. We hypothesized that the stronger the level of addiction, the more influence craving would have on task performance. To this end, we obtained the switch costs separately for craving and non-craving conditions (switch minus repeat); in this case, a greater number would suggest participants had more difficulty switching tasks. We then took the difference of these differences (i.e. craving minus non-craving). A positive number would suggest that the switch cost was greater under craving, and a negative number would suggest the switch cost was greater under non-craving conditions, with a difference of zero indicating these costs did not differ as a function of craving. Although there was no correlation between the FTND and the switch costs as a function of craving ($p = .5$), there was a significant correlation between the number of cigarettes smoked and the switch costs ($r = 0.562$, $p = .004$). Further, to determine how the incongruency effects that emerged as a function of craving were influenced by the level of nicotine dependence, we conducted an analogous analysis for the dependence measure. Specifically, we took the incongruent minus congruent RTs separately for craving and non-craving, and then subtracted the differences for non-craving from the differences for craving. As above, a positive number would suggest that greater incongruency effects were present when subjects were craving, and a more negative number would suggest that greater incongruency effects were present when subjects were non-craving. Although no significant correlation with the number of cigarettes per day was observed ($p = .28$), there was a significant relationship between the FTND and congruency effects ($r = .471$, $p = .02$). In both of these cases (as seen in Figure 2e), as the level of addiction to nicotine increased, so did the costs of switching and incongruency when subjects were craving.

3.3 | ERP results

3.3.1 | Cue processing

P1 effects

The sensory-evoked P1 component in response to the cue was examined as a function of craving, task switching and previous-trial feedback. Specifically, a 2 × 2 × 2 repeated measures ANOVA with the factors of craving (craving, non-craving), task switching (switch, repeat) and feedback (prev-high, prev-low) was conducted on the mean amplitude of the P1 (110–150 ms). For the P1, a marginal effect of craving emerged ($F(1,23) = 4.12$, $p = .054$, $\eta_p^2 = 0.15$), with the P1 tending to be larger when subjects were in a state of craving. Additionally, there was a significant interaction between craving and feedback ($F(1,23) = 5.84$, $p = .024$, $\eta_p^2 = 0.20$), and a significant 3-way interaction for craving × switching × feedback ($F(1,23) = 6.85$, $p = .02$, $\eta_p^2 = 0.23$). The two-way interaction was driven by a significant difference between craving and non-craving status in response to cues following high feedback ($t(23) = 2.65$, $p = .009$), with subjects showing a larger P1 following high feedback when craving. The 3-way interaction was mainly driven by the P1 amplitude for the craving repeat following high feedback being larger than that for several other conditions (versus craving repeat after low ($t(23) = 3.08$, $p = .005$; versus non-craving repeat after high ($t(23) = 3.48$, $p = .002$), versus craving switch after high ($t(23) = 3.08$, $p = .005$)).

CNV

A 2 × 2 × 2 repeated measures ANOVA was conducted on the mean amplitudes of the early (700–1,000 ms) and late (1,000–1,300 ms) phases of the CNV component, with the factors of craving (craving, non-craving), task switching (switch, repeat) and previous-trial feedback (prev-high, prev-low). In the early phase, there was a main effect of craving ($F(1,23) = 4.36$, $p = .048$, $\eta_p^2 = 0.16$), with subjects having a larger CNV when they were *not* craving. There was also a significant switching by feedback interaction ($F(1,23) = 6.92$, $p = .015$, $\eta_p^2 = 0.23$). In the later phase of the CNV, the main effect of craving was no longer present ($p = .8$), but a main effect of switching emerged ($F(1,23) = 5.78$, $p = .025$, $\eta_p^2 = 0.20$), with the CNV being larger for switch trials than repeat, and the switching by feedback interaction remained significant ($F(1,23) = 7.85$, $p = .01$, $\eta_p^2 = 0.25$). For both the early and the late phases of the CNV, the switching by feedback interaction was driven by a significant difference between repeat versus switch after

high feedback (early: $t(23) = 4.02$, $p = .001$; late: $t(23) = 4.58$, $p > .001$). Figure 3 shows the waveforms and mean amplitude graphs for the processing of the cue.

3.3.2 | Target processing

Based on previous work, we expected to see an incongruency-related effect occurring roughly 350–550 ms following target onset over posterior central scalp sites (see Methods for details). The mean response amplitude during this period was submitted to a 2 × 2 × 2 × 2 repeated measures ANOVA with the factors of craving (craving, non-craving), task switching (switch, repeat), feedback on the previous trial (prev-high, prev-low), and congruency (congruent, incongruent). This revealed a main effect of congruency ($F(1,23) = 16.99$, $p < .001$, $\eta_p^2 = 0.43$), with incongruent trials showing the expected enhanced relative negativity compared to congruent trials. There was also a trending main effect of feedback ($F(1,23) = 4.04$, $p = .06$, $\eta_p^2 = 0.15$), with trials following low feedback tending to show more of a negativity relative to trials following high feedback. Additionally, a significant 3-way interaction between craving, task switching and congruency ($F(1,23) = 6.76$, $p = .02$, $\eta_p^2 = 0.23$) was present. Figure 4 depicts the significant effects. Post hoc t tests revealed that this interaction was primarily driven by the presence of significant differences between incongruent and congruent trial types for non-craving repeat congruent versus non-craving repeat incongruent ($t(23) = 4.76$, $p < .001$), craving repeat congruent versus craving repeat incongruent ($t(23) = 2.12$, $p = .04$), and craving switch congruent versus craving switch incongruent ($t(23) = 3.90$, $p = .001$), but not between non-craving switch congruent versus non-craving switch incongruent ($p = .54$). Further, a significant difference between non-craving repeat congruent and non-craving switch congruent was the final significant

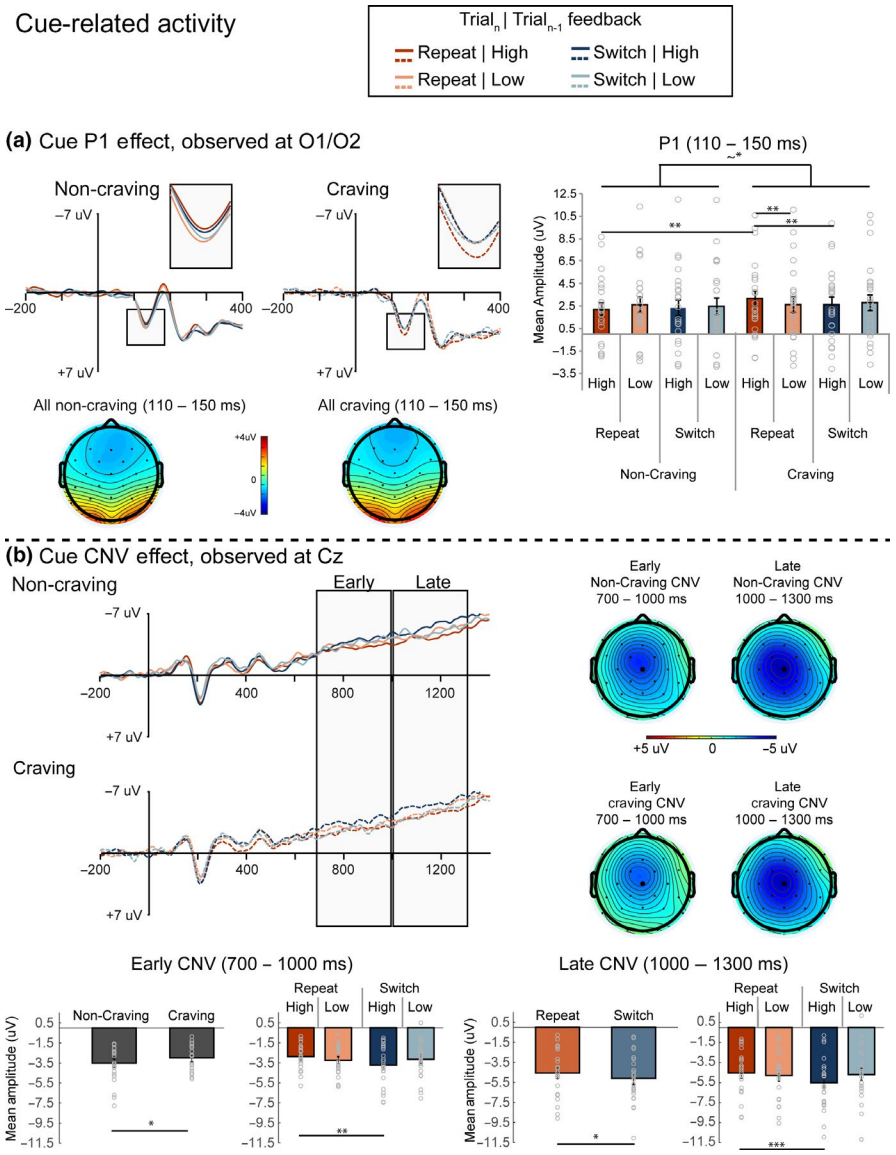


FIGURE 3 Cue-Related Activity. Note, legend presented above A applies to both parts of the figure, and all instances where "high" or "low" are written refers to the feedback received on the previous trial. (a) P1. The sensory-evoked P1 (110–150 ms) is depicted here, zoomed in for the traces and with mean amplitudes for each condition shown in the bar graphs. The topographic maps (lower right) show the distribution of this effect (posterior positivity) collapsed across all conditions for craving and for non-craving. (b) CNV. The CNV was analysed in an early (700–1,000 ms) and a late (1,000–1,300 ms) time period, depicted separately for non-craving and craving for task switching and previous-trial feedback conditions. Topographic distributions (right) show the CNV for these respective time periods, collapsed across all conditions for craving and all conditions when non-craving. The thick black dot in the centre of the topomaps highlights site Cz where the statistical analyses were conducted. *$p < .05$ to .01, **$p < .01$ to .001, ***$p < .001$. All error bars represent the standard error of the mean (*SEM*). [Colour figure can be viewed at wileyonlinelibrary.com]

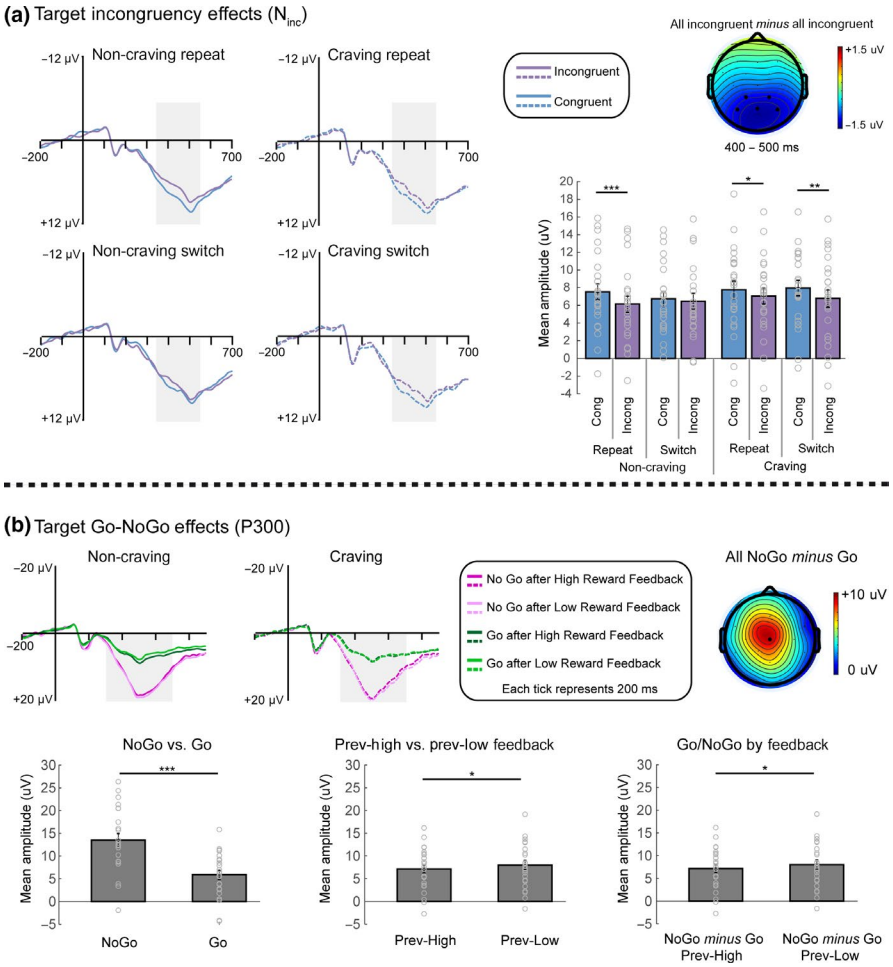


FIGURE 4 Target-Related Effects. (a) The incongruency-related effect, the N_{inc} (measured from 350–550 ms, grey shaded area), is depicted here for each craving condition and task type separately. As can be seen, the N_{inc} was significantly present as the difference of incongruent versus congruent trial types, except in the instance of the non-craving switch condition. Topographic distribution is shown for all conditions of incongruent minus congruent, with black dots representing the ROI used for statistical analyses. (b) The Go/NoGo-related effects were observed as a larger P300 (measured from 300 to 700 ms depicted in the grey shaded area) for NoGo trials relative to Go. The black dot on the topographic distribution indicates the site, Cz, where the P300 was measured, and the topographic distribution is averaged from 400 to 600 ms. *$p < .05$ to .01, **$p < .01$ to .001, ***$p < .001$. All error bars represent the standard error of the mean (*SEM*). [Colour figure can be viewed at wileyonlinelibrary.com]

difference observed, which appeared to be driving the interaction ($t(23) = 3.25$, $p = .004$).

The Go/NoGo component of the task was also examined to determine whether there were any effects or interactions with craving. Specifically, for the P300 (300–700 ms) at site Cz, a 2 × 2 × 2 × 2 repeated measures ANOVA was conducted with the factors of craving (craving, non-craving), task switching (switch, repeat), feedback on the previous trial (prev-high, prev-low) and trial type (Go, NoGo). As expected, there was a highly significant effect of trial type, with NoGo trials having a larger P300 response than Go trials ($F(1,23) = 60.91$, $p < .001$, $\eta_p^2 = 0.73$). There was a significant interaction between trial type and feedback ($F(1,23) = 6.89$, $p = .015$, $\eta_p^2 = 0.23$), and a trending interaction between task switching and previous feedback ($F(1,23) = 3.64$, $p = .07$, $\eta_p^2 = 0.14$). The trial type by feedback interaction was the result of there being a larger difference between go and NoGo trials following low compared with high previous feedback.

3.3.3 | Feedback processing

The neural response to the feedback was reflected in the presence of a P300 component, and the mean amplitudes of which were submitted to a 2 × 2 repeated measures ANOVA with the factors of craving (craving, non-craving) and current feedback level (high reward, low reward). This revealed only a significant effect of feedback level, with the P300 being larger when participants received a low reward ($F(1,23) = 27.12$, $p < .001$, $\eta_p^2 = 0.54$). Craving did not impact the processing of the feedback stimulus, either through a main effect or by interacting with the type of feedback the participants received. Figure 5 depicts the feedback-related waveforms.

4 | DISCUSSION

In the present study, we investigated the impact of craving on several cognitive control processes (task switching, response inhibition, incongruency) in smokers when they had recently smoked (non-craving) and when they had been deprived of smoking for three hours (craving). The interactions of craving with these control processes were complex, as discussed in detail below, but its influence seemed to primarily manifest as decreased preparation for an upcoming target and subsequent increased incongruency effects. Importantly, craving did not interact with inhibitory

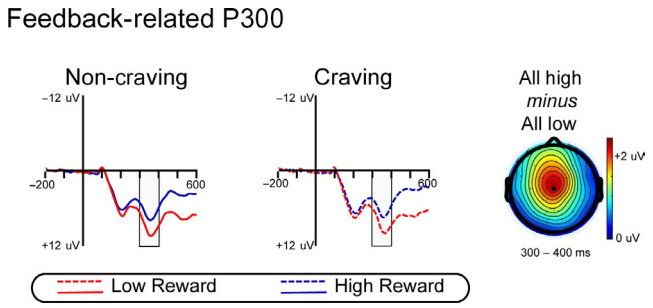


FIGURE 5 Feedback-Related Effects. The waveforms shown are for the P300 (300 to 400, indicated in the box) at site Cz. The P300 was larger in response to low reward than high reward, but this did not interact with craving. The topographic distribution shows the P300 for high reward minus low reward, collapsed across craving. [Colour figure can be viewed at wileyonlinelibrary.com]

control processes or current trial feedback-related processes, suggesting that a brief period of nicotine deprivation selectively influences cognitive control processes.

4.1 | Behavioural effects of switching and incongruency regardless of craving state

Regardless of whether or not smokers were craving, the task used here elicited the expected behavioural effects. Specifically, for both the accuracy and RT data, participants showed the expected performance decrements when they had to switch tasks and when the target stimulus was incongruent. Such behavioural effects are in line with what has previously been reported for tasks involving task switching (e.g. Braver, Reynolds, & Donaldson, 2003) and incongruency (MacLeod, 1991), and confirm that our paradigm was able to elicit similar robust effects. Together, these main effects on behaviour indicate under conditions of craving and non-craving this task was tapping into the intended cognitive control processes.

4.2 | Main effects of craving

As we found previously (Donohue, Woldorff, et al., 2016), craving has a general effect on overall arousal. Here, when we examined the effects of craving on the P1 component in response to the cue stimuli, we found that this component was (marginally) enhanced when participants were in a state of craving. This effect thus replicates our prior results and suggests that across multiple tasks smokers are in a heightened attentional state when they have not smoked for several hours. Interestingly, in the current study, this did not ramify as overall faster RTs or enhancement across all later components, suggesting that this heightened arousal does not necessarily provide any general cognitive benefit, particularly in tasks where control-related processes must be recruited.

The other main effect of craving observed was a decreased amplitude in the CNV under conditions of craving. This difference was short-lived and was observed only in the early time window of the CNV. Nevertheless, it is likely that this lack of initial preparation had consequences for subsequent target processing. As the CNV appears to increase with more cognitive effort (Falkenstein, Hoormann, Hohnsbein, & Kleinsorge, 2003), it could be the case that early on, smokers were not able to mobilize as much preparatory effort (e.g. keeping in working memory what the upcoming task would be, what the corresponding response buttons were, attentional-focus preparation), and this happened regardless of whether or not the task was repeated or switched. It is conceivable that craving puts smokers in an attentional state that is less proactive (Braver, 2012), which, in this case, manifested as reduced preparatory activity reflected in the CNV.

4.3 | Interactions between craving, task switching and incongruency

Although smokers were able to essentially "catch up" on the amount of preparatory activity they invoked when craving, as indicated by a lack of a difference in the late CNV amplitude, it would appear that the lack of early preparation did indeed have consequences when the target appeared, particularly in the case when participants had to switch tasks and/or an incongruent stimulus were present. In both the behavioural data and the target-related N_{inc} response, there was a three-way interaction present between craving, task switching and incongruency, which, albeit through different effects, manifested as a lack of preparatory up-regulation when smokers were craving and needed to switch tasks, resulting in larger incongruency-related effects for the target stimulus.

When smokers were in a non-craving state, the incongruency-related differences (in the N_{inc} component) were not present under conditions of switching, whereas they were under conditions of repeating. What this suggests is that when subjects were switching tasks and not craving, they had sufficient cognitive control resources and were so focused on the task that, once the target appeared, regardless of whether or not it was congruent or incongruent, they were able to attend to the relevant feature and block out the irrelevant information. When the task repeated, and they were not in a state of craving, the smokers appeared to have invoked less control and therefore had a greater reaction to the incongruent stimuli. This general pattern of activity has been seen in other domains of conflict-related cognitive control. For example, tasks looking at conflict-adaptation effects have

demonstrated that when incongruent trials follow an incongruent trial, responses are faster, ACC conflict-related activity is decreased, and DLPFC activity is increased, relative to when incongruent trials follow a congruent trial (Egner & Hirsch, 2005; Gratton, Coles, & Donchin, 1992; Kerns, Cohen, & MacDonald, Cho, Stenger, & Carter, 2004). In those cases, the increased preparation comes from a previous-incongruent trial, which is a challenging event and subjects often respond with increased preparation for the next trial. Here, the switch itself is what is more challenging and necessitates the increased preparation. This would suggest that when smokers were not craving, they were more flexibly using cognitive control and thus modulating the amount of activity necessary as a function of the task.

In contrast, when the smokers were craving, the incongruency effects for switches and repeats were similar. That is, these conflict-adaptation-like effects were not present, suggesting that they were not modulating the level of control as a function of switching/repeating tasks. This ramified behaviourally in that when participants were craving, the incongruent trials on the switch condition elicited longer RTs than incongruent trials on the repeat condition. This suggests that participants were experiencing more conflict under conditions of craving and switching. This was confirmed in the neural data, where, for both switching and repeating, a significant incongruency-related N_{inc} effect was present, whereas when smokers were not in a state of craving, this incongruency-related effect was only present for repeat trials. Increased incongruency effects in a Stroop conflict task have also been observed in a study looking at smokers who failed to quit (i.e. those who could not overcome their level of craving) relative to those who successfully quit (Krönke, Wolff, Benz, & Goschke, 2015). Although that study did not measure the levels of craving in its participants, their data do suggest that smokers who are able to successfully quit (and inhibit/overcome craving overall) have enhanced levels of cognitive control, which our participants were not showing in their state of craving.

Together, the current results suggest that craving shifts participants to a more reactive state, wherein cognitive control processes are not as strongly (or reliably) invoked. A behavioural study specifically looking at task switching found that deprived smokers showed less flexibility compared with non-deprived smokers and controls (Lyvers, Maltzman, & Clinical, 1994), which would generally support our neural findings here. Although we had hypothesized, based on previous literature, that task switching would be more strongly impacted by craving than incongruency, the current data suggest that they are both impacted. Importantly, however, there was no significant craving by incongruency interaction either behaviourally or neurally (with the N_{inc} component), and there was also no craving by switching interaction (behaviourally or neurally) present. Only when both incongruency and task switching were considered, did we observe a significant (3-way) interaction between these factors and craving. That is, in the early stages of nicotine deprivation, smokers exhibit impairment in cognitive control when these processes are pitted together. Moreover, the level of smoking here, as measured in cigarettes per day, strongly correlated with the behavioural task switching costs as a function of craving, with heavier smokers showing increased performance decrements when craving, while the incongruency-related costs correlated with the level of nicotine dependence in the FTND. It may, therefore, be the case that had we measured smokers with a larger consumption (> a pack/day) and/or given our smokers a longer period of abstinence, individual craving by switching and craving by incongruency interactions would have emerged. Regardless, speaks to the disruptiveness that craving can cause when it comes to these control processes, and underscores the necessity to curb its influence for successful smoking cessation.

4.4 | Craving and response inhibition

Importantly, craving did not modulate all control processes. It did not have an influence on the inhibitory processes, with the caveat that only the P300 and behaviour were examined here, as there was no clear difference in the N2 between the Go and NoGo conditions. At first glance, this lack of a difference on the P300 is a bit surprising, both given that craving did influence the other control-related tasks and that smokers appear to have deficits in inhibitory control, as has been observed in other Go/NoGo tasks (e.g. Evans et al., 2009). In fact, given the interactions between craving and task switching and incongruency, one would predict that, at the very least, craving would have also interacted with inhibition as a function of task switching. Nevertheless, no influence of craving on inhibitory control in and of itself or in combination with other factors was observed. The task used here, however, was a hybrid of many control-related tasks, and not just a Go/NoGo task, and it is possible that because an increased level of control may have been required (Chmielewski & Beste, 2017), the smokers were already at ceiling for their inhibition, even when craving. Moreover, given that subjects knew that they needed to remain in the room and not go out and smoke, they may have already activated a certain level of longer-lasting inhibitory control to accomplish this, which could have transferred over to the task in the craving session, during which remaining in the experiment and not smoking would have been particularly challenging. It could also be the case that after only a short deprivation, inhibitory deficits are not found, as they have been shown to emerge only after longer (e.g. 10–72 hr) periods of abstinence in other studies examining inhibition in

smokers (Charles-Walsh, Furlong, Munro, & Hester, 2014; Harrison, Coppola, & McKee, 2009; Lydon et al., 2015; Tsaur, Strasser, Souprountchouk, Evans, & Ashare, 2015).

4.5 | The influence of feedback

Feedback, like inhibitory control, did not modulate the P300 response as a function of craving. Because this ramified into how soon the smokers could leave the experiment (the more high feedback they got, the sooner the experiment ended), we had expected to see a stronger differentiation between high and low feedback under conditions of craving versus non-craving, but this was not the case. Regardless of the session, participants displayed a stronger neural response to the low feedback versus the high, suggesting that they were either surprised by it (Squires, Wickens, Squires, & Donchin, 1976) or that their attention was more captured by it, perhaps because of the motivational salience (Nieuwenhuis, Aston-Jones, & Cohen, 2005) of this feedback (i.e. low feedback requires more time spent in the experiment).

Although the feedback-related response was not modulated by craving on the current trial, the feedback participants received on the previous trial did influence both the cue and target processing on the current one, where it did interact with craving. The first manifestation of this occurred at the level of the P1, where the amplitude of this component was highest when subjects were in a craving state and when they received a cue for a repeat trial after receiving high feedback. In addition to overall arousal, the amplitude of the P1 is known to vary with the amount of attention allocated to a stimulus, with higher amplitudes indicating greater attention (e.g. Heinze et al., 1994). Here, it is likely that the smokers were in fact motivated by the high feedback (both with the inherent value of more points, and what that meant for them leaving earlier and getting to smoke sooner), and by the fact that a repeat trial indicated that they needed less cognitive control to solve the task, making this trial a "cognitive win" of sorts. The high feedback also yielded a stronger difference in the CNV activity on the switch versus repeat trials, with smokers showing an increased CNV following high feedback on a switch trial compared with a repeat trial. Perhaps the reward from having just received a high feedback was motivation enough for the smokers to engage these preparatory regions a bit more when the upcoming task was a switch and therefore involved more control.

Behaviourally, feedback on the previous trial modulated the response on the current trial, with participants being more accurate but slower after low versus high feedback. The modulation of behaviour by feedback from the previous trial suggests that the smokers were sensitive to this form of reward manipulation. Although they were not receiving money based on their performance, the positive but low feedback and the notion that wining enough points would let them go early was enough to consistently slow their performance after a lower amount of points to ensure accuracy. To date, there is some evidence to suggest that feedback processing (on correct vs. incorrect trials) may be altered in smokers compared with controls, particularly for the later-stage components of feedback processing (the Pe; Franken, Strien, & Kuijpers, 2010). Our data suggest that craving may also influence this processing, not on the present trial, but moving forward to the next trial, indicating the complex interaction craving may have with motivation.

4.6 | Nicotine enhancement versus deprivation

The results presented here have been considered in terms of the influence of craving on these control processes. It is also important, however, to consider that nicotine itself has a modulating effect on cognition (see Newhouse, Potter, Dumas, & Thiel, 2011 for review). When non-smokers have been administered nicotine, nicotine has been found to increase response speed in attention-related tasks (Foulds et al., 1996; Griesar, Zajdel, & Oken, 2002; Meinke, Thiel, & Fink, 2006), despite not showing any effects on early EEG attentional components (P1 and N1; Meinke et al., 2006). Interestingly, the P3a and P3b components (indices of cognitive control processes) were not altered in an oddball task when non-smokers were administered nicotine versus placebo (Evans, Jentink, Sutton, Rensburg, & Drobes, 2014). Taken together, these results suggest that while nicotine does improve response speed, its direct effect on attention and control-related processes may be limited, too small to be characterized with EEG, or only present in a subgroup of subjects (see Logemann, Böcker, Deschamps, Kemner, & Kenemans, 2014 who observed effects on the N1 in subjects who also showed large changes in blood pressure in response to nicotine administration).

In smokers, of course, it cannot be fully determined if the effects observed as a function of smoking/nicotine deprivation versus administration are due to the enhancement of performance from nicotine, or the relative decrement of performance from craving. Given that the neural effects of nicotine administration in non-smokers are rather limited, it is likely that the results we see here are the result of craving altering these measures, rather than nicotine altering them. Moreover, we did not see overall changes in RTs as a function of smoking, suggesting that our pattern of results is more complex than just the nicotine-enhanced response speed. Nevertheless, more research needs to be conducted to fully assess the influence of nicotine on a wider variety of cognitive tasks and circumstances. Of note, there is some evidence (albeit in a small sample), that in a smoker three hours after

smoking a cigarette, the majority of receptors in the brain are still occupied by nicotine (Brody et al., 2006), suggesting that our deprivation period may not have been long enough to see strong nicotine-related effects, while still long enough to induce the feeling of craving, as assessed by the questionnaire (QSU) data.

5 | CONCLUSION

The present study demonstrated that cognitive control processes are impaired in smokers when they are craving as compared to when they are sated. Specifically, craving smokers were less able to flexibly implement cognitive control, which manifested as increased deficits on task switching and incongruency processing. Importantly, the disruption in cognitive control by craving was not present for every form of control, indicating that craving is not general in its actions, but specific control-related processes are affected. Even in the absence of nicotine-related cues, and after only three hours of deprivation, craving had an impact on both behavioural and neural measures of cognitive control. This further bolsters the notion that the difficulty many people have in quitting an addiction is not just due to a general impairment in control systems, but that they may be further impaired when trying to abstain (and thus are craving), increasing the likelihood of a relapse.

ACKNOWLEDGEMENTS

The authors thank Steffi Bachmann for her help with participant recruitment and data acquisition. This work is supported by DFG SFB779 TPA14N awarded to S.E.D., J.A.H. and M.A.S.

CONFLICT OF INTEREST

The authors have no conflicts of interest to declare.

AUTHOR CONTRIBUTIONS

S.E.D., J.A.H. and M.A.S. designed the experiment. S.E.D. collected the data and S.E.D. analysed the data. K.L. provided analytical tools. J.M.H. and H.J.H. provided conceptual input throughout the project. S.E.D. wrote the manuscript. M.G.W., J.A.H. and M.A.S. edited the manuscript.

DATA AVAILABILITY STATEMENT

The data from this study are available from the corresponding author upon reasonable request.

ORCID

Sarah E. Donohue https://orcid.org/0000-0002-2790-2552
Mircea A. Schoenfeld https://orcid.org/0000-0001-9003-4092

REFERENCES

Albert, J., López-Martín, S., Hinojosa, J. A., & Carretié, L. (2013). Spatiotemporal characterization of response inhibition. *NeuroImage*, *76*, 272–281. https://doi.org/10.1016/j.neuroimage.2013.03.011

Astle, D. E., Jackson, G. M., & Swainson, R. (2006). Dissociating neural indices of dynamic cognitive control in advance task-set preparation: An ERP study of task switching. *Brain Research*, *1125*, 94–103. https://doi.org/10.1016/j.brainres.2006.09.092

Astle, D. E., Jackson, G. M., & Swainson, R. (2008). Fractionating the cognitive control required to bring about a change in task: A dense-sensor event-related potential study. *Journal of Cognitive Neuroscience*, *20*, 255–267. https://doi.org/10.1162/jocn.2008.20015

Badre, D., & Nee, D. E. (2018). Frontal cortex and the hierarchical control of behavior. *Trends in Cognitive Sciences*, *22*, 170–188. https://doi.org/10.1016/j.tics.2017.11.005

Banich, M. T. (2009). Executive function: The search for an integrated account. *Current Directions in Psychological Science*, *18*, 89–94. https://doi.org/10.1111/j.1467-8721.2009.01615.x

Belin, D., Belin-Rauscent, A., Murray, J. E., & Everitt, B. J. (2013). Addiction: Failure of control over maladaptive incentive habits. *Current Opinion in Neurobiology*, *23*(4), 564–572. https://doi.org/10.1016/j.conb.2013.01.025

Bilano, V., Gilmour, S., Moffiet, T., Turasan d'Espaignet, E., Stevens, G. A., Commar, A., … Shibuya, K. (2015). Global trends and projections for tobacco use, 1990–2025: An analysis of smoking indicators from the WHO Comprehensive Information Systems for Tobacco Control. *The Lancet*, *385*, 966–976. https://doi.org/10.1016/S0140-6736(15)60264-1

Billieux, J. L., Gay, P., Rochat, L., Khazaal, Y., Zullino, D., & Van der Linden, M. (2010). Lack of inhibitory control predicts cigarette smoking dependence: Evidence from a non-deprived sample of light to moderate smokers. *Drug and Alcohol Dependence*, *112*, 164–167. https://doi.org/10.1016/j.drugalcdep.2010.06.006

Braver, T. S. (2012). The variable nature of cognitive control: A dual mechanisms framework. *Trends in Cognitive Sciences*, *16*, 105–112. https://doi.org/10.1016/j.tics.2011.12.010

Braver, T. S., Reynolds, J. R., & Donaldson, D. I. (2003). Neural mechanisms of transient and sustained cognitive control during task switching. *Neuron*, *39*, 713–726. https://doi.org/10.1016/S0896-6273(03)00466-5

Brody, A. L., Mandelkern, M. A., London, E. D., Olmstead, R. E., Farahi, J., Scheibal, D., … Mukhin, A. G. (2006). Cigarette smoking saturates brain alpha 4 beta 2 nicotinic acetylcholine receptors. *Archives of General Psychiatry*, *63*, 907–915.

Buzzell, G. A., Fedota, J. R., Roberts, D. M., & McDonald, C. G. (2014). The N2 ERP component as an index of impaired cognitive control in smokers. *Neuroscience Letters*, *563*, 61–65. https://doi.org/10.1016/j.neulet.2014.01.030

Carter, B. L., & Tiffany, S. T. (1999). Meta-analysis of cue-reactivity in addiction research. *Addiction*, *94*, 327–340. https://doi.org/10.1046/j.1360-0443.1999.9433273.x

Carter, C. S. (1998). Anterior cingulate cortex, error detection, and the online monitoring of performance. *Science*, *280*, 747–749. https://doi.org/10.1126/science.280.5364.747

Carter, C. S., & van Veen, V. (2007). Anterior cingulate cortex and conflict detection: An update of theory and data. *Cognitive, Affective, & Behavioral Neuroscience*, *7*, 367–379. https://doi.org/10.3758/CABN.7.4.367

Charles-Walsh, K., Furlong, L., Munro, D. G., & Hester, R. (2014). Inhibitory control dysfunction in nicotine dependence and the influence of short-term abstinence. *Drug and Alcohol Dependence*, *143*, 81–86. https://doi.org/10.1016/j.drugalcdep.2014.07.008

Chmielewski, W. X., & Beste, C. (2017). Testing interactive effects of automatic and conflict control processes during response inhibition – A system neurophysiological study. *NeuroImage*, *146*, 1149–1156. https://doi.org/10.1016/j.neuroimage.2016.10.015

Crone, E. A., Wendelken, C., Donohue, S. E., & Bunge, S. A. (2006). Neural evidence for dissociable components of task-switching. *Cerebral Cortex*, *16*, 475–486. https://doi.org/10.1093/cercor/bhi127

Dawkins, L., Powell, J. H., West, R., Powell, J., & Pickering, A. (2007). A double-blind placebo-controlled experimental study of nicotine: II—Effects on response inhibition and executive functioning. *Psychopharmacology (Berl)*, *190*, 457–467. https://doi.org/10.1007/s00213-006-0634-6

Delorme, A., & Makeig, S. (2004). EEGLAB: An open source toolbox for analysis of single-trial EEG dynamics including independent component analysis. *Journal of Neuroscience Methods*, *134*, 9–21. https://doi.org/10.1016/j.jneumeth.2003.10.009

Dinn, W. M., Aycicegi, A., & Harris, C. L. (2004). Cigarette smoking in a student sample: Neurocognitive and clinical correlates. *Addictive Behaviors*, *29*, 107–126. https://doi.org/10.1016/j.addbeh.2003.07.001

Donohue, S. E., Appelbaum, L. G., McKay, C. C., & Woldorff, M. G. (2016). The neural dynamics of stimulus and response conflict processing as a function of response complexity and task demands. *Neuropsychologia*, *84*, 1–15. https://doi.org/10.1016/j.neuropsychologia.2016.01.035

Donohue, S. E., Woldorff, M. G., Hopf, J.-M., Harris, J. A., Heinze, H.-J., & Schoenfeld, M. A. (2016). An electrophysiological dissociation of craving and stimulus-dependent attentional capture in smokers. *Cognitive, Affective, & Behavioral Neuroscience*, *16*, 1–13. https://doi.org/10.3758/s13415-016-0457-9

Egner, T., & Hirsch, J. (2005). Cognitive control mechanisms resolve conflict through cortical amplification of task-relevant information. *Nature Neuroscience*, *8*, 1784–1790. https://doi.org/10.1038/nn1594

Evans, D. E., Jentink, K. G., Sutton, S. K., Van Rensburg, K. J., & Drobes, D. J. (2014). 7 mg nicotine patch fails to enhance P300 neural indices of cognitive control among nonsmokers. *Pharmacology, Biochemistry and Behavior*, *126*, 77–82. https://doi.org/10.1016/j.pbb.2014.09.001

Evans, D. E., Park, J. Y., Maxfield, N., & Drobes, D. J. (2009). Neurocognitive variation in smoking behavior and withdrawal: Genetic and affective moderators. *Genes, Brain and Behavior*, *8*, 86–96. https://doi.org/10.1111/j.1601-183X.2008.00445.x

Falkenstein, M., Hoormann, J., Hohnsbein, J., & Kleinsorge, T. (2003). Short-term mobilization of processing resources is revealed in the event-related potential. *Psychophysiology*, *40*, 914–923. https://doi.org/10.1111/1469-8986.00109

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*, 175–191. https://doi.org/10.3758/BF03193146

Fedota, J. R., Matous, A. L., Salmeron, B. J., Gu, H., Ross, T. J., & Stein, E. A. (2016). Insula demonstrates a non-linear response to varying demand for cognitive control and weaker resting connectivity with the executive control network in smokers. *Neuropsychopharmacology*, *41*, 2557–2565. https://doi.org/10.1038/npp.2016.62

Ferguson, S. G., & Shiffman, S. (2009). The relevance and treatment of cue-induced cravings in tobacco dependence. *Journal of Substance Abuse Treatment*, *36*, 235–243. https://doi.org/10.1016/j.jsat.2008.06.005

Flaudias, V., Picot, M. C., Lopez-Castroman, J., Llorca, P.-M., Schmitt, A., Perriot, J., … Guillaume, S. (2016). Executive functions in tobacco dependence: Importance of inhibitory capacities. *PLoS ONE*, *11*, e0150940–e151012. https://doi.org/10.1371/journal.pone.0150940

Foulds, J., Stapleton, J., Swettenham, J., Bell, N., McSorley, K., & Russell, M. A. (1996). Cognitive performance effects of subcutaneous nicotine in smokers and never-smokers. *Psychopharmacology (Berl)*, *127*, 31–38. https://doi.org/10.1007/BF02805972

Franken, I. H. A., Van Strien, J. W., & Kuijpers, I. (2010). Evidence for a deficit in the salience attribution to errors in smokers. *Drug and Alcohol Dependence*, *106*, 181–185. https://doi.org/10.1016/j.drugalcdep.2009.08.014

Garavan, H., Ross, T. J., & Stein, E. A. (1999). Right hemispheric dominance of inhibitory control: An event-related functional MRI study. *Proceedings of the National Academy of Sciences of the United States of America*, *96*, 8301–8306.

Glass, J. M., Buu, A., Adams, K. M., Nigg, J. T., Puttler, L. I., Jester, J. M., & Zucker, R. A. (2009). Effects of alcoholism severity and smoking on executive neurocognitive function. *Addiction*, *104*, 38–48. https://doi.org/10.1111/j.1360-0443.2008.02415.x

Goldstein, R. Z., & Volkow, N. D. (2011). Dysfunction of the prefrontal cortex in addiction: Neuroimaging findings and clinical implications. *Nature Reviews Neuroscience*, *12*, 652–669. https://doi.org/10.1038/nrn3119

Gratton, G., Coles, M. G., & Donchin, E. (1992). Optimizing the use of information: Strategic control of activation of responses. *Journal of Experimental Psychology: General*, *121*, 480–506. https://doi.org/10.1037/0096-3445.121.4.480

Gratton, G., Cooper, P., Fabiani, M., Carter, C. S., & Karayanidis, F. (2017). Dynamics of cognitive control: Theoretical bases, paradigms, and a view for the future. *Psychophysiology*, *310*, 1–29.

Griesar, W. S., Zajdel, D. P., & Oken, B. S. (2002). Nicotine effects on alertness and spatial attention in non-smokers. *Nicotine & Tobacco Research*, *4*, 185–194. https://doi.org/10.1080/14622200210123617

Harper, J., Malone, S. M., & Bernat, E. M. (2014). Theta and delta band activity explain N2 and P3 ERP component activity in a go/no-go task. *Clinical Neurophysiology*, *125*, 124–132. https://doi.org/10.1016/j.clinph.2013.06.025

Harrison, E. L. R., Coppola, S., & McKee, S. A. (2009). Nicotine deprivation and trait impulsivity affect smokers' performance on cognitive tasks of inhibition and attention. *Experimental and Clinical Psychopharmacology*, *17*, 91–98. https://doi.org/10.1037/a0015657

Heatherton, T. F., Kozlowski, L. T., Frecker, R. C., & Fagerström, K. O. (1991). The Fagerström test for nicotine dependence: A revision of the Fagerström tolerance questionnaire. *British Journal of Addiction*, *86*, 1119–1127.

Heinze, H. J., Mangun, G. R., Burchert, W., Hinrichs, H., Scholz, M., Münte, T. F., … Hillyard, S. A. (1994). Combined spatial and temporal imaging of brain activity during visual selective attention in humans. *Nature*, *372*, 543–546. https://doi.org/10.1038/372543a0

Helfrich, R. F., & Knight, R. T. (2016). Oscillatory dynamics of prefrontal cognitive control. *Trends in Cognitive Sciences*, *20*, 916–930. https://doi.org/10.1016/j.tics.2016.09.007

Hopf, J.-M., Luck, S. J., Girelli, M., Hagner, T., Mangun, G. R., Scheich, H., & Heinze, H. J. (2000). Neural sources of focused attention in visual search. *Cerebral Cortex*, *10*, 1233–1241. https://doi.org/10.1093/cercor/10.12.1233

Huster, R. J., Enriquez-Geppert, S., Lavallee, C. F., Falkenstein, M., & Herrmann, C. S. (2013). Electroencephalography of response inhibition tasks: Functional networks and cognitive contributions. *International Journal of Psychophysiology*, *87*, 217–233. https://doi.org/10.1016/j.ijpsycho.2012.08.001

Kerns, J. G., Cohen, J. D., MacDonald, A. W., Cho, R. Y., Stenger, A., & Carter, C. S. (2004). Anterior cingulate conflict monitoring and adjustments in control. *Science*, *303*, 1023–1026. https://doi.org/10.1126/science.1089910

Killen, J. D., & Fortmann, S. P. (1997). Craving is associated with smoking relapse: Findings from three prospective studies. *Experimental and Clinical Psychopharmacology*, *5*, 137–142. https://doi.org/10.1037/1064-1297.5.2.137

Krönke, K.-M., Wolff, M., Benz, A., & Goschke, T. (2015). Successful smoking cessation is associated with prefrontal cortical function during a Stroop task: A preliminary study. *Psychiatry Research: Neuroimaging*, *234*, 52–56.

Libera Della, C., Zandonai, T., Zamboni, L., Santandrea, E., Sandri, M., Lugoboni, F., Chiamulera, C., & Chelazzi, L. (2019). Revealing dissociable attention biases in chronic smokers through an individual-differences approach. *Scientific Reports*, *9*, 1–12.

Liotti, M., Woldorff, M. G., Perez, R., & Mayberg, H. S. (2000). An ERP study of the temporal course of the Stroop color-word interference effect. *Neuropsychologia*, *38*, 701–711. https://doi.org/10.1016/S0028-3932(99)00106-2

Logemann, H. N. A., Böcker, K. B. E., Deschamps, P. K. H., Kemner, C., & Kenemans, J. L. (2014). The effect of the augmentation of cholinergic neurotransmission by nicotine on EEG indices of visuospatial attention. *Behavioural Brain Research*, *260*, 67–73. https://doi.org/10.1016/j.bbr.2013.11.044

Lopez-Calderon, J., & Luck, S. J. (2014). ERPLAB: An open-source toolbox for the analysis of event-related potentials. *Frontiers in Human Neuroscience*, *8*, 213. https://doi.org/10.3389/fnhum.2014.00213

Luijten, M., Littel, M., & Franken, I. H. A. (2011). Deficits in inhibitory control in smokers during a Go/NoGo task: An investigation using event-related brain potentials. *PLoS ONE*, *6*, e18898–e18907. https://doi.org/10.1371/journal.pone.0018898

Luijten, M., Machielsen, M., Veltman, D., Hester, R., de Haan, L., & Franken, I. (2014). Systematic review of ERP and fMRI studies investigating inhibitory control and error processing in people. *Journal of Psychiatry and Neuroscience*, *39*, 149–169. https://doi.org/10.1503/jpn.130052

Lydon, D. M., Roberts, N. J., & Geier, C. F. (2015). Reduced influence of monetary incentives on Go/NoGo performance during smoking abstinence. *Nicotine & Tobacco Research*, *17*, 1178–1181.

Lyvers, M., Maltzman, I., & Clinical, Y. M. E. A. (1994). (n.d.) Effects of cigarette smoking and smoking deprivation on Wisconsin Card Sorting Test performance. *Journal of Experimental Psychology: General*, *2*, 283–289. https://doi.org/10.1037//1064-1297.2.3.283

MacLeod, C. M. (1991). Half a century of research on the Stroop effect: An integrative review. *Psychological Bulletin*, *109*, 163–203. https://doi.org/10.1037/0033-2909.109.2.163

Mayr, U., & Kliegl, R. (2003). Differential effects of cue changes and task changes on task-set selection costs. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *29*, 362–372.

McKay, C. C., van den Berg, B., & Woldorff, M. G. (2017). Neural cascade of conflict processing: Not just time-on-task. *Neuropsychologia*, *96*, 184–191.

Meinke, A., Thiel, C. M., & Fink, G. R. (2006). Effects of nicotine on visuo-spatial selective attention as indexed by event-related potentials. *Neuroscience*, *141*, 201–212. https://doi.org/10.1016/j.neuroscience.2006.03.072

Morie, K. P., De Sanctis, P., & Foxe, J. J. (2014). Reward contingencies and the recalibration of task monitoring and reward systems: A high-density electrical mapping study. *Neuroscience*, *273*, 100–117. https://doi.org/10.1016/j.neuroscience.2014.05.002

Nagai, Y., Critchley, H. D., Featherstone, E., Fenwick, P. B. C., Trimble, M. R., & Dolan, R. J. (2004). Brain activity relating to the contingent negative variation: An fMRI investigation. *NeuroImage*, *21*, 1232–1241. https://doi.org/10.1016/j.neuroimage.2003.10.036

Nestor, L., McCabe, E., Jones, J., Clancy, L., & Garavan, H. (2011). Differences in "bottom-up" and 'top-down' neural activity in current and former cigarette smokers: Evidence for neural substrates which may promote nicotine abstinence through increased cognitive control. *NeuroImage*, *56*, 2258–2275. https://doi.org/10.1016/j.neuroimage.2011.03.054

Newhouse, P. A., Potter, A. S., Dumas, J. A., & Thiel, C. M. (2011). Functional brain imaging of nicotinic effects on higher cognitive processes. *Biochemical Pharmacology*, *82*, 943–951. https://doi.org/10.1016/j.bcp.2011.06.008

Nieuwenhuis, S., Aston-Jones, G., & Cohen, J. D. (2005). Decision making, the P3, and the locus coeruleus–norepinephrine system. *Psychological Bulletin*, *131*, 510–532. https://doi.org/10.1037/0033-2909.131.4.510

Perlato, A., Santandrea, E., Della Libera, C., & Chelazzi, L. (2014). Biases of attention in chronic smokers: Men and women are not alike. *Cognitive, Affective, & Behavioral Neuroscience*, *14*, 742–755. https://doi.org/10.3758/s13415-014-0287-6

Pfefferbaum, A., Ford, J. M., Weller, B. J., & Kopell, B. S. (1985). ERPs to response production and inhibition. *Electroencephalography and Clinical Neurophysiology*, *60*, 423–434. https://doi.org/10.1016/0013-4694(85)91017-X

Poljac, E., & Yeung, N. (2014). Dissociable neural correlates of intention and action preparation in voluntary task switching. *Cerebral Cortex*, *24*, 465–478. https://doi.org/10.1093/cercor/bhs326

Potenza, M. N., Sofuoglu, M., Carroll, K. M., & Rounsaville, B. J. (2011). Neuroscience of behavioral and pharmacological treatments for addictions. *Neuron*, *69*, 695–712. https://doi.org/10.1016/j.neuron.2011.02.009

Razani, J., Boone, K., Lesser, I., & Weiss, D. (2004). Effects of cigarette smoking history on cognitive functioning in healthy older adults. *American Journal of Geriatric Psychiatry*, *12*, 404–411. https://doi.org/10.1097/00019442-200407000-00008

Ridderinkhof, K. R., Ullsperger, M., Crone, E. A., & Nieuwenhuis, S. (2004). The role of the medial frontal cortex in cognitive control. *Science*, *306*, 443–447. https://doi.org/10.1126/science.1100301

Schlienz, N. J., Hawk, L. W., & Rosch, K. S. (2013). The effects of acute abstinence from smoking and performance-based rewards on performance monitoring. *Psychopharmacology (Berl)*, *229*, 701–711. https://doi.org/10.1007/s00213-013-3131-8

Sebastian, A., Pohl, M. F., Klöppel, S., Feige, B., Lange, T., Stahl, C., … Tüscher, O. (2012). Disentangling common and specific neural subprocesses of response inhibition. *NeuroImage*, *64*, 1–15.

Silton, R. L., Heller, W., Towers, D. N., Engels, A. S., Spielberg, J. M., Edgar, J. C., … Miller, G. A. (2010). The time course of activity in

dorsolateral prefrontal cortex and anterior cingulate cortex during top-down attentional control. *NeuroImage*, *50*, 1292–1302. https://doi.org/10.1016/j.neuroimage.2009.12.061

Smith, J. L., Mattick, R. P., Jamadar, S. D., & Iredale, J. M. (2014). Deficits in behavioural inhibition in substance abuse and addiction: A meta-analysis. *Drug and Alcohol Dependence*, *145*, 1–33. https://doi.org/10.1016/j.drugalcdep.2014.08.009

Squires, K. C., Wickens, C., Squires, N. K., & Donchin, E. (1976). The effect of stimulus sequence on the waveform of the cortical event-related potential. *Science*, *193*, 1142–1146. https://doi.org/10.1126/science.959831

Tiffany, S. T., & Drobes, D. J. (1991). The development and initial validation of a questionnaire on smoking urges. *British Journal of Addiction*, *86*, 1467–1476. https://doi.org/10.1111/j.1360-0443.1991.tb01732.x

Tsaur, S., Strasser, A. A., Souprountchouk, V., Evans, G. C., & Ashare, R. L. (2015). Time dependency of craving and response inhibition during nicotine abstinence. *Addict Res Theory*, *23*, 205–212. https://doi.org/10.3109/16066359.2014.953940

Ullsperger, M., Fischer, A. G., Nigbur, R., & Endrass, T. (2014). Neural mechanisms and temporal dynamics of performance monitoring. *Trends in Cognitive Sciences*, *18*, 259–267. https://doi.org/10.1016/j.tics.2014.02.009

Vandamme, K., Szmalec, A., Liefooghe, B., & Vandierendonck, A. (2010). Are voluntary switches corrected repetitions? *Psychophysiology*, *36*, 1176–1181. https://doi.org/10.1111/j.1469-8986.2010.01032.x

Wagner, M., Schulze-Rauschenbach, S., Petrovsky, N., Brinkmeyer, J., von der Goltz, C., Gründer, G., … Winterer, G. (2012). Neurocognitive impairments in non-deprived smokers-results from a population-based multi-center study on smoking-related behavior. *Addiction Biology*, *18*, 752–761. https://doi.org/10.1111/j.1369-1600.2011.00429.x

West, R., & Alain, C. (1999). Event-related neural activity associated with the Stroop task. *Cognitive Brain Research*, *8*, 157–164. https://doi.org/10.1016/S0926-6410(99)00017-8

Weywadt, C. R., Kiehl, K. A., & Claus, E. D. (2017). Neural correlates of response inhibition in current and former smokers. *Behavioural Brain Research*, *319*, 207–218. https://doi.org/10.1016/j.bbr.2016.11.030

Zhang, R., Geng, X., & Lee, T. M. C. (2017). Large-scale functional neural network correlates of response inhibition: An fMRI meta-analysis. *Brain Structure and Function*, *222*, 3973–3990. https://doi.org/10.1007/s00429-017-1443-x

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

How to cite this article: Donohue SE, Harris JA, Loewe K, et al. Electroencephalography reveals a selective disruption of cognitive control processes in craving cigarette smokers. *Eur J Neurosci*. 2020;51:1087–1105. https://doi.org/10.1111/ejn.14622

Illinois Department of Innovation & Technology - Business Enterprise Program Report

BACKGROUND AND INTRODUCTION

Through the Department of Innovation & Technology (DoIT), the State of Illinois (State) contracted CW Financial & Management Group (CWFMG) to conduct a complete analysis of their Business Enterprise Program (BEP). This analysis included a detailed assessment of the associated processes assisting the department in meeting its BEP goals and increase DoIT solicitations and contract awards. CWFMG conducted vendor meetings and interviews with current and potential BEP firms and reviewed recent years of contracting and subcontracting activities and the use of commodity codes.

OBJECTIVES

- Review and analyze commodity codes in relation to Information Technology (IT)/Telecom products and services
- Identify procurement categories with insufficient BEP vendors and assist with finding qualified vendors to become certified
- Analyze IT products and services in specified categories by DoIT and develop minority participation opportunities
- Identify new opportunities for services in specified commodity codes that provide opportunities for upcoming contracts for services subject to BEP goals
- Work with prime vendors on existing contracts to identify qualified BEP vendors to meet and increase BEP goals
- Coordinate meetings between DoIT vendors and certified BEP vendors to assist with awareness and education of both parties as to state contract opportunities
- Identify new minority vendors that have the capacity to perform opportunities identified in the commodity review
- Provide a detailed assessment of gaps and suggested areas for improvement in BEP utilization

TECHNICAL APPROACH

CWFMG developed a work plan that allowed team members to review data and engage in outreach to develop recommendations. The final work plan consisted of, but was not limited to, the following:

- Review and analyze recent and current DoIT contracts
- Review and analyze procurement process
- Collecting data, populating data, and analyzing results
- Conducting utilization analysis
- Conducting vendor outreach
- Assessing the availability of qualified firms
- Analyzing the utilization and availability of subcontracting of BEP firms
- Gathering anecdotal obstacles and challenges of BEP firms
- Preparing a final report that presents remedies if indicated by findings

EXECUTIVE SUMMARY OF FINDINGS AND RECOMMENDATIONS

The following information presents the findings and recommendations resulting from the evaluation and analysis of DoIT's Business Enterprise Program. While the findings below guide DoIT on measures to improve BEP participation, CWFMG notes that some findings relate to obstacles and challenges that may be consistent throughout the State of Illinois. Therefore, CWFMG recognizes that DoIT does not have absolute jurisdiction to remedy some of the findings.

FINDING 1: Increase BEP Subcontracting Opportunities on Telecom Contracts

Our analysis revealed that the BEP goals on existing telecom contracts do not adequately reflect or exercise full opportunities for BEP participation on these contracts. For example, CWFMG identified that the State's contract number CMS793372P (Wireless/Cellular Services Equipment) with Verizon Wireless had established a BEP participation goal of 13%. However, there appears to be far more opportunity for BEP participation on this contract to reach the current aspirational BEP goal of 20% and more than likely to hit the future goal of 30%. It is imperative that DoIT maximizes BEP participation on this contract as it is one of its large contracts. Falling short on BEP goals related to this contract will cause increased pressures on all other contract opportunities for the Department to meet its overall BEP aspirational goals.

RECOMMENDATION FOR FINDING 1:

Engage current prime vendors on BEP contracts to encourage the expansion of BEP utilization on their contracts:

There are several areas of opportunity to increase BEP utilization on the State's contract with Verizon Wireless. CWFMG identified several areas of this contract that would allow for significant participation with BEP vendors. In addition, the team met with DoIT staff and discussed the following six areas where our analysis indicates BEP participation opportunities exist:

1. Installation and maintenance of accessory equipment such as boosters, enhancers, etc. may be outsourced to BEP vendors. This includes provisions under the contract for NetworkFleet and MobileIron.
2. Opportunities exist in outsourcing order provisioning and fulfillment of hardware (cell phones and accessories) to BEP vendors.
3. Services related to Verizon Wireless' web portal and enterprise help desk that provide support and monitoring with opportunities for BEP participation.
4. Training, as required by the contract, has a significant opportunity for BEP participation.
5. Commercial printing and direct mail of brochures, welcome kits, and similar promotional and marketing materials may be subcontracted to BEP firms.
6. While for the most part, Verizon is the reseller of manufacturer equipment, i.e., Apple or Samsung devices, the vendor may have limitations in allowing subcontracting of this function. However, opportunities may exist for BEP firms to become resellers of accessories and ancillary equipment.
7. There is a significant opportunity for BEP participation under the contractually required area of Reporting, Status, and Monitoring Specifications. This requirement provides that Verizon Wireless submit periodic data to the State and may be best practice to have an unaffiliated third party provide these services.

CWFMG encourages DoIT to re-engage the prime vendor to expand BEP participation in the areas outlined above and to include other areas as the prime vendor may suggest.

FINDING 2: DOIT'S BEP CHALLENGES RELATED TO THE SECTOR.

One of the challenges that DoIT faces for their BEP program is one related to their sector. The information technology sector is unique as compared to other sectors. Unlike sectors such as Construction or Architecture and Engineering, where BEP participation opportunities are more abundant, much of the services and products procured by DoIT are proprietary and not conducive to BEP and small business participation. For example, our analysis of DoIT software contracts, one of their largest procurement categories, found approximately 80% of them had 'limited to no potential' for BEP participation. However, our analysis found that there is a great deal of opportunity on small purchase contracts. We also found that there were areas within large contracts that offered opportunities for BEP participation. These contracts are highly technical and would need technical expertise to identify and scope out these opportunities.

RECOMMENDATION FOR FINDING 2:

Actions Needed to Address Challenges Created by the Sector:

CWFMG recommends that DoIT implement the following actions to help with the challenges faced in their sector and to enhance BEP opportunities:

1. Maximize opportunities for BEP participation through the increased use of the Small Business Set-Aside program. (See the recommendation for Finding # 6).
2. Utilize their in-house technical expertise to identify and scope out BEP participation opportunities on the large contracts and develop estimates and/or goals for BEP participation for these contracts. These actions also support the recommendation for Finding 1 in that this is better performed under a newly established CPO for Information & Technology.

FINDING 3: MANY BEP FIRMS LACK CAPABILITIES, CAPACITY, AND AGILITY TO RAPIDLY RESPOND TO SOLICITATIONS UPON ISSUANCE

Through the outreach to current and potential BEP firms, CWFMG discovered that several firms had maintained staff with only a few employees and there were some instances where the only employee was the business owner. These firms maintained a willingness to scale up to meet the needs of DoIT; however, they first need to know and understand the areas of their business that require scaling up and the timing of when to bring on resources. Many firms may not be able to maintain sufficient staff due to an inability to participate in State contracting at or near the representation of their firms. CWFMG's interactions with these firms indicate that many firms can scale up their capabilities and capacity with reasonable notice for preparedness.

RECOMMENDATION FOR FINDING 3:

Assist BEP Vendors Building Capability and Capacity:

CWFMG recommends that DoIT issue Pre-Solicitation Notices and conduct Market Research whenever possible. While we understand that The Department of Central Management Services (CMS) issues periodic spending plans, these spending plans appear to provide the best information for the procurement of general services as the descriptions listed in the spending plans do not provide adequate detail of the scopes of work. Therefore, CWFMG recommends DoIT issue Pre-Solicitation Notices through direct email to BEP vendors certified under related commodity codes. It is most beneficial if these Pre-Solicitation Notices are issued with as much lead time as possible to allow BEP firms to build capabilities and capacity directed at the scope of work issued in the Pre-Solicitation Notice.

In addition, CWFMG recommends that DoIT conduct Market Research for planned solicitations to assess the capabilities and capacity of the BEP pool of vendors. The Market Research should request that BEP-certified firms already qualified under the Department's Project Resources Sheltered Market (PRSM) procurement vehicle demonstrate their solutions for the scope of work issued in the Market Research. If two or more qualified firms demonstrate their capabilities to the Department, the solicitation should then be issued under the PRSM procurement vehicle. Increased use of the Small Business Set-aside program (as outlined in recommendation #7) will help BEP vendors to increase capabilities and capacity and will benefit the program overall.

FINDING 4: BASED ON OUR REVIEW OF PAST CONTRACTS WE FIND THAT BEP SUBCONTRACTING GOALS APPEAR TO BE SUGGESTIVE

CWFMG's review of previous DoIT contracts demonstrated that Prime Vendors often did not make good-faith efforts in meeting their BEP goals. There appeared to be waivers granted on contracts where there may have been little opportunity for BEP participation related to IT-related deliverables but appeared to be opportunities in areas such as finance, administration, and logistics.

RECOMMENDATION FOR FINDING 4:

Establishing Standards for Sub-Contracting Goals and Good Faith Efforts:

CWFMG recommends that DoIT make BEP subcontracting goals mandatory on all awards of large contracts. As stated before, opportunities for subcontracting on these contracts need not be limited to IT-related products and services. Therefore, it should be incumbent on the Prime Vendor awarded these large contracts to assess the scope of work to determine the opportunities that exist for subcontracting. This measure will emphasize Prime Vendors conducting outreach in advance of awards to build up their relationships with BEP vendors.

Additionally, CWFMG recommends that DoIT develop policies to define the Good Faith Efforts of Prime Vendors. These Good Faith Efforts should include but not be limited to the following:

- Prime Vendors must actively participate in Department sponsored or Department approved vendor outreach/matchmaking with the BEP vendor community as a prerequisite to seeking a waiver

- Contacting BEP firms that have reasonably been determined to have capabilities to participate in the related scope of work within a determined number of days prior to the bid opening date
- Provide reasonable assistance to BEP firms with obtaining necessary resources and capacity to participate in the scope of work
- Negotiating in good faith with interested BEP firms and not rejecting them as unqualified without sound reasons based on their capabilities. Any rejection of a BEP firm based on lack of qualifications should have the reasons documented in writing.
- Enter into Mentor/Protégé agreements
- Provide prompt payment agreements to enable BEP firms to meet cash-flow demands

FINDING 5: DOIT APPEARS TO LACK ADVANCED METRICS AND PERFORMANCE MEASURES TO ASSESS THE EFFECTIVENESS OF THE DEPARTMENT'S EFFORTS:

During CWFMG's data gathering period, most of the data had related to the performance measures was provided to us from CMS. However, CWFMG finds that DoIT's efforts for increasing BEP participation currently exceed the results of the other State agencies. As a result, DoIT should implement a system of developing and tracking performance measures to best direct its efforts in accordance with the needs of the BEP vendor pool.

RECOMMENDATION FOR FINDING 5:

Establish Performance Metrics:

CWFMG recommends that DoIT begin tracking the following performance measures:

- Growth in BEP prime contracting
- Growth in the number of BEP firms winning their first award
- Growth in the number of BEP firms for each relevant commodity code
- Number of contracts that exceed BEP goals
- Number of Mentor/Protégé agreements
- Number of contracts that fail to meet BEP goals

These recommended performance measures are suggestions that will need management input to expand and contract applicable metrics.

FINDING 6: MANY VENDORS ENGAGED DURING THE OUTREACH PERIOD REQUIRED SIGNIFICANT EDUCATION AND APPEARED TO NOT BE PROCUREMENT READY

After CWFMG spoke with many BEP certified vendors, it remained clear that continued outreach and education of BEP vendors are necessary. Many of the vendors that we engaged were not procurement ready based on our opinion. For example, many vendors that originated their certifications under the City of Chicago and Cook County were certified under the Business Enterprise Program but not registered in the Illinois Procurement Gateway, Small Business Set-Aside, and the State's bid system (BidBuy). Many vendors commented that they were unaware of the necessity to register in other systems within the State in order to do business directly with the State. These vendors also told CWFMG that they were confused by the necessity of the need to register in multiple systems.

Vendors also told us that they incorrectly thought that the assignment of commodity codes under their BEP registration was part of a self-certifying process. During their registration process, many disclosed that they selected the commodity codes that fit their capabilities and were unaware that they were not assigned the commodity codes upon their certification. The vendors failed to demonstrate capabilities as part of the registration process by uploading past contracts, licenses, and certifications.

RECOMMENDATION FOR FINDING 6:

Increase Vendor Outreach:

While many of the issues concerning the lack of education with processes and registrations are global throughout the State, CWFMG recommends DoIT continue and expand its outreach efforts to BEP vendors. DoIT should continue to conduct periodic virtual and in-person seminars to assist with education and outreach. Almost all of the gaps in BEP vendor registrations encountered were easy to resolve. Most BEP firms that CWFMG analyzed were unaware and seemingly attributed their lack of success in contracting with the State to their lack of overall faith in the State's desire to be more inclusionary in the contracting. Also, through our outreach, we discovered that many BEP vendors had not registered under the Small Business Set-Aside. CWFMG is recommending that DoIT continue to urge BEP vendors to register under this set-aside through its seminars and other forms of outreach.

FINDING 7: PRIME CONTRACTING OPPORTUNITIES FOR BEP FIRMS ARE MOST ABUNDANT UNDER THE SMALL BUSINESS SET-ASIDE

Due to the size limitations of most BEP firms, the State's Small Business Set-Aside provides the best opportunities for BEP firms to win awards as the prime vendor. Most BEP firms qualify for the Small Business Set-Aside, so this set-aside provides opportunities for BEP vendors with competition only from similarly situated vendors. In particular, the Department's Project Resources Sheltered Market (PRSM) vehicle further limits competition to BEP vendors. Currently, spending under the Small Business Set-Aside is directed at non-BEP vendors at disproportionate levels. The PRSM procurement vehicle offers the Department the opportunity to increase spending with BEP vendors as a result of the sheltered market.

RECOMMENDATION FOR FINDING 7:

Increase Use of Small Business Set-Aside Programs:

The PRSM procurement vehicle offers the Department the opportunity to increase opportunities for BEP vendors as a result of the sheltered market status. The Department should increase the use of procurement opportunities through this and like programs. Additionally, CWFMG recommends that DoIT allow BEP vendors to subcontract with similarly situated BEP vendors on small-dollar contracts. Many of the firms that we engaged with lacked full-service capabilities and had limitations on capacity. Allowing BEP firms to team with each other will help build capable teams with sufficient capacity to best respond to the State's needs.

Through our outreach, we discovered that many BEP vendors were not registered under the Small Business Set-Aside. CWFMG is recommending that DoIT continues to urge BEP vendors to register under this set-aside through its seminars and other forms of outreach. (Repeated recommendation from #6)

FINDING 8: BEP SUBCONTRACTING GOALS DO NOT ADEQUATELY REPRESENT THE CAPACITY OF BEP FIRMS TO PERFORM SERVICES ON EXISTING CONTRACTS AND POTENTIALLY FUTURE SOLICITATIONS

Currently, CMS is tasked with establishing subcontracting goals for BEP firms. On February 11, 2021, CMS issued a press release titled "The State of Illinois Announces New Methodology to Increase Diversity in Contracting." Within the press release, CMS details their improved methodology for establishing BEP subcontracting goals. The new methodology divides the number of BEP certified vendors registered with the State under relevant commodity codes by the overall number of vendors under relevant commodity codes in BidBuy. The formula is clearly defined as follows:

BEP Vendors/All Vendors in BidBuy = BEP Subcontracting Goal

The previous formula used a denominator comprised of vendors from the Dun & Bradstreet Hoovers database which is a more expansive database than BidBuy. Therefore, CMS should be commended for their efforts for increasing BEP subcontracting goals. However, CWFMG finds that the new and improved methodology will likely remain a challenge for DoIT to meet its aspirational goals for spending with BEP firms. There are two main challenges the Department will have with this new and improve methodology:

1. The formula is standardized, and as a result, is expected to over project goals on solicitations with little opportunity for subcontracting and under project goals on solicitations with substantial subcontracting opportunities.

2. Many BEP firms have not been assigned all commodity codes that represent their capabilities due to confusion in the registration process.

RECOMMENDATION FOR FINDING 8:

Utilize a More Individualized Process for Determining BEP Goals on Each Solicitation:

CWFMG recommends that BEP subcontracting goal setting be removed from CMS's responsibility due to the need for unique consideration with each of DoIT's solicitations. As an example, (also see Finding #2) CWFMG reviewed contracts for proprietary software and maintenance where there were very few subcontracting opportunities. Conversely, we reviewed contracts where there was an abundance of subcontracting opportunities, yet the subcontracting goals appeared to be well understated. The State recently signed into law Senate Bill 1608 which increases BEP aspirational goals from 20% to 30%. For DoIT to reasonably meet those goals, a great amount of individual analysis will be necessary for goal setting on each solicitation.

Also, House Bill 2270 seeks to amend the Procurement Code to provide that each chief procurement officer has the authority to designate veteran small business set-asides a fair proportion of construction, supply, and service contracts. Similarly, CWFMG recommends the same for BEP. Further, CWFMG recognizes Information Technology as a highly technical, unique, dynamic, and individualized sector of all goods and services procured by the State. We view Information Technology as a universal service throughout the State rather than a general service.

As a result, CWFMG encourages the State to establish a new Chief Procurement Officer (CPO) for Information & Technology to administer the volume and complexities related to this sector. If implemented by the State, the CPO for Information & Technology will be best situated for determining subcontracting goals to provide the Department with opportunities to meet newly established aspirational goals provided in Senate Bill 1608.

CONCLUSIONS:

While CWFMG recognizes that there are many opportunities for DoIT to improve its BEP program and enhance opportunities for BEP vendors, there is also a lot of work that needs to be done to achieve that. However, CWFMG would be remiss if we do not commend DoIT for proactive efforts in this area. Some of these include increasing its vendor outreach efforts by conducting seminars and other events, increasing resources for the BEP program, analyzing and redesigning some of the procurement vehicles, and utilizing the service of a business consultant to provide them with a roadmap. In light of the increased mandates from Senate Bill 1608, we found these efforts to be above those seen to be conducted by other agencies.

Policies

Nerevu Group, LLC
820 SW Adams St. Suite C
Peoria, IL 61602

Drug-Free Work Policy

We all must recognize that drug use and abuse negatively affect the company, the employee, job performance and co-workers. In this regard, Nerevu Group, LLC (Company) has adopted a Drug-Free workplace policy effective immediately. While we hope that this policy protects and benefits the company, we hope even more that it protects and benefits the employee and co-workers and creates a safe and efficient work environment.

For the purpose of clarification, alcohol is considered a drug under this policy.

Impairment Prohibited

No employee shall report for work or work impaired by any substance that is legal or illegal. “Impaired” means under the influence of a substance such that the employee’s motor senses (i.e., sight, hearing, balance, reaction, reflex) or judgment either are or may be reasonably presumed to be affected.

Possession Prohibited

No employee at any work site will possess any quantity of any substance, legal or illegal, which in sufficient quantity could cause impaired performance, except for authorized substances. “Work site” means any office, building, or property (including parking lots) owned or operated by the company, or any other site at which an employee performs work for the company. “Possess” means to have a drug or drugs either in or on an employee’s person, personal effects, motor vehicle, tools, and areas entrusted to the employee such as desks, files and company vehicles.

Inspections

1. For purposes of assuring compliance with the prohibition of possession of drugs, employees may be subject to inspection for drugs. Any refusal by the employee to submit to an inspection is an act of insubordination subject to disciplinary action.

2. An employee's person, work area, desk, files, company motor vehicle, and similar areas are subject to inspection for drugs at any time on a random or any other nondiscriminatory basis for purposes of complying with this policy. Similarly, an employee's own car, lunch box, personal containers, etc., may be inspected for drugs when brought onto any work site.

Help And Medical Treatment

1. The company believes that drug use and abuse is an illness requiring medical treatment. In this regard, the company will:

    1.a. Encourage affected individuals to voluntarily seek medical help.

    1.b. Assist supervisors in dealing with associated problems related to the employee's work performance.

    1.c. Discourage supervisors, fellow employees, and possibly family members from "covering up" for the affected individual.

2. If the employee seeks help prior to discovery of drug use and abuse, then confidentiality, job security, and promotional opportunities of the employee will be protected; if the employee does not seek help for drug abuse, and the problem comes to the attention of the company, then the employee will be subject to disciplinary action.

3. The company may refer an employee to a drug use and abuse counseling agency for help because of deteriorating job performance or excessive absenteeism of the employee associated with use and abuse of drugs.

Eligibility For Benefits

Since misuse of drugs is a treatable illness, an employee participating in the company medical insurance program is eligible for insurance benefits as addressed in the insurance schedule for drug treatment.

Effect On Company Rules

It is emphasized that recognizing drug use and abuse as an illness does not detract from company rules and regulations in respect to intoxication on the job, or having drugs on company property, which will continue to be enforced unless management approves otherwise.

Discipline

Any violation of this policy may result in summary discipline for the employee, up to and including discharge.

Signature

	04/20/22
Reuben Cummings, President	Date

NEREVU

Nerevu Group, LLC
820 SW Adams St. Suite C
Peoria, IL 61602

Sexual Harassment Policy

The company is committed to providing a workplace that is free from all forms of discrimination, including sexual harassment. Any employee's behaVIor that fits the definition of sexual harassment is a form of misconduct which may result in disciplinary action up to and including dismissal. Sexual harassment could also subject this company and, in some cases, an individual to substantial civil penalties.

The company's policy on sexual harassment is part of its overall affirmative action efforts pursuant to federal and state laws prohibiting discrimination based on age, race, color, religion, national origin, citizenship status, unfavorable discharge from the military, marital status, disability and gender. Specifically, sexual harassment is prohibited by Title VII of the Civil Rights Act of 1964 and the Illinois Human Rights Act.

Each employee of this company must refrain from sexual harassment in the workplace. No employee — male or female — should be subjected to unsolicited or unwelcome sexual overtures or conduct in the workplace Furthermore, it is the responsibility of all supervisors and managers to make sure that the work environment is free from sexual harassment. All forms of discrimination and conduct which can be considered harassing, coercive or disruptive, or which create a hostile or offensive environment must be eliminated. Instances of sexual harassment must be investigated in a prompt and effective manner.

All employees of this company. particularly those in a supervisory or management capacity, are expected to become familiar with the contents of this policy and to abide by the requirements it establishes.

Definition Of Sexual Harassment

According to the Illinois Human Rights Act, sexual harassment is defined as: Any unwelcome sexual advances, requests for sexual favors or any conduct of a sexual nature when:

1. all original works for authorship which you make (solely or jointly with others) within the scope of Nerevu Group, LLC's business which are protectable by copyright are "works made for hire," as that term is defined in the United States Copyright Act and
2. Submission to such conduct is made, either explicitly or implicitly, a term or condition of an individual's employment;
3. Submission to or rejection of such conduct by an individual is used as the basis for employment decisions affecting such individual; or
4. Such conduct has the purpose or effect of substantially interfering with an individual's work performance or creating an intimidating, hostile, or offensive working environment.

The courts have determined that sexual harassment is a form of discrimination under Title VII of the U.S. Civil Rights Act of 1964, as amended in 1991. One example of sexual harassment is a case where a qualified individual is denied employment opportunities and benefits after rejecting the supervisor's sexual advances or request(s) for sexual favors or the individual is terminated. Another example is when an individual is subjected to unwelcome sexual conduct by co-workers because of his or her gender which makes it difficult for the employee to perform his or her job. Other conduct, which may constitute sexual harassment, includes:

- Verbal: Sexual innuendos, suggestive comments, insults, humor, and jokes about sex, anatomy or gender-specific traits, sexual propositions, threats, repeated requests for dates, or statements about other employees, even outside of their presence, of a sexual nature.
- Non-Verbal: Suggestive or insulting sounds (whistling), leering, obscene gestures, sexually suggestive bodily gestures, "catcalls", "smacking" or "kissing" noises.

- Visual: Posters, signs, pin-ups or slogans of a sexual nature, viewing pornographic material or websites.
- Physical: Touching, unwelcome hugging or kissing, pinching, brushing the body, any coerced sexual act, or actual assault.
- Textual/Electronic: “Sexting” (electronically sending messages with sexual content, including pictures and video), the use of sexually explicit language, harassment, cyber stalking and threats via all forms of electronic communication (e-mail, text/picture/video messages, intranet/on-line postings, blogs, instant messages and social network websites like Facebook and Twitter).

While the most commonly recognized forms of sexual harassment involve the types of conduct described above, non-sexual conduct can also constitute a violation of the applicable laws when that conduct is directed at the victim because of his or her gender (for example, a female employee who reports to work every day and finds her tools stolen, her work station filled with trash and her equipment disabled by her male co-workers because they resent having to work with a woman).

The most severe and overt forms of sexual harassment are easier to determine. On the other end of the spectrum, some sexual harassment is more subtle and depends, to some extent, on individual perception and interpretation. The courts will assess sexual harassment by a standard of what would offend a "reasonable person."

For this reason, every manager, supervisor and employee must remember that seemingly "harmless" and subtle actions may lead to sexual harassment complaints. The use of terms such as "honey", "darling" and "sweetheart" is objectionable to many women who believe that these terms undermine their authority and their ability to deal with men on an equal and professional level. And while use of these terms by an individual with authority over a female employee will rarely constitute an adverse employment action, it may lead to the creation of a hostile work environment.

Another example is the use of a compliment that could potentially be interpreted as sexual in nature. Below are three statements that might be made about the appearance of a woman in the workplace:

- "That's an attractive dress you have on."
- "That's an attractive dress. It really looks good on you."
- "That's an attractive dress. You really fill it out well."

The first statement appears to be simply a compliment. The last is the most likely to be perceived as sexual harassment, depending on individual perceptions and values. To avoid the possibility of offending an employee, it is best to follow a course of conduct above reproach or to err on the side of caution.

Sexual harassment is unacceptable misconduct, which affects both genders. Sexual harassment will often involve a man's conduct directed at a woman. However, it can also involve a woman harassing a man or harassment between members of the same gender.

Responsibility Of Individual Employees

Each individual employee has the responsibility to refrain from sexual harassment in the workplace.

An individual employee who sexually harasses a fellow worker is, of course, liable for his or her individual conduct.

The harassing employee will be subject to disciplinary action up to and including discharge in accordance with company policy or any applicable collective bargaining agreement, as appropriate.

Responsibility Of Supervisory Personnel

Each supervisor is responsible for maintaining the workplace free of sexual harassment. This is accomplished by promoting a professional environment and by dealing with sexual harassment as with all other forms of employee misconduct. It must be remembered that supervisors are the first line of defense against sexual harassment. By setting the right example, a supervisor may discourage his or her employees from acting inappropriately. In addition, supervisors will often be the first to spot objectionable conduct or the first to receive a complaint about conduct which he or she did not observe.

The courts and the Illinois Human Rights Commission have found that organizations as well as supervisors can be held liable for damages related to sexual harassment by a manager, supervisor, employee, or third party (an individual who is not an employee but does business with an organization, such as a contractor, customer, sales, representative, or repair person).

Liability is either based on an organization's responsibility to maintain a certain level of order and discipline among employees, or on the supervisor, acting as an agent of the organization. It should be noted that recent United States Supreme Court cases involving sexual harassment claims against supervisors have made the employer's liability for supervisors' actions even stricter. Therefore, supervisors must understand that their adherence to this policy is vitally important; both with regard to their responsibility to maintain a work environment free of harassment and, even more importantly, with regard to their own individual conduct. The law continues to require employers to remain vigilant and effectively remedy sexually harassing conduct perpetrated by individual(s) on their coworkers. Supervisors must act quickly and responsibly not only to minimize their own liability but also that of the company.

Specifically, a supervisor must address an observed incident of sexual harassment or a complaint, with equal seriousness, report it, take prompt action to investigate it, implement appropriate disciplinary action, take all necessary steps to eliminate the harassment and observe strict confidentiality. This also applies to cases where an employee tells the supervisor about behavior considered sexual harassment but does not want to make a formal complaint.

Also, supervisors must ensure that no retaliation will result against an employee making a sexual harassment complaint.

Furthermore, managers/supervisors should remind employees, on a regular basis, that their incoming and outgoing electronic messages on employer owned/issued equipment are subject to monitoring and that employees have no expectation of privacy on employer owned/issued electronic equipment. Inform employees that if they are subjected to inappropriate electronic communications while at work or on employer-owned equipment, or even on their personal cell phones and computers, that they should contact their supervisor or Human Resources immediately. Advise managers, supervisors, and

employees not to “friend” each other on social networks and to limit their electronic messages to relevant business matters. Investigate complaints on a case-by case basis and remind employees of the company’s code of conduct and ethics rules if applicable.

Procedures For Filing A Complaint

An employee who either observes or believes herself/himself to be the object of sexual harassment should deal with the incident(s) as directly and firmly as possible by clearly communicating her/his position to the offending employee, her/his supervisor and company contact: Reuben Cummings.

It is not necessary for sexual harassment to be directed at the person making a complaint.

The following steps may also be taken: document or record each incident (what was said or done, the date, the time, and the place). Documentation can be strengthened by written records such as letters, notes, memos, and telephone messages.

All charges, including anonymous complaints, will be accepted and investigated regardless of how the matter comes to the attention of the company. However, because of the serious implications of sexual harassment charges and the difficulties associated with their investigation and the questions of credibility involved, the claimant's willing cooperation is a vital component of an effective inquiry and an appropriate outcome.

No one making a complaint will be retaliated against even if a complaint made in good faith is not substantiated. In addition, any witness will be protected from retaliation.

Proper responses to conduct which is believed to be sexual harassment may include the following:

- **Electronic/Direct Communication.** If there is sexual harassing behavior in the workplace, the harassed employee should directly and clearly express her/his objection that the conduct is unwelcome and request that the offending behavior stop. The initial message may be verbal. If subsequent messages are needed, they should be put in writing in a note or a memo.

- **Contact with Supervisory Personnel.** At the same time direct communication is undertaken, or in the event the employee feels threatened or intimidated by the situation, the problem must be promptly reported to the immediate supervisor or Reuben Cummings. If the harasser is the immediate supervisor; the problem should be reported to the next level of supervision or Reuben Cummings.

- **Formal Written Complaint.** An employee may also report incidents of sexual harassment directly to Reuben Cummings. Reuben Cummings will counsel the reporting employee and be available to assist with filing a formal complaint. The company will fully investigate the complaint and advise the complainant and the alleged harasser of the results of the investigation.

- **Resolution Outside Company.** The purpose of this policy is to establish prompt, thorough and effective procedures for responding to every complaint and incident so that problems can be identified and remedied internally. However, an employee has the right to contact the Illinois Department of Human Rights (IDHR) or the Equal Employment Opportunity Commission (EEOC) about filing a formal complaint. An IDHR complaint must be filed within 180 days of the alleged incident(s) unless it is a continuing offense. A complaint with the EEOC must be filed within 300 days. In addition, an appeal process is available through the Illinois Human Rights Commission, (IHRC) after IDHR has completed its investigation of the complaint. Where the employing entity has an effective sexual harassment policy in place and the complaining employee fails to take advantage of that policy and allow the employer an opportunity to address the problem, such an employee may, in certain cases, lose the right to further pursue the claim against the employer.

Administrative Contacts

- Illinois Department of Human Rights (IDHR)
  - Chicago: 312-814-6200 or 800-662-3942
  - Chicago TTY: 866-740-3953
  - Springfield: 217-785-5100
  - Springfield TTY: 866-740-3953
  - Marion: 618-993-7463
  - Marion TTY: 866-740-3953
- Illinois Human Rights Commission (IHRC)
  - Chicago: 312-814-6269
  - Chicago TTY: 312-814-4760
  - Springfield: 217-785-4350
  - Springfield TTY: 217-557-1500
- United States Equal Employment Opportunity Commission (EEOC)
  - Chicago: 800-669-4000
  - Chicago TTY: 800-869-8001

An employee, who is suddenly transferred to a lower paying job or passed over for promotion after filing a complaint with IDHR or EEOC, may file a retaliation charge, also due within 180 days (IDHR) or 300 days (EEOC) of the alleged retaliation.

An employee who has been physically harassed or threatened while on the job may also have grounds for criminal charges, such as assault or battery.

False And Frivolous Complaints

False and frivolous charges refer to cases where the accuser is using a sexual harassment complaint to accomplish some end other than stopping sexual harassment. It does not refer to charges made in good faith which cannot be proven. Given the seriousness of the consequences for the accused, a false and frivolous charge is a severe offense that can itself result in disciplinary action.

Signature

	04/20/22
Reuben Cummings, President	Date

Capability Statements

Nerevu Group, LLC
https://www.nerevu.com

820 SW Adams St. Suite C
Peoria, IL 61602

NEREVU

DATA TALKS
NEREVU LISTENS

Our Company

At Nerevu Group, LLC, we offer a portfolio of services that help organizations uncover the insights hidden in their real-time data. By creating interactive dashboards, developing web applications, and integrating disparate data silos, we usher our clients into the data-driven future.

Snapshot

Gov. Contact	Reuben Cummings, President
Company	Nerevu Group, LLC
Established	2014 as a Peoria Assumed Name Business
Incorporated	2019 as an Illinois LLC
Identifiers	**DUNS**: 079909596 | **CAGE**: 7GUB9
Certifications / Registrations	Illinois Minority Business Enterprise (MBE) Small Business Set-Aside Program (SBSP)

NIGP

20854	Microcomputer, Internet & Web Site Software
91829	Computer Software Consulting
92000	Data Processing, Computer, Programming, & Software Services

Past Performance

Client	Project	Core Capability
GO2 FOUNDATION FOR LUNG CANCER	Concept to Clinic	Predictive Analytics
Illinois Central College	Illinois Workforce Equity Initiative Website	API Development
OSF HEALTHCARE	CommunityConnect Dashboard	Dashboard Development

Our Capabilities

Data Analytics

KPI Consulting, Database Design, Data Visualization, Predictive Analytics, Monitoring & Alerting

Software Development

Web Applications, Dashboards, APIs, Process Automation

Data Integration

ERP Integration, Data Migration, Data Warehouse Setup, API Integration

Our Distinctions

Managed by an MIT chemical engineer

15 years experience in consulting & IT

MLK Drum Major Award recipient

Author of popular open source ETL and stream processing libraries

Peoria data-community organizer

Our Technologies

aws

HEROKU

Flask

PostgreSQL

python

node JS

NEREVU GROUP, LLC

820 SW ADAMS ST. SUITE C ◆ PEORIA, IL 61602

WWW.NEREVU.COM ◆ (234) 738-2266 ◆ GOVBIZ@NEREVU.COM

Nerevu Group, LLC
820 SW Adams St. Suite C
Peoria, IL 61602

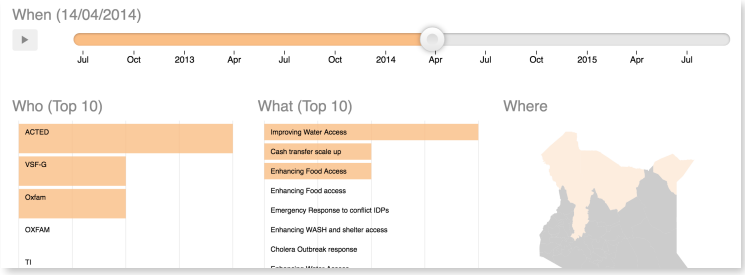
Our Capabilities

API Development | Dashboard Development | Web Applications | Predictive Analytics | Data Integration | Process Automation | Monitoring & Alerting

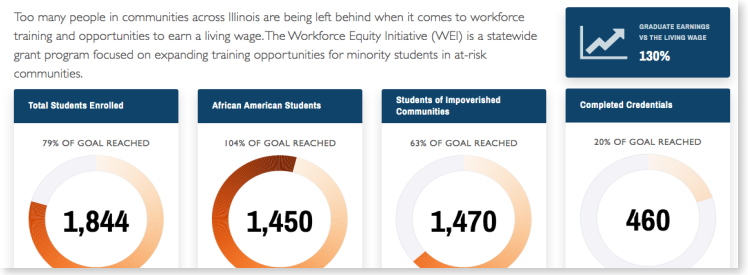
Projects

Client	Project	Client Type	Prime	Capabilities
Oxfam Kenya	La Niña Consortium 4W	NGO	✗	
Illinois Central College (ICC)	Illinois Workforce Equity Initiative Website	Non-profit	✓	
Addario Lung Cancer Foundation (ALCF)	Concept to Clinic	Healthcare	✗	
OSF Healthcare	Community Care Dashboard	Healthcare	✓	
Greater Peoria Economic Development Council	Data Hub Automation	Government	✓	
Peoria Innovation Alliance	Traffic Insight Dashboard	Non-profit	✓	
United Nations OCHA	Humanitarian Data Exchange (HDX)	NGO	✓	

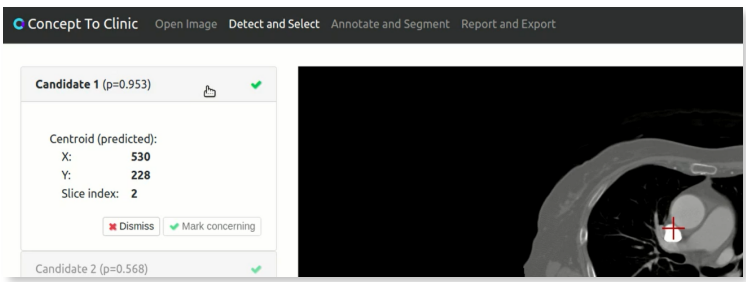
Screenshots



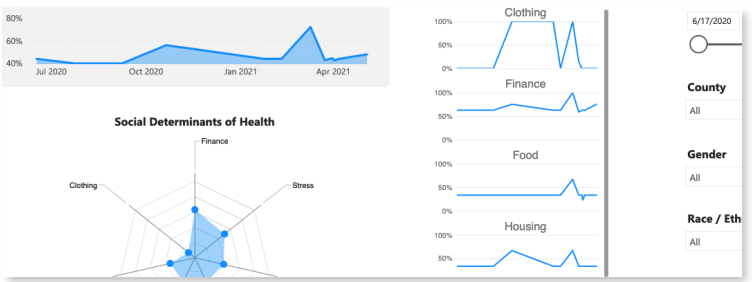
La Niña Consortium



Workforce Equity Initiative



Concept to Clinic



CommunityConnect (OCC) Dashboard

CW Financial & Management Group

Core Competencies

- Small Business Development
- Small Business Outreach
- Procurement Training
- Contract Administration
- Illinois Procurement Gateway Registration
- Illinois Small Business Set Aside Registration
- Illinois Business Enterprise Program Registration

Company Data

CW Financial & Management Group LLC provides a wide range of financial and management services. We stand firm in our motto that "Good enough…never is…"

Registrations

- SDVOB, VOSB
- Black Owned
- DUNS: 117021419
- CAGE Code: 8AQ22

NAISC Codes

541310 – Architectural Services
541330 – Engineering Services
541611 – Admin Management
541620 – Environmental Consulting
541690 – Other Scientific and Technical Consulting

Differentiators

CW Financial & Management Group is able to achieve the highest level of service in outreach and small business development due to our extensive knowledge of the State of Illinois contract and procurement systems.

Service Disabled Veteran Owned Small Business
SDVOSB
CVE

Company Overview

CW Financial & Management Group's (CWFMG) owner, Craig Williams, was a long-time employee of the State of Illinois. He served as a budget analyst for the Illinois Governor's Office of Management & Budget and as the CFO of the State's mental health system. As a result, Mr. Williams has in-depth knowledge of the State's procurement system and the statute that governs it. In 2021, CWFMG conducted outreach to minority owned businesses for the Illinois Department of Innovation & Technology. We were able to conduct outreach to minority owned businesses who were not yet certified under the State's Business Enterprise Program (BEP) and work with them to register. In addition, we worked with existing BEP firms to enhance their registrations with additional commodity codes and other registrations under the State.

Craig@CWFMGroup.com

Denise Moore
Biography 2022

Denise is an entrepreneur, financial professional, volunteer, and served two terms as the first African American woman elected to the Peoria City Council, representing Peoria's First District from 2013 - 2021. Denise is the Founder/CEO of the Black Business Alliance Peoria Chapter, Inc. (a 501c3 non-profit corporation), overseeing both WPNV 106.3 LP FM, Peoria's only African American owned community radio station, and the Minority Business Development Center that is helping build minority businesses, contractors, and the workforce.

In **1995,** Denise founded and co-owned what would become the largest African American gift store outside of Chicago and St. Louis. She and her husband went on to own two store locations in central Illinois, 1996-Moore Cultural Expressions in Normal and 2010-Moore Art on Water in Peoria. Denise also branched out to business consulting starting Up4Moore to provide motivation and small business advising while focusing on personal empowerment and financial literacy

In **1997**, Denise founded the Black Business Alliance, Inc (BBA) in Bloomington/Normal, (a 501c3 non-profit) to educate aspiring and operating business owners on the tools necessary to start and sustain a minority business in a majority culture. As the President of the BBA in Bloomington, Denise was also the editor and publisher of a monthly newsletter called 'The Griot' as a method to inform African Americans on issues impacting the community and founded WXRJ 94.9 LP FM radio station in Bloomington, Illinois, which continues to be the community's first and only African American radio station. Denise was named Outstanding Toastmaster President in Mclean County during this time and served six years as the Keynote Facilitator of Peoria's Annual Women's Business expo. **In 2013**, she went on to start the Black Business Alliance Peoria Chapter, WPNV 106.3 LP FM radio station and the Minority Business Development Center in Peoria, Illinois in **2015**. Called Peoria's Neighborhood Voice, (WPNV) seeks to connect and inform the minority community. Prior to these roles, she was a financial professional with Mass Mutual and served in various leadership capacities at State Farm Insurance for 17 years.

Denise and her husband received the Dr. Martin Luther King Jr. *'Leadership Award'* for their radio station programming in the areas of Public Affairs, Community Education and Empowerment.in **2016** and Denise was honored in **2017** to receive the President Barack Obama *'Lifetime Achievement Award'*. Also, Peoria has named Denise a *'Woman of Influence'* by iBi magazine, a *'Business Pioneer'* by the Marketeer magazine and received the *'Woman Making Modern History'* award by AfraVictoria magazine. In **2018,** Denise received the *'Great Partner Award'* for "Outstanding Contributions to Regional Economic Development" from the Greater Peoria Economic Development Council, the *'Love In Action'* award from Common Place, a community based social service agency for her work uplifting the community and the *'Excellence Award in Economic Empowerment*' from the 100 Black Men of Central Illinois. In **2019**, for her leadership on the Peoria City Council, Denise received the "*Outstanding Commitment as an Elected Official*' award from the State of Illinois Treasurers' office, the '*Deborah Sawyer Award*' in recognition of her work advancing women in small business development from the Illinois Black Chamber of Commerce and the '**2019** *Small Business Advocate of the Year*' award from the Turner Center for Entrepreneurship, part of the America SBDC network.

Denise was appointed to the State of Illinois Small Business Development Center (SBDC) Advisory Board in **2016**, serves on the board of, the Peoria Innovation Alliance board and past board member of PCCEO (Peoria's Community Action Agency) board, Downtown Development Corporation and Proctor Hospital Foundation board.

Denise is a graduate of Illinois State University with a BS in Business Administration, has earned the coveted Chartered Property & Casualty Underwriter designation and is a Financial Services Institute Associate. Denise is married to Garry and has one daughter and two grandsons.